March 20, 2019
Coos Bay Planning Commission
Coos Bay, OR 97420

RE:187-18000153-PLNG-01 Jordan Cove Energy Project

We strongly object to the proposed exemption from the current zoning regulations that are in place along the Coos Bay shoreline. These regulations were put in place to safeguard this estuary habitat and were based on sound science when they went into effect.

Circumventing these regulations for corporate benefit is disallowing the citizens of Oregon, who are the real stakeholders, the right to object to the estuary damage that will happen from excavating mud flats that contain shrimp and clam beds.

Dredging and destroying clam beds and sand shrimp beds will hurt our fisheries. Our fisheries support tourism and also support ocean wildlife. Dredging will also impact crab production and this will hurt commercial and recreational crabbing.

It has become obvious that our politicians have been polluted with influence money from corporations that are not invested in our community.

Do you really believe Pembina cares about our safety or the unknown future damages this project will cause to our environment and our fisheries?

My biggest concern is leaving this safety burden for our children or grandchildren. I cannot with a good conscience support the LNG risk.

Coos Bay's health should not be sacrificed for exporting Canadian natural gas. Thank you for your consideration.

Sincerely,

Power Hooker Tackle Company LLC
Chuck Erickson-member
PO BOX 1083
Coos Bay, OR 97420

CONFEDERATED TRIBES OF
COOS, LOWER UMPQUA & SIUSLAW INDIANS
1245 Fulton Ave. Coos Bay, OR 97420
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March 21, 2019

City of Coos Bay Planning Commission
500 Central Avenue
Coos Bay, Oregon 97420

SENT VIA EMAIL (hhearley@lcog.org; jcallister@lcog.org; cjohnson@coosbay.org)

RE: Comprehensive Plan Amendment 187-18-00153: Jordan Cove Energy Navigation and Efficiency and Reliability of the Coos Bay Deep Draft Navigation Channel

Dear Members of the Planning Commission:

The Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians ("Tribe") respectfully submits these comments on Comprehensive Plan Amendment 187-18-00153: Jordan Cove Energy Navigation and Efficiency and Reliability of the Coos Bay Deep Draft Navigation Channel (the "Proposal").

1. BACKGROUND

The application proposes dredging, or "Navigational Reliability Improvements" ("NRIs") SR four locations within the Coos Bay Deep Draft Navigational Channel. The dredging is referred to as NRIs. Three of the proposed NRIs are within Coos County and one (Dredge Area #4) is within the City of Coos Bay.

This Proposal is one component of the approval process for the Jordan Cove Energy Project ("JCEP") and the Pacific Connector Gas Pipeline ("PCGP").

The JCEP will involve the construction and operation of a Liquified Natural Gas ("LNG") terminal that would receive a maximum of 1.2 million dekatherms per day of natural gas and produce a maximum of 7.8 million tons of LNG for export each year. The LNG terminal will cool natural gas into its liquid form in preparation for export from Coos Bay. The LNG terminal is composed of Ingram Yard, South Dunes site, the Access and Utility Corridor, and the Roseburg Forest Products property. The LNG terminal and associated facilities would cover 538-acres of land, including 5.2 acres of open water and 169-acres of wetlands.

The Pacific Connector Gas Pipeline, to which this Proposal is a part, involves the construction of a 36-inch underground 229-mile natural gas pipeline from Malin, Oregon to Coos Bay. Over the

229-mile pipeline route, the applicants propose to cross Coos Bay, the South Coast watershed (Coos and Coquille Subbasins), the Umpqua watershed, the Rogue watershed, and the Klamath watershed (Upper Klamath and Lost Subbasins). Overall pipeline construction would impact 30,778-feet (5.83 miles) of wetlands and 3,028-feet of waterways. Approximately 48,675 cubic yards of material would be excavated and discharged into wetlands and 9,519 cubic yards of material would be excavated and discharged into waterways. Within Coos Bay, Jordan Cove proposes to install the 36-inch pipeline across the Bay using two horizontal directional drills ("HDD") of 5,200 and 9,000 feet each.

The actions described in the Proposal before the City are part of a larger regulatory process that necessitates a myriad of federal, state, and local approvals to comments. The JCEP and pipeline, are subject to review and approval by the Federal Energy Regulatory Commission, who can approve the projects only if there is a demonstrated public need for the projects and if the projects can comply with federal, state, and local environmental and cultural resource laws. Both projects must also comply with permitting requirements from the Army Corps of Engineers, the Oregon Department of Environmental Quality, the Oregon Department of State Lands, the Oregon Department of Energy, and others. In addition, there are several permits pending with Coos County and a hearing heard earlier this week with the City of North Bend. All of these federal, state, and local approvals are necessary for the two projects to proceed.

2. POSITION OF THE TRIBE

Before addressing specific concerns, the Tribe would like to strongly concur with proposed Condition of Approval #2, as well as the request of JCEP on page 35 of its Narrative in Support of the Application to adopt terms and requirements of the Memorandum of Agreement ("MOA") and the Cultural Resource Management Plan ("CRPA") as a condition of approval of this proposal in order to satisfy the requirements of CBEMP Policy #18. The MOA is a product of years of negotiations between the Tribe and the applicant, and will serve as the framework through which the Tribe's cultural resources within the Project area are properly identified and protected. We appreciate the applicant's willingness to partner with us to accomplish these important objectives.

The purpose of the MOA and CRPA is to set forth binding, "appropriate measures" to protect cultural, historic, and archaeological resources as required by CBEMP Policy #18, including sites shown on the map of inventoried sites, sites identified by the State Historic Preservation Officer ("SHPO") or Tribal Historic Preservation Officer ("THPO"), and, as stated on page 2 of the MOA, "unknown or unrecorded cultural, archaeological and/or historical sites" that may "be encountered within the Project area."

The importance of Coos Bay to the Tribe and the presence of archaeological and cultural resources through the area impacted by this proposal cannot be understated. The Coos people have continuously used the estuary since time immemorial to the present as demonstrated by archaeological sites, named places in Hanis and Miluk dialects of the Coosan Language, and the presence of prehistoric and historic burials of peoples at former villages and subsistence sites of our people. The Coos Bay estuary is a central feature of Coos culture and identity.

Coos Bay includes hundreds of sites of nearby fish weirs and traps, former villages, and loci of events in the oral literature of the Coos people. We have used the estuarine and shore lands in the area all our lifetimes to fish, gather shellfish, harvest berries, medicines, and plants for consumption or cultural purposes. The main stem was used as a primary transportation route for

the Coos and is still used for fishing and canoeing by Tribal members today as well as for resource gathering and/or ceremonial purposes.

Tribal members have significant connections to the Bay, including named villages, abundant traditional food sources, historic fish weirs, gathering areas and numerous ceremonial and burial sites. And while records capture village areas edging nearly all the shorelines of the Bay the estuary was not static until the jetties were built so it is likely that occupation shifted as water pathways, sand deposits and significant events such as the earthquake and tsunami of the 1700s changed the Bay's shorelines. For example, in October 2017, there was an inadvertent discovery on the edge of the shipping channel that was 25 to 30 feet below the bottom of the Bay (under Corp Permit NWP-2017-41.1- geotechnical pipeline work). In that case, there was a midden discovered that was subsequently radiocarbon dated to approximately 3,000 years ago.

The Tribe has consistently maintained the many cultural resources within Jordan Cove area and the bay should be considered eligible for listing as a Traditional Cultural Property on the National Register of Historic Places. On July 31, 2006, the Tribe passed Resolution No. 2006-097 which designated Jordan Cove and the surrounding area as a TCP. The Tribe reaffirmed this designation on July 29, 2015 in Resolution No. 2015-049. Last year, the Tribe submitted an application to the Oregon SHPO for listing Jordan Cove and Bay of the Coos People (Coos River Estuary), *Q'alay ta Kukwis shichdii me*, as a TCP on the National Register. The Oregon SHPO recently recommended to the National Park Service that the *Q'alay ta Kukwis shichdii me* should be listed in the National Register.

Given the significance of the Bay to the Tribe and its rich cultural resources, it is essential that the MOA and CRPA be adopted as a condition of approval as proposed by JCEP, as agreed by the Tribe, and as required by Policy #18.

The Tribe does not take a position "for" or "against" the Proposal. Instead, the Tribe seeks to ensure that any permits issued for the JCEP LNG terminal and natural gas pipeline comply with all laws applicable to the Project, including proper consideration and protection of cultural and natural resources. The City's review of this proposal is governed by Oregon's Statewide Planning Goals, the Coos Bay Estuary Management Plan ("CBEMP"), and a number of other local and state requirements.

3. SPECIFIC COMMENTS

a. Draft Condition of Approval #3 states, "Prior to the commencement of any dredging associated with an Estuarine and Coastal Shoreline Uses and Activities permit, JCEP shall obtain, and provide evidence to the Coos Bay Community Development Director, of all necessary DSL and Federal Section 404 authorizations. JCEP shall provide the City with copies of these approved authorizations for the record." **This condition should be amended to state, "… all necessary DSL, Clean Water Act approvals, including a Section 404 permit from the Army Corps of Engineers and the 401 Certification from the Oregon Department of Environmental Quality ("ODEQ"), and approval from the Federal Energy Regulatory Commission."**

Statewide Goal 6 provides that the Proposal "maintain and improve the quality of the air, water and land resources of the state." The staff report indicates, "[I]t relies entirely on state and federal regulations for direction and implementation. Staff believe it is reasonable to find that the applicant will comply with federal and state environmental

standards in the future if and when federal and state permits for dredging are secured." Moreover, CBEMP Policy #5 requires this Proposal to be consistent with the objectives of the Estuarine Resources Goal and to otherwise comply with the "requirements of state and federal law." In addition to the permits referenced in the draft condition, this Proposal is subject to a Clean Water Act Section 401 certificate[1] and approval from the Federal Energy Regulatory Commission ("FERC") (FERC reviews applications for the construction and operation of natural gas pipelines to ensure compliance with the Natural Gas Act and ensure compliance with the National Environmental Policy Act and other federal requirements).[2] Because the FERC approval and 401 certificate (both federal requirements) are not addressed in the draft condition, it should be amended as proposed.

b. Statewide Goal 8 provides that the Proposal must not interfere with recreation in Bay. Consistent with this, the Tribe requests that the City and the applicant consider measures to minimize disruption of fishing, fishing, and shellfish gathering during dredging and maintenance dredging thereafter. The attached document illustrates important shellfish areas in the Bay. The Coos Bay region is an important recreational Dungeness crab fishery area. Estimates from the 2007-2011 period found a minimum of 10,661 to a maximum of 15,023 crabbing trips were made in Coos Bay from April to October per year.[3] According to the State, nearly 90 percent of the boat use-days in Coos Bay involved fishing (including angling, crabbing, and clamming). Coos County recreation expenditures, including hunting, fishing, wildlife, viewing, and shell fishing totaled $6.2 million dollars in 2008. Travel-generated expenditures for these activities in Coos County generated $33.5 million dollars in 2008.[4] **Accordingly, the Tribe requests that an additional condition of approval be adopted that specifically requires that notice be provided to the community (including notice at boat launches and other recreation sites) that describes when dredging will occur and areas that may be closed/restriction from boat use during dredging.**

c. CBEMP Policy #5 requires a finding that there is a demonstrated "public need" for the project. Likewise, OAR 660-004-0022(1) provides that the applicant must demonstrate a need for the proposed use/activity. OAR 660-004-0020 (2)(a) states that the exception shall state the "[r]easons [to] justify why the state policy embodied in the applicable goals should not apply." The stated need for the Proposal is that the existing navigation channel is insufficient. However, evidence in the record indicates that this is not the case. In May 2018, the Coast Guard indicated "that the waterway in its current state" is "considered suitable for the LNG marine traffic associated with the proposed project" and can accommodate vessels with a maximum length of 300 meters or approximately 984 feet which is over 200 feet longer than any of the proposed current LNG vessels. *See*

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[1] Information about this process is available on the State's webpage at https://www.oregon.gov/deq/Programs/Pages/Jordan-Cove.aspx.

[2] Information about the FERC process is available on the federal permitting dashboard website at https://www.permits.performance.gov/permitting-projects/jordan-cove-lng-terminal-and-pacific-connector-gas-pipeline.

[3] "The Oregon Recreational Dungeness Crab Fishery, 2007-2011 54, (July 2012) available at https://www.dfw.state.or.us/MRP/shellfish/docs/2012-04.pdf.

[4] "Fishing, Hunting, Wildlife Viewing, and Shellfishing in Oregon - 2008 State and County Expenditure Estimates"; Prepared for the Oregon Department of Fish and Wildlife - Travel Oregon; Dean Runyan Associates; May 2009, available at http://www.dfw.state.or.us/agency/docs/Report 5 6 09--Final%20%282%29.pdf.

Exhibit 4 at 9-10. Additionally, "simulated transits were piloted by the Coos Bay Pilots and witnessed by the USCG…these successful simulations expand the ability for Jordan Cove LNG to use any class of LNG carrier (membrane, Moss, or SBT) with physical dimensions equal to or smaller than observed during the simulated transits." *See* Exhibit 4 at 15. Accordingly, while there may be a desire for greater dredging, there is not a demonstrated need as evidenced by the Coast Guard's statements.

d. CBEMP Policy #5 requires that "adverse impacts" of the project of the Proposal are minimized. This requires that conditions are adopted to minimize impacts of the Proposal.

First, the staff report indicates that the "in-water work window" for the project will be October 1 to February 15 "to reduce impacts to sensitive life stages of fish in the bay." Staff Report at 17. However, as indicated by the photos taken below by the Tribe's Natural Resource Department staff of herring spawn by Fossil Point taken this last February, the Bay serves as an important spawning area for herring.[5] Herring spawning in the Bay occurs during February. **Accordingly, in order to avoid adverse impacts to herring spawning as required by CBEMP Policy # 5, the City must adopt a condition of approval that provides that in-water work should end by February 1.**

[5] ODFW, Natural Resources of Coos Bay Estuary at 40 ("Spawning occurs from January through April, and herring remain in the bay through summer.), available at https://odfw.forestry.oregonstate.edu/freshwater/inventory/pdffiles/Natural%20Resources%20of%20Coos%20%20Estuary%20No.6.pdf. *See also* http://www.clamdigging.info/Pacific%20Herring.html ("Herring occasionally spawn in most all of Oregon's bays but spawn consistently in Coos Bay, Umpqua Bay and Yaquina Bay from February through early April but most consistently during March."); http://www.milebymile.info/Chetco%20Bay.html ("Pacific herring enter the bay to spawn in February, March and into April.").

Second, Coos Bay is a crucial "nursery" habitat for the Dungeness crab and impacts must be minimized. In her statement given to the Department of State Lands at the Public Hearing for Jordan Cove in Salem, Oregon, Professor Sylvia B. Yamada stated that dredging could negatively impact this important nursery habitat for the native species of Coos Bay and its estuary, including the Dungeness crab.[6] According to Professor Yamada, the highest number of juvenile crabs are found in soft sediments and eel grass beds of estuaries, where the young crabs find food and shelter from predators. Indeed, Professor Yamada stated that she herself has consistently trapped an average of 15 young Dungeness crabs per trap in her Coos Estuary study site, located along the Trans Pacific Parkway (adjacent to Jordan Cove). Turbidity associated with in-water activities, such as dredging can adversely impact these crabs and their habitat. In study conducted by Professor Yamada and designed to simulate a dredging operation, she found that between 45 to 85 percent of the Dungeness crabs exposed to the operation died. In order to comply with Policy # 5, conditions of approval should be developed to avoid any discharge of turbidity into habitat areas or destruction of aquatic resources.

The concerns about the impacts of dredging to crab and associated Bay habitat are further echoed in the attached comments from the Oregon Department of Fish and Wildlife ("ODFW") to the Department of State Lands – "The expected hydrological changes at the site due to the project development will potentially result in a number of changes to the biological communities at those locations (e.g. densities, species composition, predatory interactions, etc.). These changes may occur in areas adjacent to or a considerable distance from the project area where there is little or no construction activity." ODFW Comments at 18. "Mobilization of substrates will occur during the initial dredging and with continued regular disturbance associated with maintenance dredging (estimated 360,000 CY in the first 10yrs.; 36,000/yr.) within the project area." *Id.* at 20. "Marked change will occur to the productivity of the dredged portion of the bay and little recovery is expected over time due to the continual need for maintenance dredging. Maintenance dredging for the JCEP will result in a continually disturbed

[6] Public Hearing for Jordan Cove Removal-Fill Permit Application – Salem, OR: Before the Or. Dept. of State Lands (1.15.2019) at 2:17:07, 2:17:19 (statement of Sylvia B. Yamada, Assistant Professor, Senior Research; Dep't of Zoology, Oregon State Univ.), available at https://www.youtube.com/watch?v=aRQATTbaE6k.

condition preventing development of any reliable estuarine production in the affected areas. Additionally, the Port of Coos Bay project will likely dredge substantially more on an annual basis." *Id.* at 6.

The Tribe requests that the City include a condition of approval that requires the monitoring of turbidity and other dredging impacts recommended in the attached ODFW comments at page 20 be adopted as a specific condition of approval by the City in order to minimize adverse impacts of the Proposal.

e. State Goal 5 and CBEMP Policy # 18 both require protection of historic, cultural, and archaeological resources. In order to be compliant, an inventory of cultural resources and natural resources should be done by local municipalities, including the City of Coos Bay. Appropriate mitigation areas should be identified by the City in conjunction with an inventory. Currently, the City of Coos Bay does not have an inventory of these resources and relies on the County's inventory, which is grossly outdated. Directly adjacent to and on either side of the Bay, collectively, are two village sites, four cultural landscape features, and one natural landscape feature including a rock feature that is part of a Coos Myth Tale noted in the TCP nomination and submitted to the SHPO and National Park Service for consideration as a National Register site that is based on information compiled from archaeological investigations and ethnographic informants. The proposed dredging has the potential to both directly and indirectly impact these cultural sites both from the dredging activity itself and from potentially increased shoreline erosion and potential changes to current sediment dispersal patterns. While the CRPA addresses monitoring and mitigation of impacts to these resources when they cannot be avoided, it does not address the City's obligation for inventory and effects determinations under the CBEMP for these resources.

Thank you for consideration of these comments. If you have any questions about these comments, please contact me at mcorvi@ctclusi.org or by phone at 541-435-7151.

Sincerely,

Margaret Corvi
Culture and Natural Resource Director
Confederated Tribes of Coos, Lower Umpqua & Siuslaw Indians

cc: JCEP
FERC Docket
SHPO
DSL

ATTACHMENTS (2)

Coos Bay Shellfish Areas

Coos Bay is the largest estuary entirely in Oregon and provides many opportunities for clamming and crabbing. The lower bay (west of the railroad bridge) is "marine dominated", meaning there is little freshwater influence. These stable high salinities contribute to the lower bay being ideal habitat for clams and crabs. Upper bay areas (east of the railroad bridge) tend to have more freshwater influence and popular bay clam species and adult Dungeness crab are not found.

North Spit:

The western side of lower Coos Bay features popular and productive boat crabbing and bay clam digging.

Access is difficult (4x4 road or boat only). Paved road ends at the former aquaculture facility (access point #6).

Gaper and butter clams are found densely throughout. Other bay clam species are found sparsely, and harvested less often.

Strawberry Island (SI):

This is the only vegetated island in lower Coos Bay. Gaper and butter clams are found throughout; large butter clams can be dug in the gravelly beds east of the island. Access is by boat or wading from the beach at a good low tide.

Clam Island (CI):

This "island" emerges at a +2' or lower tide and is only accessible by boat. Clam Island features the highest densities of gaper and butter clams in Coos Bay. Adjacent shoreline flats boast excellent clamming as well.

Aptly named "Hungrymans cove" is a small alcove that separates the shoreline with the island, a good place to crab on a windy day.

Training Jetty (TJ):

This tideflat constrained between the shoreline and the "training jetty" is known to have large gaper clams, though they are often deeply dug in.

Charleston area:

Clamming in Charleston is excellent throughout, access is easy.

Point Adams (PA):

Large cockles can be raked along the sandy beach at a very low tide. Gapers occasionally recruit to the beach southeast of the point.

Charleston Triangle (CT):

Gapers and butters are abundant. Easily accessed from parking areas south of docks (access point #1).

Charleston Flat (CF):

Gapers and butters can be dug throughout the areas south of the South Slough Bridge. Cockles can be raked toward the south end of this area. Access is from the Charleston Visitor Center (access point #2).

Barview (BV):

Butter clams throughout in good numbers. Gapers and native littlenecks are also found.

South Slough (SS):

Further up South Slough, all tideflats up to Valino Island are excellent for gaper, butter, and cockle clams. Access is exclusively by boat.

Lower Coos Bay crabbing:

Beyond the edges of the navigational channel, look for depths of 15-35'. Boat traffic can be high in this area. Be legal and considerate by placing gear outside of channel and by using sinking crab line.

Charleston crabbing:

Commercial boat docks provide good access. Try to avoid sea lions.

Mid to Upper Coos Bay:

These areas of Coos Bay may be more difficult to access but may be worthwhile for digging softshell clams

Upper Coos Bay (UC):

The areas "up bay" of the railroad bridge are soft and muddy. Softshell clams can be found throughout, but finding firm walking substrate is challenging. Areas around Trans Pacific Parkway and North Slough are occasionally used.

Airport (AP):

Extensive clam beds, west of the runway, are rarely accessed, but very productive. Gapers and cockles are found. Access is by boat only.

Empire:

The areas on the east side of lower Coos Bay are excellent for butter and gaper clamming and easily accessed.

Empire (EP):

Parking and access is at a city parking area opposite of Fulton Avenue (access point #5).

Pigeon Point (PP):

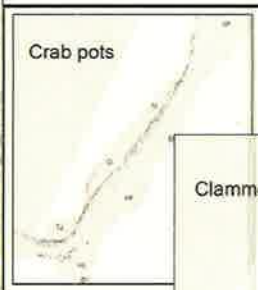
This expansive clam bed is productive and easily accessed. A butter clam bed can be found directly west of the county easement area opposite of Grinnell Road (access point #4).

Further down the bay, the Fossil Point area has good beds of butter and gaper clams. Digging can be a little more difficult as substrates include shell, cobble and gravel, wear gloves.
Access is northward of a parking area at Beacon Lane (access point #3).

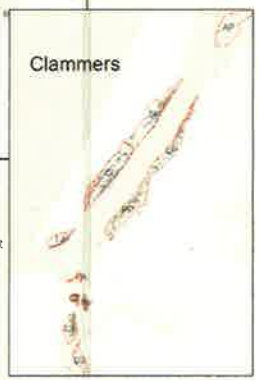
Empire pier crabbing:

The pier next to the Empire boat ramp can be good summer to fall.

Shellfish use survey results: In 2012 and 2013 ODFW staff performed surveys, noting exact location of crab pots and clammers on selected days. Each dot represents an observed crab buoy or clammer.



Boat crabbing is most popular on the west side of lower Coos Bay.



Clamming is spread out throughout the lower bay, however is most popular right near Charleston.

Legend

- Clamming areas
- Crabbing areas
- Shore crabbing
- Boat ramps

N

0 0.5 1 2 Miles

A shellfish license is required for all harvesters 14 years or older.

Shellfish regulations, species ID and more can be found at www.dfw.state.or.us/MRP/shellfish

This chart can be found at: www.dfw.state.or.us/MRP/shellfish/maps/Coos.asp or by scanning the adjacent QR code.

Design and photographs by Scott Groth.

Oregon
Kate Brown., Governor

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February 3, 2019

Robert Lobdell, Aquatic Resource Coordinator
Department of State Lands
775 Summer St. N.E., Ste 100
Salem, OR 97301

RE: Jordan Cove Energy Project Removal-Fill Application # APP0060697 Revised

Mr. Lobdell,

The Oregon Department of Fish and Wildlife (ODFW) appreciates the opportunity to provide comment to the Department of State Lands (DSL) on the Jordan Cove Energy Project (the project) application (#APP0060697) for removal and fill activity in wetlands and waterways. The Jordan Cove Energy Project proposes construction of a liquefied natural gas export terminal to be located on the North Spit of Coos Bay (Jordan Cove LNG Terminal; JCEP) and a 229-mile pipeline extending from the intersection of the GTN and Ruby pipelines to Coos Bay (the Pacific Connector Gas Pipeline; PCGP). It is the policy of the state of Oregon to manage fish and wildlife to prevent serious depletion of indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state (ORS 496.012, ORS 506.109). In accordance with our mission, ODFW has reviewed this removal-fill application and offers the following comments and recommendations. Should you have any questions or require any further detail, please contact Sarah Reif, ODFW Energy Coordinator, at 503-947-6082 or sarah.j.reif@state.or.us.

ODFW Comment History

ODFW has been providing assessment and comment on the project since it was first proposed in 2008. Although the project has changed somewhat in scope and location, the proposal includes the same components as originally proposed. The comments provided herein are largely a carry-forward of those submitted by ODFW in previous years, and those most recently submitted by ODFW to the US Army Corps of Engineers for the Jordan Cove Energy project 404/408 Permit Application (NWP-2017-41), to the Oregon Department of Environmental Quality for their Section 401 Water Quality Certification, and to the Federal Energy Regulatory Commission for their 2017 Notice of Intent to Prepare and Environmenal Impact Statement for Docket No. PF 17-4-000. Given the scale of the project and the complexity of the application's 3300 pages, ODFW welcomes additional coordination with DSL if more site-specific recommendations would be needed or helpful.

General Comment on Economic Benefit

ODFW recognizes the project is anticipated to provide immediate economic benefits to the local communities of Coos County and other counties within the range of the pipeline portion of the project. However, this benefit should be evaluated in the context of both the potential adverse environmental effects and negative impacts to the long-standing current and future economically important industries (e.g. commercial fishing, recreational fishing and hunting, aesthetics, wildlife viewing, and aquaculture) that depend on healthy and abundant fish, wildlife, and habitats. Fish and wildlife recreational expenditures in 2008 accounted for 2.5 billion in income for the state of Oregon (Runyan and Associaated 2009). In Oregon, the commercial crabbing fishery is a tremendous economic engine with potential to be impacted by this project. For example, the 2017-2018 Dungeness crab season (December to August) generated $74 million in ex-vessel value (see https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/Crab%20Newsletter_2018_final.pdf, and https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/news_publications.asp) . Like many other important fisheries, Dungeness crab use Coos Bay and the surrounding nearshore area for nursery habitat that may be affected by this project's proposed dredging activity, and the Coos Bay fishing fleet relies heavily on crab for its profits.

Oregon Fish Passage Law Compliance and Consistency

ORS 509.585 (Oregon Fish Passage Law) applies to all project components that cross waters of the state where native migratory fish species are or were historically present. ODFW administers fish passage rules and regulations. The project proposes numerous components that will cross waters of the state, which are defined in OAR 635-412-0005(46). These waterway crossing components and corresponding construction methods include LNG pipeline construction techniques (horizontal directional drilling, conventional boring, dry or wet open cut trenching), new or temporary access roads, and tidegate construction/modification. The extensive road network necessary to access, construct, and maintain the project will cross multiple streams or waterways and will use a variety of road-stream crossing construction techniques and methods (culverts, fords, bridges). In order to mitigate potentially significant environmental harm to the state's fish and wildlife resources, these project components must be designed, constructed, and maintained consistent with Oregon fish passage law and policies.

To fulfill this statutory requirement and ensure the project is designed and constructed consistent with Oregon's fish passage policy, the applicant should submit specific stream crossing design details at each project component that will cross waters of the state of Oregon. The expectation and goal of these design details are to specifically identify and depict how each waterway crossing proposed by the project will meet fish passage rules and regulations. To date the applicant has met with ODFW to discuss conceptual design details, however the applicant has not formally submitted its fish passage plans for ODFW review and approval. ODFW anticipates frequent, interactive coordination with the applicant to complete the fish passage approvals prior to construction.

Oregon In-water Blasting Permits

In-water blasting has the potential to injure aquatic fish and wildlife due to percussive shock waves produced by the energy associated with the explosion. This percussion can cause direct injury and stressors

including bursting of swim bladder, hemorrhage, damage to sensory organs, and trigger displacement behavior in fish species.

As required by OAR 635-425-0000 through 0050 (In-water Blasting Permits) the project shall apply for in-water blasting permits at any stream crossing locations where the use of explosives is desired in the course of removing any obstruction in any waters of this state, in constructing any foundations for dams, bridges, or other structures, or in carrying on any trade or business (OAR-635-425-0005). Further, it is the policy of the Oregon Fish and Wildlife Commission to discourage in-water blasting unless it is the only practicable method to accomplish project goals. ODFW may issue in-water blasting permits only if they contain conditions for preventing injury to fish and wildlife and their habitat (OAR 635-425-0015).

The applicant has engaged ODFW in discussions regarding the need for and intent to apply for in-water blasting permits before construction begins. However, specific locations and plans have not yet been discussed. ODFW understands the applicant has not been able to physically access all stream crossing locations preventing the collection of necessary site-specific geotechnical information necessary to demonstrate in-water blasting is the only practicable method to accomplish project goals at certain locations. ODFW anticipates that frequent and iterative coordination with the applicant subsequent to physical access to in-water blasting location(s) will result in the applicant obtaining blasting permit approval from ODFW for all sites where this construction method is necessary and considered the least impactful method (to fish, aquatic wildlife, and their habitats). The applicant should only submit in-water blasting permit application after obtaining access to site locations and having collected necessary site-specific information to complete applications.

In-Water Work Windows

The application indicates in some sections of the document an intent to follow the ODFW Guidelines for Timing of In-Water Work To Protect Fish and Wildlife Resources (see https://www.dfw.state.or.us/lands/inwater/Oregon_Guidelines_for_Timing_of_%20InWater_Work2008.pdf). However, in other parts of the document the applicant refers to FERC guidelines for wetland and waterbody procedures (Part 2 Attachment P.6). The FERC default in-water work windows identified in this attachment do not align with ODFW recommended work windows and are not adequate to fully protect Oregon's fishery resources at the site-specific scale. Further, Oregon law does not recognize the terms used in the FERC guidance such as "minor waterbody", "intermediate waterbody", or "major waterbody". A FERC "minor waterbody" might be important habitat for threatened or endangered fisheries or other wildlife and warrant greater protections than the generic conditions outlined in the FERC document. The FERC document also provides differing guidance for work in "coldwater" fisheries, however Oregon does not designate waterbodies using these terms. Application of the FERC waterbody procedures will likely create conflict with the definitions and Oregon's Fish Passage Laws and In-Water Blasting Laws, therefore ODFW recommends Oregon's in-water work guidelines be applied to native fish-bearing waterways throughout the project. ODFW recommends that any needed variation from the recommended work windows be discussed with the applicable ODFW Fish District to ensure impacts to fish and aquatic resources are minimized.

Fish and Wildlife Habitat Mitigation Policy Consistency

ODFW recommends that impacts to fish and wildlife habitats be addressed consistent with the ODFW Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through 0025). This rule governs ODFW's provision of biological advice and recommendations concerning mitigation for losses of fish and wildlife habitat caused by development actions. Based on standards in the rule, ODFW determines the appropriate category to apply to land or water where a development action is proposed. If ODFW determines that such habitat is Category 1, ODFW must recommend that impacts to the habitat be avoided. If impacts cannot be avoided, ODFW must recommend against the development action. If ODFW determines that such habitat is Category 2, ODFW must recommend that impacts to the habitat be avoided. If impacts cannot be avoided, ODFW must recommend a high level of mitigation (as specified in more detail in the rule). If such mitigation is not required, ODFW must recommend against the development action. Subsequent specific mitigation goals follow for habitats determined to be Category 3, 4, 5 and 6, and for which impacts cannot be avoided.

In this comment letter and those submitted to the other state and federal agencies involved in the permitting of this project, ODFW has recommended a coordinated, interagency habitat mitigation plan for the entire project including both the LNG terminal and the pipeline. At this time it is not clear how the applicant intends to approach mitigation beyond what is proposed in the Compensatory Wetland Mitigation Plan (Attachment I to this application, as well as an updated version posted to the FERC docket #CP17-494-000 on 1/29/2019). However, it may be notable to DSL that the applicant and ODFW will be meeting in the coming weeks of February 2019 to provide clarification on their proposed approach to habitat mitigation.

ODFW offers the following analysis and recommendations to address impacts not only to wetlands and waterways, but also to upland habitats. It is ODFW's perspective that upland impacts have the potential to affect habitat functions and values within the wetland and waterways.

When DSL and the applicant are prepared to discuss these comments, ODFW can provide more detailed, site-specific recommendations which have been collected by ODFW District Biologists throughout the years of the project in its various iterations.

JORDAN COVE LIQUEFIED NATURAL GAS (JCEP) FACILITY PROJECT COMPONENT

Introduction

The proposed JCEP project is large in scope, will have ecological impacts, and have legacy implications for aquatic habitats of Coos Bay and upland habitats on the North Spit. The North Spit is one of the only ocean peninsula land features in the state with estuarine, ocean, wetland, and upland habitats available for fish and wildlife within a very small geographical area. This unique landform and bay provide a number of strategic benefits for production of fish and wildlife. Coos Bay is the largest estuary located entirely in Oregon and supports populations of fish and shellfish that contribute to large commercial and recreational fisheries. The aquatic and upland habitats encompassed by JCEP and workforce housing project area have been subjected historically to a number of landscape and waterway alterations including: dredging, rip-rap installation, leveling, and removal of native coastal pine forest, filling of wetlands, and other development related impacts. These habitats historically would have been primarily characterized as

Category 2 or 3 habitats, (providing essential, important, and/or limited habitat function for fish and wildlife) under the ODFW Habitat Mitigation Policy. Although negatively impacted historically, much of the tidal, subtidal, and upland habitats at the proposed project site have received only minimal disturbance in the past two decades and substantial recovery of ecological function has occurred.

Aquatic Estuarine Discussion

According to the DSL removal-fill application, the LNG terminal and associated facilities would permanently impact 22.5 acres of estuarine wetland habitat (identified in the application as those acres requiring mitigation) and an additional 58+ acres of deep subtidal wetland habitat. These subtidal, tidal, intertidal, and shoreline features provide critical habitat for a number of culturally and economically important game and non-game species including, but not limited to: Dungeness crab (*Cancer magister*), red rock crab *(Cancer productus*), cockles (*Clinocardium nuttallii*), gapers (*Tresus capax)*, butter clams (*Saxidomus giganteus)*, littleneck clams (*Protothaca staminea*), rockfish (*Sebastes spp.*), lingcod (*Ophiodon elongates*), greenling (*Hexagrammos decagrammus*), California halibut (*Paralichthys californicus*), English sole (*Parophrys vetulus*), Pacific sand dabs (*Citharichthys sordidus*), ghost shrimp (*Callianassa californiensi*), mud shrimp (*Upogebi pugettensi*), starry flounder *(Platichthys stellatus)*, smelts (Osmeridae family), (Engraulidae family), sardines (Clupeidae family), fall run Chinook salmon *(Oncorhynchus tshawytscha)*, green sturgeon *(Acipenser medirostris)*, white sturgeon *(A. transmontanus)*, (OC) ESA threatened coho salmon *(O. kisutch)*, and possibly Pacific lamprey (*Entosphenus tridentata*). There is some potential that Pacific smelt (eulachon) (*Thaleichthys pacificus)* may be found in the JCEP area of Coos Bay. Additionally, the mudflats in the JCEP area support a commercial ghost shrimp fishery.

Dredging of the Bay and Channel

The JCEP project will dredge materials from North Spit and Coos Bay in order to create the slip for ships to load liquefied natural gas (LNG) and navigate along the Coos Bay channel to the ocean. According the application, dredging of the access channel will remove 1.9 million cubic yards (mcy) of material, which is then proposed for disposal at Ingram Yard, South Dunes site, Roseburg site, and the Kentuck Mitigation Project site. Dredging of the Navigational Reliability Improvements (NRIs) will remove an additional 590,000 cubic yards (CY) of material, which is then proposed for disposal at APCO Sites 1 and 2.

The Port of Coos Bay has also proposed a navigation channel modification project that will convey benefit to the JCEP project both in terms of financial savings and through increased transport efficiency. Accordingly, ODFW contends that the Jordan Cove Energy Project and the Port of Coos Bay navigation channel modification project are connected actions and should be evaluated by all permitting authorities as such. Some of the impacts of the combined projects include:

- Deepening and widening of the existing Coos Bay navigational channel to 37’ deep and 300’ wide
- Expansion of the Coos Bay navigational channel to 45’ deep and 450’ wide from the channel entrance to River Mile 8.2
- Alteration of the hydrodynamic characteristics of the Coos Bay estuarine tidal basin in response to deepening and widening, including:
    - Physical changes in the intrusion of marine waters, coupled with alteration of the salinity regime, conductivity, exchange volume, tidal prism, tidal currents, and other parameters

  - Shifts in the location, configuration, and spatial extent of marine-dominated, estuarine, and freshwater-tidal habitats
  - Changes in the composition of ecological communities that reside within the water column, marine-dominated, estuarine, and freshwater-tidal habitats
  - Changes in the location and potential for rearing of juvenile fish
- Disposal of dredge material at upland sites on the JCEP project lands located southwest of the OR Highway 101 bridge at the APCO Sites, and disposal of dredged material at the Kentuck Project Site;
- Impacts to the ocean floor outside the mouth of Coos Bay where a large quantity of dredged material (estimated at 18-25 million CY) will be deposited at an ocean disposal site, or multiple sites, that have not been fully identified;
- Deposition of dredged materials on the ocean floor will alter the physical characteristics of the benthic habitat due to both the substantial modification of the bottom topography and the anticipated characteristics of the dredged material (e.g. estimated 8.5 million CY of sandstone and siltstone debris);
- Deposition of dredged materials on the ocean floor will impact the benthic communities of resident marine fish and invertebrates, as well as transient species of concern including green sturgeon (*Acipenser medirostris*);
- Dredged materials transported away from the deposition sites have the potential to negatively affect important nearby rocky reef habitats;
- Disposal of dredged materials may occur in areas of heavy Dungeness crab commercial fishing activity, potentially interfering with crab habitat and fishing vessels; and
- Excessive mounding of sediments can alter the wave climate, creating enhanced risk to commercial fishing vessels that navigate nearshore waters during stormy conditions.
- Installation of a large rock apron at the toe of the North Jetty at the entrance to Coos Bay;
- Excavation of a new vessel turning basin with a length of 1400 feet, width 1100 feet at -37 feet deep (constructed approximately between River Miles 7.3 to 7.8);
- Disposal of 590,000 CY of dredged material through mechanical or hydraulic methods (24 inch pipeline laid on bottom of Coos Bay 8.3 miles) then distributed between the APCO 1 and 2 disposal sites;
- Significant impacts to subtidal habitat within Coos Bay that is important for production of species such as Dungeness crab (*Cancer magister*), white sturgeon (*Acipenser transmontanus*), and California halibut (*Paralichthys californicus*).

Marked change will occur to the productivity of the dredged portion of the bay and little recovery is expected over time due to the continual need for maintenance dredging. Maintenance dredging for the JCEP will result in a continually disturbed condition preventing development of any reliable estuarine production in the affected areas. Additionally, the Port of Coos Bay project will likely dredge substantially more on an annual basis.

ODFW recommends DSL consider how the proposed "slip" will create a new deepwater alcove backwater likely resulting in a number of significant biological effects (e.g. change to water flow patterns in the vicinity, salinity patterns, turbidity associated with initial and repeated dredging, and shallow water conversion to deep water). While hydrodynamic models provide some insight into the physical changes that the site and bay may undergo, biological changes should be studied in situ to accommodate unknown

variables. The actual JCEP longer-term, indirect impacts to the larger estuary may not be accurately predicted prior to construction.

No less important are the wildlife resources in the uplands that will be displaced by this complete conversion of upland habitat to a new deep-water terminal/zone and long-term daily disturbance factors attributable to project activities. The magnitude and long-term severity of these potential impacts may be difficult to estimate through models and best professional judgment. ODFW recommends carefully planned and executed long term monitoring of these changes to the bay and estuary for the life of the project. ODFW recommends the monitoring program inform an adaptive management approach to confirm estimates of both impact and mitigation to ensure habitat functions as are fully restored or compensated for commensurate to the actual shorter or longer term impacts of the action.

Upland Habitat Discussion

A notable portion of the impacted uplands at the JCEP site will be converted from terrestrial habitats to aquatic habitats, in order to construct a slip moorage for vessels. ODFW recommends the applicant and DSL address these potential impacts to upland species who would likely lose habitat in the conversion to jurisdictional waterway. Columbian black-tailed deer (*Odocoileus columbianus)* use the flats and vegetated sand dunes within the project area year long. Black bear (*Ursus americanus*) and coyotes (*Canis latrans)* also use upland habitats at the site. There are also 11 species of amphibians (8 salamanders, 3 frogs) at least 10 species of reptiles that have been found to occur on the North Spit. Avian wildlife on the proposed project area are generally diverse and include great blue heron (*Ardea herodias*), snowy egret (*Egretta thula),* and osprey (*Pandion haliaetus)* among many others. Two species that were formerly on the Endangered Species list, bald eagles (*Haliaeetus leucocephalus)* and peregrine falcons *(Falco peregrinus),* use the site seasonally or on occasion.

Adjacent to the slip is a large dune occupied by a mature shore pine vegetation community that is potential habitat for the coastal marten (*Martes caurina*), a State Sensitive species and one that has recently been petitioned for listing on the federal Endangered Species Act list (Federal Register 2015; USFWS deemed the Humboldt coastal marten a distinct population segment but found a listing was not warranted). While information regarding distribution, connectivity of habitat, and abundance is still largely unknown at this time, a group of conservation organizations has also petitioned the Oregon Fish and Wildlife Commission to consider listing the coastal marten on the State of Oregon Endangered Species List. Currently ODFW considers the coastal marten a State Sensitive Species and an Oregon Conservation Strategy Species because of the limited extent of its preferred habitat (late successional mixed conifer forest and apparent association with shore pine) and its apparent low survival rate in fragmented forests elsewhere in the United States. ODFW recommends DSL consider the potential impacts to habitat connectivity for the coastal marten in its review of the habitat conversion at the slip. ODFW is considering this patch of forested dune habitat Category 2 according the ODFW Fish and Wildlife Habitat Mitigation Policy.

Aquatic Freshwater Discussion

In previous versions of the project, ODFW worked with the applicant's consultant to categorize freshwater habitats at the LNG terminal site according to the ODFW Fish and Wildlife Habitat Mitigation Policy. These wetland habitats provide functionally important ecological features on North Spit as they contribute to nutrient cycling where the sandy soil types are very limited in primary nutrients, and are freshwater

refugia within a short distance to saline habitats. The wetlands and open water ponds are important for production of a number of amphibians including rough skinned newts (*Taricha granulosa*), red-legged frogs *(Rana aurora),* as well as several species of tree frog (i.e. Pacific tree frog *Pseudacris regilla*). Three-spined stickleback *(Gasterosteus aculeatus)* occupy a number of the ponds and deeper wetlands. Numerous waterfowl species transition through these ponds including mallards (*Anas platyrhynchos*), greater scaup (*Aythya marila*), wood ducks (*Aix sponsa*), and Canada geese (*Branta Canadensis*).

COMPENSATORY WETLAND MITIGATION PLAN (CWMP)

The comments in this section are applicable to both the JCEP terminal and PCGP pipeline components of the project.

It should be noted that the numbers for waterbody crossings vary across documents. ODFW found differing numbers in the applicant's Compensatory Wetland Mitigation Plan as compared to the FERC Applicant Prepared Biological Assessment and those differed again from the numbers reported in the FERC Resource Reports. Recognizing that project design shifts over time while documents remain static depending on time of publication, it does make it difficult to assess impacts without consistent numbers as well as inconsistent definitions of waterbody (as opposed to the normal terminology used by the state for 'waterway' and 'wetland').

With regard to avoidance and minimization measures discussed in the plan, ODFW appreciates the applicant's efforts to co-locate facility components with existing infrastructure and previously disturbed areas where possible. ODFW supports the minimization measures and best management practices identified in the CWMP, but also directs DSL and the applicant's attention to the comments provided throughout this letter that would further help to minimize impacts to fish and wildlife habitats.

ODFW requests a determination from DSL as to whether the applicant's treatment of temporary versus permanent impacts meets applicable DSL removal-fill statutes and guidance. The applicant notes that while DSL treats any impact duration longer than two-years as permanent, the US Army Corps of Engineers does not define temporary. The applicant states that for the sake of consistency, the Compensatory Wetland Mitigation Plan only addresses 'actual' permanent impacts and temporary impacts will be addressed in a separate site restoration plan. ODFW interprets this to mean that the applicant is considering anything less than a permanent impact to be temporary and therefore not requiring a mitigation offset. This interpretation does not meet the ODFW Fish and Wildlife Habitat Mitigation Policy which directs ODFW to consider the nature, extent, and ***duration*** of impacts and that offsets should persist for the life of the impact. Because of the 'duration' language in the mitigation policy, ODFW bases its recommendations not only on the physical loss of habitat, but also the length of time for which that habitat is unavailable to fish and wildlife (referred to as temporal loss of habitat). Impacts that the applicant might consider temporary in nature might actually result in temporal loss of habitat that should be mitigated in order to prevent depletion of a species with short generational turnover, and to meet the mitigation policy's goal of 'no net loss'. ODFW contends that unavoidable impacts, greater than DSL's 24-month guideline, ought to be addressed in the CWMP.

ODFW seeks confirmation from DSL that out-of-proximity mitigation for freshwater wetland impacts will meet the DSL removal-fill statutes and guidelines. It is ODFW's understanding that mitigation for the unavoidable impacts to freshwater wetlands along the 229-mile pipeline will be consolidated into the

uppermost 10 acres of the Kentuck Mitigation Site in Coos Bay. ODFW reviewed the section of the CWMP that discussed the reasoning for consolidation (page 2). The ODFW Fish and Wildlife Habitat Mitigation Policy recommends in-proximity mitigation for impacts to habitat categories 2 and 3. Since the CWMP did not provide a categorization of habitats according to the ODFW mitigation policy, ODFW is reliant upon DSL's determination that in-proximity mitigation options were considered and found to be untenable or that the Kentuck option provided greatest overall net benefit to Oregon's wetland resources.

ODFW requests confirmation from DSL that permanent and intermittent streams impacted by the project will not reach the volume threshold for inclusion in this removal-fill application. It does not appear that the CWMP addressed impacts to perennial and intermittent streams. It is possible that volume thresholds were not met. But it is also possible the applicant considered those impacts to be temporary (as per their interpretation, see above) and therefore did not include them in the CWMP. However, ODFW contends that some streams may take longer than 24 months to recover their pre-disturbance function and values and should have been considered in the CWMP. As such, ODFW requests DSL confirmation of concurrence with the applicant's determination, otherwise work collaboratively with ODFW and the applicant to rectify this omission.

Kentuck Mitigation Site

The Kentuck mitigation site is approximately 100 acres, with the uppermost 10 acres planned for freshwater wetland habitats and the remainder planned for estuarine wetland habitats. The current mitigation plan proposes a network of tidal channels and removal of a segment of East Bay Drive in order to connect these channels to Coos Bay tidal inflow/outflow. Additionally a portion of Kentuck Creek streamflow will be guided through the new channel network using a modestly complex configuration of culverts and tidegates. The habitats at the Kentuck site have been diked, drained, tidegated, cultivated, grazed, and stream networks channelized since the late 1800's resulting in substantial degradation of the ecological productivity. Historically the site would have been defined as Category-2 intertidal Algae/Mud/Sand habitats, under ODFW Habitat Mitigation Policy, however, currently the function for native fish and wildlife species is considered Category-4 and 5 in some locations. Mitigation restoration will reestablish natural hydrologic regimes to a substantial degree at the site, although the entrance of tidal flow will be truncated partially due to the limited opening through East Bay Drive and partial reintroduction of Kentuck Creek flow. Historically full volume flood flows from Kentuck Creek would have been able to support a broader range of euryhaline conditions for native fish and wildlife. Additionally, tidal flows would have been a combination of sheetflow and channel flow prior to installation of East Bay Drive. The mitigation restoration will establish tidal channel flow, however, without full removal of the length of East Bay Drive (which ODFW is not suggesting as an option), sheetflow will not be re-established.

Algae-mud-sand habitats are considered Category 2 under ODFW Habitat Mitigation Policy. Saltmarsh habitats are also considered Category 2 in function. The JCEP project impacts to intertidal habitats includes primarily: Category 2 Intertidal Unvegetated Sand; Category 2 Shallow Subtidal; Algae/Mud/Sand; Category 2 eelgrass; and Category-3 Deep Subtidal. The majority (very roughly 82 acres; based on LiDAR evaluation) of the Kentuck within the proposed mitigation area is currently below elevation 5.0ft MLLW. Excavation of a tidal channel through East Bay Drive with the current elevations within the mitigation area would allow nearly all lands within the site to be inundated with the majority of tides. The JCEP project proposes using the Kentuck Mitigation site for dredge material disposal

(300,000 CY) that would elevate a substantial proportion of the project area above elevation 5.0ft MLLW decreasing the land area that will be inundated regularly. ODFW recognizes that following placement of fill, the higher elevation areas will eventually vegetate to saltmarsh ecotype, which is considered high in value and limited in Coos Bay. Overall, ODFW supports the applicant's proposal for restoration at Kentuck Slough because, if successful, the project will improve the quality and diversity of rare estuarine habitats.

Eelgrass Mitigation

The proposed project includes construction of a marine terminal slip and dredging of an access channel. These activities will permanently destroy about 1.9 ac of established native eelgrass (*Zostera marina*).

Dredging in the intertidal and shallow subtidal zones within the project area is expected to have significant deleterious effects on native eelgrass habitats and the species found therein. Eelgrass is recognized by ODFW as a Category 2 Habitat and as a Strategy Species by the ODFW Nearshore Strategy (marine and estuarine component of the ODFW Oregon Conservation Strategy). Beds of eelgrass occur at several locations throughout the Coos Bay tidal basin where they provide numerous ecological functions, including heterogeneous habitat for a number of fish and wildlife species, nursery habitat for invertebrates and fish, forage areas for shorebirds and waterfowl, primary production and a source of organic-rich detritus, stabilization of unconsolidated sediments, trapping of suspended sediments, and contribute to improvements to estuarine water quality (Thom et al. 2003; Kentula and DeWitt 2003). In particular, the emergent blades and rhizomes of eelgrass beds provide complex and heterogeneous multi-dimensional habitat within the unconsolidated soft-sediments in the intertidal and shallow subtidal zones. In many cases, the abundance and species composition of macroinvertebrate, shellfish, and fish communities differ within eelgrass beds in comparison with un-vegetated areas where eelgrass is absent. Eelgrass beds are known to provide habitat for numerous species of invertebrates, including polychaete worms, cockles, gaper clams, butter clams, littleneck clams, Dungeness crab, grass shrimp and epibenthic invertebrates such as harpacticoid copepods, isopods, and gammerid amphipods, In addition, eelgrass beds also provide habitat for a diverse community of fishes, including juvenile salmonids, sculpin, English sole, shiner perch, lingcod, rockfish, pipefish, and herring.

Long-term efforts to remove root wads, large woody debris, and other natural structures embedded in the un-vegetated soft sediment of Coos Bay in order to facilitate commercial shipping and recreational boating have greatly exacerbated the lack of structural complexity along the shoreline and further increase the ecological importance of eelgrass beds. The heterogeneous canopies of eelgrass beds provide both primary complexity and an ecological edge effect that presents an important biophysical transition zone for fish and invertebrates that forage in adjacent un-vegetated habitats.

Native eelgrass is recognized by ODFW as a Category 2 Habitat, and the ODFW goal is no net loss of either habitat quantity or quality and to provide a net benefit of habitat quantity or quality (OAR 635-415-0025). To achieve the mitigation goal, ODFW recommends avoidance of the impacts through alternatives to the proposed development action, or mitigation of the impacts (if unavoidable) through reliable in-kind, in proximity habitat mitigation to achieve no net loss of either pre-development habitat quantity or quality.

In order to offset the loss of 1.9 ac of eelgrass the JCEP includes a proposed eelgrass mitigation plan that relies on the "best case scenario" for full success by creating 6.03 ac of eelgrass (3:1 ratio) within a 9.34

ac site in the intertidal zone near the impact area. ODFW has noted a number of potential issues associated with the proposed eelgrass mitigation plan that have not been considered/addressed fully by the applicant.

The eelgrass mitigation plan does not demonstrate that serious consideration has been given to avoidance of the impacts to eelgrass beds. In this regard, the plan should describe the alternative sites that were considered, characterize the location, species composition, and abundance of the eelgrass and other submerged aquatic vegetation at the alternative sites, and provide the rationale for rejection of the alternative sites and acceptance of the proposed site. The existing plan is incomplete because it does not provide a full description of the steps that were taken to avoid adverse impacts to existing eelgrass beds in Coos Bay.

The proposed eelgrass mitigation plan does not give adequate consideration to the difference in habitat quality that is anticipated between the eelgrass impact area and the eelgrass mitigation site. The plan proposes to excavate 9.34 ac of existing algae/mud-sand algae habitat located in the intertidal zone near the North Bend Airport to an elevation of -2.00 ft NAVD, and to convert the algae/mud-sand habitat into 6.03 ac of eelgrass. The proposed conversion of algae/mud-sand habitat to eelgrass habitat is problematic because algae-mud-sand is recognized as Category-2 value habitat under ODFW Fish and Wildlife Mitigation Policy (OAR 635-415). Eelgrass habitat and algae/mud-sand are both considered as Category-2 habitat, but they provide different functions and values. Accordingly, diminishing the quantity and quality of algae/mud-sand habitat in order to offset the loss of eelgrass habitat is not 'in kind' and does not create a 'net benefit', and therefore does not meet the ODFW Fish and Wildlife Mitigation Policy goals for Category 2 habitat.

Earlier attempts to mitigate for the damage or loss of eelgrass beds have met with limited success in Pacific Northwest estuaries. For example, Thom et al. (2008) conducted a review of 14 eelgrass mitigation and transplant projects, and they concluded that it is sometimes possible to restore eelgrass under favorable site conditions and when the reason for the initial loss of eelgrass is understood and corrected. The authors also noted, however, that eelgrass restoration science is hampered by knowledge gaps which reduce restoration success. The underlying mechanisms for recent eelgrass loss in the Pacific Northwest region are not obvious, which suggests that the scientific understanding of eelgrass biology and ecosystem conditions is currently inadequate to fully support environmental management actions (Thom et al. 2008).

There are often hydrologic flow regime complexities that affect potential for success in eelgrass restoration:

- Habitat conditions created through excavation or filling are often ephemeral and subject to subsequent deposition/erosion that results in movement of conditions outside of the range of preferred variability for eelgrass.
- Flow regimes including severity of wave action and current speed contribute to the potential success of a site for eelgrass establishment and growth. Sites that are created through excavation or fill are an artificial modification of conditions that have formed through the geomorphological features that drive flow regimes. Factors such as water depth reflect deposition/erosion rates from water transported sediments. Excavation or filling to a specific elevation is attempting to alter the natural elevation conditions in relation to hydrologic conditions for many sites that might serve as potential mitigation. Resultantly there is limited potential for success of projects that modify water depth/elevation of the substrates for

creating conditions appropriate for eelgrass mitigation unless the site chosen has substrate elevation that has been artificially created from previous disturbance or the conditions are dominated by factors other than hydrology.

- Use of eelgrass sites immediately adjacent to or within the mitigation area for obtaining plants/shoots results in impacts to these locations, potentially weakening the vigor of eelgrass at these locations which is counter to goals.
- Excavation of locations adjacent to existing eelgrass beds can result in hydrologic changes such as erosion of surrounding substrates resulting in impacts to currently productive stands.
- The monitoring plan should include more robust methods such as diver or low tide visual count surveys with established known planting densities at time-0 and subsequent measurable surveys with quantifiable methods.
- Due to the potential for minimal success the eelgrass mitigation ratio is likely insufficient to offset impacts.

For all of the reasons listed in the discussion above, ODFW recommends the eelgrass mitigation strategies be re-evaluated to favor avoidance.

PACIFIC CONNECTOR GAS PIPELINE (PCGP) PROJECT COMPONENT

Introduction

The following narrative is intended to set the general context for the specific comments and recommendation in the table below.

The PCGP removal-fill application to DSL proposes construction of a 36" steel gas pipeline from the North Spit of Coos Bay, Oregon (229 miles) to Malin, OR in order to connect the JCEP export facility to the Ruby LNG pipeline carrying gas primarily from the Rocky Mountain region. The PCGP would affect multiple perennial and/or intermittent waterways along the pipeline route. The applicant proposes to utilize horizontal directional drilling (HDD) for the crossing of the Coos Bay estuary, Coos River, Rogue River, and Klamath River. The applicant would use dry open-cut crossing methods where HDD methods are not planned. These actions will have temporary and permanent impacts to aquatic fish and wildlife which ODFW recommends be addressed consistent with the ODFW Fish and Wildlife Habitat Mitigation Policy, be performed consistent with ODFW In-Water Work Windows, and be permitted where applicable via ODFW In-Water Blasting and ODFW Fish Passage Authorizations.

ODFW recommends careful review be performed by DSL to consider the potential direct impacts to fish and wildlife habitat, as well as the indirect impacts to water quality associated with an increase in watershed runoff caused by this project, particularly in areas where the pipeline is proposed on slopes exceeding 50%, and where vegetation will be removed from riparian corridors. PCGP has the potential to cause negative direct impacts to fish and wildlife, and negative indirect impacts to water quality, within the Coos, Coquille, South Umpqua, Upper Rogue, Upper Klamath, and Lost River watersheds.

Please see the above discussions for Oregon Fish Passage Laws, In-Water Blasting, and ODFW Fish and Wildlife Habitat Mitigation Policy because they are all particularly relevant to the PCGP portion of the project and have yet to be formally addressed by the applicant.

Aquatic Discussion

The aquatic habitats in Coos Bay have been impacted historically from dredging, rip-rap installation, upland and tidal mudflat leveling, filling of tidal wetlands/saltmarsh, and other development/utilization impacts, However, substantial recovery of ecological potential has occurred due to improvements in forest management (reducing sediment inputs) and regulations conserving wetlands and waterways. The current and desired future condition of the waterbodies that will be affected by the pipeline is predominantly linked to management actions in the riparian habitats and adjacent uplands. Many of the streams that will be impacted by the pipeline have been ecologically degraded historically by a number of human impacts including: removal of native coastal riparian forest, road construction with subsequent chronic sediment contribution, and debris torrent/mass-wasting events related to forestry activities. The majority of these streams, many of which are critical for native salmon, trout, sculpin, lamprey, and other aquatic species production, are in a gradual trend of recovery following management guidelines and Best Management Practices implemented from 1970-1992 through agency and private ownership coordinated efforts (Oregon Coast Coho Conservation Plan; ODFW 2007). Actions such as pipeline construction and maintenance with associated long-term disturbance introduce an added burden inhibiting ecological recovery. Pipeline stream crossings have the potential to negatively affect watercourse ecosystems through alteration of channel beds and banks, increasing total suspended solids (TSS), alteration of substrate size and quantity in the reach and changes to the immediate area benthic community. These changes could have negative impacts for fish due to decreased food availability, changes in foraging range increasing predation, aquatic habitat simplification, and decrease in overall health.

Please see the estuarine aquatic impacts discussion in the JCEP section above, as those species and habitats listed therein are also relevant to the proposed pipeline sections of the Coos Bay estuary not included in the areas planned for horizontal directional drilling.

ODFW recommends careful evaluation of the risks of long-distance horizontal directional drilling (HDD) across the Coos Bay estuary, the Coos River, Rogue River, and Klamath River as well as the direct pipe crossing proposed for the South Umpqua River. ODFW recommends emergency preparedness plans be developed to address unforeseen failures (see the table below for further discussion of risk).

Outside of the estuary, there are numerous critical concerns with placement of the pipeline on steep slopes and direct routing parallel to the slope. Coastal sandstone soils are highly susceptible to mass-wasting when undercut and generally disturbed. A relatively extensive access road network will be created to access the pipeline installation and facilitate pipeline maintenance, which will further create potential for mass-wasting slope failures and general sediment production over the current condition. Stream health related to anadromous fish production has largely been assessed to be predominantly "Poor" (Scale: "Very Poor"; "Poor; Fair"; "Good"; "Excellent") in the Coos and Coquille River basins, with similar stream health conditions in the South Umpqua River basin. This "Poor" condition rating is largely related to upland disturbance increasing sediment loading and loss of riparian forest since 1900. Additionally, the proposed access road networks will likely have long-term chronic effects to fish and wildlife unless seeded, mulched, and closed. Sediment transport to streams is considered a substantial factor currently suppressing recovery of OC Endangered Species Act (ESA) threatened Coho salmon. Extensive research has documented the impacts of sediments to salmonids. Work to reduce sediment input into coastal and inland streams that will be impacted by the pipeline is foundationally critical for

enhancing spawning and rearing habitat for fall Chinook salmon, Oregon Coast (OC) threatened Coho salmon, Pacific lamprey (*Entosphenus tridentata*), winter steelhead (*O. mykiss irrideus)* and coastal cutthroat trout (*O. clarki clarki)* as water quality is directly linked to hatch rates and food available for these species. Sediment loading above natural background levels contributes to embedding of substrates, which often results in reduced hatch rates for eggs in redds, inability of fry to emerge from redds, inhibited production of macroinvertebrates (invertebrates largely live in the interstitial spaces of gravels), and impacts on the ability of fish to obtain food due to the nature of salmonids to feed predominantly by using their sight (Burns 1970; Hall and Lanz 1969; Weiser and Wright 1988; Suttle et al. 2004; Tripp and Poulin 1992; Waters 1995).

The applicant should be aware that Oregon Department of Forestry (ODF) fish presence/absence surveys represent "present conditions", and although highly useful do not completely represent historical fish usage as some watersheds have culvert barriers, man-made dams, etc. that are as of yet undocumented. The State of Oregon Fish Passage Rules (OAR 635-412-0005 through 0040) are based on maintaining fish passage throughout historical and currently accessible habitat.

Upland Discussion

To the extent that DSL can consider how impacts to uplands affect waterways and water quality, ODFW encourages efforts to understand, protect, and restore/mitigate for impacts to the bay, upslope habitats, riparian corridors, and streams with the goal of minimizing reductions to the capacity of upland an aquatic habitats to produce fish and wildlife. In that context ODFW has the following desired outcomes for the DSL processes:

- Documentation and categorization of aquatic and upland habitats (consistent with OAR 635-415-0000 through 0025) that will be disturbed through the PCGP project in collaboration with ODFW staff including:
    - Numerical habitat quantity and quality assessments (acreage assessments, streams crossed, upland) by habitat category.
    - Identification of the avian, mammalian, and amphibian wildlife that will be affected by the project.
    - Identification of the aquatic vertebrate species that will primarily be impacted by the project.
- Development of an upland habitat mitigation plan in collaboration with ODFW, the U.S. Fish and Wildlife Service (USFWS), NOAA Fisheries, US Forest Service, and US Bureau of Land Management with the goal of avoiding, minimizing, and fully mitigating any residual impacts of the project to fish and wildlife resources and their habitats.
- Development of permit conditions that call for protection of fish and wildlife and the habitat they depend on during all construction, operation, maintenance, and decommissioning phases off project implementation.
- Development of a monitoring plan that would guide assessment of the benefits or lack thereof for all restorative actions and mitigation.

In the attachment below you will find a comprehensive review and comment from a number of ODFW Fish and Wildlife District Biologists whose districts would be occupied by the JCEP and PCGP projects. A list of references used in the development of this comment letter is also included in the attachment. Again, ODFW thanks the Oregon Department of State Lands for the opportunity to provide comment. We

recognize the length and complexity of these comments, and we stand ready for any follow-up discussion or additional site-specific review you may require.

Sincerely,

Sarah Reif

Sarah Reif
Energy Coordinator, Wildlife Division

ATTACHMENT TO THE ODFW FEBRUARY 2, 2019 COMMENT LETTER TO OREGON DEPARTMENT OF STATE LANDS REMOVAL-FILL APPLICATION #APP0060697

SPECIFIC COMMENTS FROM OFDW FISH AND WILDLIFE DISTRICTS

The tables below provide additional comments from ODFW fish and wildlife district staff, with an attempt not to repeat comments provided elsewhere in this letter. These comments have been accumulating over the years of Jordan Cove applications, and are based on this DSL removal-fill application #APP0060697, the US Army Corps of Engineers Public Notice NWP-2017-41, the Oregon DEQ Public Notice for Section 401 Water Quality Certification, JCEP's Resource Reports 1, 2, 3, 8, and 10, and PCGP's Resource Reports 1, 2, 3, 6, and 8. Some references to the FERC 2014 Environmental Impact Statement may also be found in these comments, as some comments have been carried forward from previous reviews given their continued relevance. For each issue identified (left column), ODFW attempted to provide a suggested resolution (right column).

JCEP – Estuarine Aquatic Concerns from ODFW Fish and Wildlife Districts

(see following page)

Issue Identification	Recommended Resolution
Port will maintain access channel depth. Will this become part of the Port's Unified Dredging Permit, which maintains the depth of several access channels and vessel berths connected to, but outside of, the navigational channel?	**Port will maintain access channel depth.** ODFW recommends clarification of whether the access channel dredging and maintenance dredging will be part of Unified Permit or not. ODFW recommends all dredging of the portions of the project outside of the footprint of the current Federal Navigation channel or within the current upland and fully isolated from the bay by the proposed soil berm occur only with in the ODFW' in-water work window: http://www.dfw.state.or.us/lands/inwater/ Minor exception: At this particular site there is some potential that Pacific smelt (eulachon) may be in this reach of the bay from January 15 until April annually. Although the presence of eulachon is considered highly unlikely, as a precautionary measure ODFW recommends adjusting the normal In-Water Work window to October 1 to January 31.
Direct Construction and Maintenance Dredging Impacts: Lethal and non-lethal impacts to marine fish, crab, shrimp, bivalves, juvenile Chinook salmon, white sturgeon; ESA listed coho salmon, green sturgeon, and Pacific eulachon; as well as non-listed Pacific lamprey, and other species may occur: • Through entrainment in the hydraulic dredge at the time of the initial construction. • Be impacted by entrainment during future maintenance dredging required to keep the berth and access to the berth serviceable. • Become attracted to the alcove and away from natural habitats, introducing risk of industrial impacts to these species (e.g. metabolic expenditure from disturbance; entrainment into cooling intakes, entrainment into ship ballast water intakes). • The access channel from navigational channel to terminal is approx. 30 acres; with the proposed dredging turbidity will likely last for 4-6 months. Four to six months could affect the life history of several estuarine species (fish	**Direct Construction and Maintenance Dredging Impacts:** During the initial dredging and excavation, monitoring of the dredge output at the storage site, ODFW recommends the applicant access/estimate the magnitude (quantification of organisms in the dredge spoils) of impact to shellfish and non-game/game fishes. **Conduct biological recovery assessments:** ODFW recommends a biological assessment of the JCEP deepwater access and slips be completed following construction to determine the degree that production of shellfish/gamefish will recover and stabilize. ODFW recommends this recovery assessment be scaled based on to productivity in undisturbed regions in the Bay (reference sites). ODFW recommends this information be provided to ODFW, other natural resource agencies, local tribes, and other interested parties within one calendar year after construction of the slip and berth is completed and annually thereafter for a period of 10 years. **Mitigation/Monitoring/Adaptive Management:** While the direct impacts of initial construction are clearly identifiable, post-project indirect impacts are likely not. ODFW recommends the Applicant address appropriate monitoring/study plans for the

and invertebrates), depending on timing. ODFW IWWW is shorter than six months long. • Port of Coos Bay channel access improvement project will dredge another 18 MCY from channel with annual maintenance dredging. Actions will produce nearly year-long need for dredging actions in various reaches of the bay. • Risk of direct collision with marine mammals, or indirect disturbance in whale communication from dredging activities and ship engine noise	project area and mitigation sites be developed by and formally agreed upon by the Applicant and pertinent stakeholders. The expected hydrological changes at the site due to the project development will potentially result in a number of changes to the biological communities at those locations (e.g. densities, species composition, predatory interactions, etc.). These changes may occur in areas adjacent to or a considerable distance from the project area where there is little or no construction activity (see Deepwater Zone recommendations below). Long-term monitoring/study (i.e. majority of the FERC certificate duration) is appropriate to understand/mitigate for ecological and biological changes associated with the project. Clarify whether or not extension of IWWW would be requested. Issue is similar to Port's Unified Dredging Permit extension request, which ended with DSL issuing extension despite ODFW's recommendation of dredging only within the recommended IWWW.
Invasive Species: Invasive species are expected to flourish within the slip as with a result of disturbance. Throughout the world, aquatic invasive species are found most prominently in locations with low velocity or no current where transient ships dock. ODFW has some concern that this slip will be an invasive species vector within the bay (given it will have low current, stable salinity, and hard substrate – sheet pile walls), and will continue over time to have the potential to vector new species into the Bay (e.g. fouling from ships).	**Invasive Species:** Invasive species can be transported in ballast water and/or through attachment to the hulls of vessels. Ballast water management guidelines are a first line defense to prevent vectoring of invasives to Coos Bay. Adherence to these guidelines is of utmost importance in order to maintain the integrity of the Coos Bay ecosystem. ODFW recommends the Applicant address how the slip and berth will be monitored for colonization by invasives. ODFW recommends that if invasives are detected, the natural resource agencies be consulted on ecological risk and recommend measures that will be taken for elimination or control and changes to operations necessary to prevent future colonization should be implemented.
Ballast/Cooling Water Uptake/Discharge: ODFW understands	**Ballast Water Management Plan:** ODFW recommends that JCEP be required to develop a site-

that primarily ballast water will be discharged at the site as a result of the conversion of the project to an LNG export facility. However, if ballast water is be pumped onto vessels for any reason, potential for entrainment of fish and shellfish species (particularly during a planktonic larval life history stage) remains a Department concern. Additionally, engine cooling water will also be taken up and released in the berth. There is concern that uptake of water at the site will result in entrainment of fish into the ballast water intake system or ship engine intakes and ultimately cause mortality (take) of these individuals. Take of plankton will occur at the site, but has been discarded by the Applicant as not of significant importance. ODFW notes information collected by the Applicant-initiated plankton study (Shanks et al. 2010); indicating that uptake of plankton will have little impact on the Bay. However, ODFW continues to encourage efforts to address concerns for potential entrainment of organisms. Describes treatment of ballast water to be discharged while in berth, but does not specify what that treatment consists of. Cooling water uptake for ships in berth is est. 6.1 million gallons per visit; screen size is 24 mm (approx. 1"); this is not ODFW/NMFS criteria; juvenile fish are likely to be entrained.	specific ballast water management plan for all vessels servicing the JCEP LNG plant prior to issuance a removal/fill permit. ODFW recommends that the plan include effective methods for preventing, controlling, and eliminating recognized invasive species. **Ballast/Cooling Water Uptake:** Given that: 1) take of plankton has been identified as significant and 2) ODFW's most critical concerns on this subject relate to nekton such as juvenile fish, crab megalope, and uptake of salmonids, ODFW recommends the following actions to address direct and indirect effects: • Clarify treatment methodology for discharged ballast water while in berth. • Clarify minimization measures to prevent uptake of nekton should ballast water intake occur. **Screening of Water During Uptake:** The water that is taken in by vessels for cooling and released or taken up as ballast must be screened consistent with Oregon Department of Fish and Wildlife fish screening criteria. Development of screening methodologies can be coordinated with department Screening Coordinator Alan Ritchey (541) 947-6229; Alan.D.Ritchey@state.or.us. There are important concerns for managing ballast water as release of ballast water at the site is considered as highly negative. Screening Criteria is included in the NOAA Passage Facility Design Criteria under section 11 starting on page 86 of http://www.nwr.noaa.gov/Salmon-Hydropower/FERC/upload/Fish-Passage-Design.pdf**.** The ODFW screening criteria is available from the following website: http://www.dfw.state.or.us/fish/screening/index.asp **Stakeholder Involvement:** ODFW recommends the applicant reconvene stakeholders to provide the input necessary to assess if the original goals of the plankton study (Shanks et al. 2010 already completed) have been met and if new direction would better address the concerns.

Hydrological/Water Quality Changes: ODFW points to three anticipated changes in the hydrology/water quality of the site that will impact fish and wildlife due to project development: A) Turbidity; B) Salinity intrusion; and C) Water temperature changes. **Turbidity:** Mobilization of substrates will occur during the initial dredging and with continued regular disturbance associated with maintenance dredging (estimated 360,000 CY in the first 10yrs.; 36,000/yr.) within the project area. Turbidity will increase over an unknown portion of the Coos Bay during construction and when maintenance dredging is conducted. It is ODFW's understanding from previous project materials that dredging will occur on the regular two year interval when the remainder of the shipping channel is dredged. However, the slip and berth represent additional acreage that will be impacted over current levels and may require an increased dredging frequency. Additionally, the hydrodynamic modeling indicates the slip will become an alcove, likely collecting sediments at a greater rate than the main shipping channel. Increased turbidity levels can result in suppression of primary production, affecting a number of ecological factors: • Survival and growth of estuarine plankton (Cloern 1987; Irwin and Claffey 1966). • Potential effects to feeding capability and subsequent reduction in planktivorous organisms (Carter et al. 2009; Horppila et al. 2004; Bash et al. 2001). • Survival and growth of species such as eelgrass are affected by factors that decrease total solar input and	**Hydrological/Water Quality Changes:** **Turbidity:** Further information is needed to determine if increased salinity intrusion has the potential to change the ecological conditions in Coos Bay to a notable degree. Further information is needed to determine if discharged cooling water will impact aquatic resources in the slip due to temperature changes. **Long-Term Biological and Hydrological Monitoring:** ODFW recommends a monitoring/study plan be developed. This plan should include: • Biological information (e.g. abundance, species composition, behavior; for both native and invasive species) project in the bay. • Hydrological information (turbidity, salinity intrusion, water temperature changes) and specifically address ecological impacts related to the deepening of the site due to dredge activities. • Modeling that has been conducted by the Applicant to date has been informative. However, it may not accurately and precisely predict what actual post-construction hydrologic and ecological condition will be. The study should use an experimental design that includes before and After Controlled Impact techniques aimed at elucidating changes in shallow and deepwater communities, correlations between biological indices, and hydrological changes. ODFW recommends that all three factors A) Turbidity; B) Salinity intrusion; and C) Water temperature changes are monitored and addressed in the following ways: **Predictive Hydrologic Model:** ODFW recommends the Applicant(s) consultant(s) develop of a predictive hydrologic model to estimate how creation of the slip and maintenance dredging of the main Coos River channel will affect salinity intrusion into the bay *(ODFW recognizes the efforts of the Applicant that have been completed to date, however, these focus primarily on hydraulic flow*

depth to which light penetrates into the water column.

- Potential reduction in production of mollusks, Dungeness crab, juvenile coho, Chinook salmon and other species.

Salinity Intrusion: The current proposal may require elevated levels of maintenance dredging to the slip and berth. The Port of Coos Bay project to improve the Navigation Channel will likely have the largest impact on Salinity Intrusion since Coos Bay was originally dredged in the early 1900's. Applicant noted that hydrologic modeling has indicated sediments will likely accumulate at an accelerated rate in the berth area. To date, ODFW is not aware of any modeling of salinity intrusion into Coos Bay and the effects to residence time of highly saline waters.

Increased salinity intrusion likely would affect Category 2 habitats in the project area, but also in an unknown portion of the remainder of the bay. Effects may include:

- Ecotone boundary changes altering aquatic plant growth patterns and distribution.
- Distribution changes for plant and animal organisms vulnerable to salinity levels.
- Changes to the available zones for reproductive success (e.g. Dungeness crab, striped bass Morone saxatilis).
- Phytoplankton community productivity change related to nutrient regime shifts (i.e. the time of year freshwater dominates for a given reach of the Bay).

Saline intrusion associated with increased dredging in the 1980's was thought to have had an impact on several species in the

rather than salinity patterns). This model should be developed and distributed for review to the natural resource agencies prior to initiation of construction at the site.

Inclusion of Hydrologic Factors in the Monitoring Plan: ODFW recommends the Applicant develop a monitoring plan (in combination with the biological monitoring plan as described above) in collaboration with ODFW and natural resource agencies to study/quantify/qualify: Turbidity effects;

- Salinity intrusion effects;
- Water temperature issues at the site.

Studies outlined in the plan should be completed for a time period necessary to meet the goals.

Data Sonde Network: As part of the monitoring plan, ODFW recommends:

- A network of data sondes be deployed to collect data on A) Turbidity; B) Salinities; C) Water temperature both at the surface and depth.
- If salinity intrusion, thermal changes, or turbidity are determined to impact fish and wildlife resources, mitigation should be appropriately identified by the applicant, ODFW, and other relevant natural resource agencies as consistent with OAR 635-415-0000 through 0025.

Bay including striped bass and American shad (*Alosa sapidissima*), although study results were inconclusive. The impacts that this intrusion would have on native shellfish and finfish species such as fall Chinook, coho salmon, Dungeness crab, and native oysters cannot be modeled and would only be detectable through real-time monitoring. Productive commercial oyster farms, which occur in euryhaline waters upstream of the project site, are currently protected from many fouling organisms and predators that occur in more stable salinities. Further intrusion of salt water will contribute to more stenohaline waters thus presenting new risk to a currently economically viable industry. Water Temperature: Ships loading at the facility will discharge heated engine cooling water that may be as much as 3°C warmer than the surrounding water. Fish that come in direct contact with this plume will experience stress. ODFW recognizes that significant cooling of this water will occur soon after it is released from the vessel and sees this issue as less concerning, however, remains interested in potential for deleterious effects.	
Species Omissions: Previous documentation has omitted Northern Anchovy (Engraulis mordaxas) species present in Coos Bay. For marine mammals, California sea lions (*Zalophus californianus*) are also present near Jordan Cove.	**Species Omissions:** Include Northern Anchovy as species present in Coos Bay and add California Sea lions to list of marine mammals near the project.
Deepwater Zone Biological Communities: Construction of the LNG slip and offloading site will create a new deepwater zone that is 25+ft in depth:	**Deepwater Zone:** It is critically important to understand what impacts the development of a large "alcove" deepwater zone at the project site will have on finfish and shellfish populations. Changes may occur to life-history patterns, movements, concentrations, overall abundance, and perhaps

This new deepwater zone will be constructed at 90˚ to the axis of the river channel forming a type of alcove morphologic feature that currently does not exist in Coos Bay. Deepwater zones that exist in Coos Bay tend to attract specific species compositions (e.g. white sturgeon, Dungeness crab, California halibut). However, these deepwater zones are in line with the main flow of the channel. Due to the location and hydrologic patterns associated with this new alcove, there needs to be monitoring to determine the species benefitted and or detrimental effects. The slip area will be highly disturbed during dredging and recover slowly, with re-disturbance at regular intervals associated with maintenance dredging. Installation of rip-rap and sheet-pile in the berth are expected to maximize the simplicity of the zone inhibiting the productive capacity for fish and wildlife. Consequently, there is concern with how construction of this site will affect life cycle patterns, population concentrations, overall abundance, and movements of certain affected species in Coos Bay. Specifically, e.g. will additional deepwater zone in this region of the bay affect the following: • Finfish/shellfish species densities in the area and other regions of the bay. If change occurs, how will this affect production of affected species in relation to current levels (e.g. predator-prey relationships with avian predation of salmonids, seal and sea lion predation to salmonids; avian predation to finfish)? • Competitive interactions associated with the value or lack of value of the slip. Additionally, it is of concern if the slip will become a zone of higher density of predatory fishes.	reproductive aspects of affected organisms in the Bay. Identifying these changes will be essential to development of a mitigation plan to compensate for negative impacts as they occur and are detected. ODFW recommends that specific studies be designed through coordination with ODFW and other natural resource agencies to determine these changes or lack thereof. **Include created "Deepwater Zones" as a Main Factor in Monitoring Study:** As described above long-term monitoring is critical to define the effects of this substantial proposed change to habitats in Coos Bay. ODFW recommends study of the effects be conducted on an on-going basis through the majority of the permit period. ODFW recommends this study attempt to document changes to populations including, but not limited to: change in species diversity, abundance, behavior, distribution, and species composition caused by the project. ODFW recommends Before and After Control Impact (BACI) study methods be used to provide before, after, and control structure for the investigations. ODFW recommends the Applicant receive guidance from ODFW and other natural resource agencies for methods and timing (beginning, sampling frequency, and ending) for these studies. Study results should be distributed annually to natural resource agencies, other interested agencies/parties. **Biological recovery assessments:** ODFW recommends a biological assessment of the deepwater access and slips be completed following construction to determine the degree that production of shellfish/finfish will recover and stabilize.

• Recreational opportunities related to current finfish/shellfish distributions (e.g. alteration of the distribution of Dungeness crab; salmon movement changes; influx of larger rockfish; etc.). • Incorrect Ecology: • Juvenile salmonids migrating would will likely be in main channel, not off-channel slip. Juvenile salmonid use of estuary includes feeding, rearing, foraging, in off-channel wetlands, sloughs, and other slow water areas. These fish may seek out low-velocity areas, including the terminal slip. • Previous documents have incorrectly not made note that killer whales, porpoises, and pinnipeds could be found in Coos Bay. They are present…pinnipeds frequently, cetaceans occasionally but commonly. Other species of whale have been rare visitors to Coos Bay, a few even travelling up-bay to the City of Coos Bay and beyond.	This recovery assessment should be scaled on a percentage basis compared to productivity in undisturbed regions in the Bay. ODFW recommends reports be completed annually and information provided to ODFW, natural resource agencies, local tribes, and other interested parties within one calendar year after construction of the slip and berth is completed and annually thereafter for a period of 10 years. **Incorrect Ecology:** • Previous documents have not noted the potential for use of the slip by juvenile salmonids and other fish or invertebrate species and monitor, and mitigate for use of terminal slip impacts to these species. • Acknowledge and consider presence of Killer Whales and other whales to be confirmed and consider potential impacts to marine mammals in the analysis and environmental protection measures
Recreational Users: It is ODFWs understanding that the U.S. Coast Guard typically requires exclusion zones of up to 500 yards surrounding LNG tankers that would transit the bay and potentially while at dock for safety and national security purposes. The application does not address this very serious potential impact to recreational and commercial boat and/or bank use of Jordan Cove and the surrounding bay areas. Any such actions by the US Coast Guard would likely result in a severe impact to public recreation for fishing, shellfish, or hunting which should be analyzed as part of the cumulative impacts of the project and fully mitigated for should they occur: Increased LNG ship traffic in Coos Bay has the potential to negatively impact public recreation because:	**Recreational Users:** ODFW recommends the Applicant clarify safety/security requirements for recreational boaters when LNG ships are in transit within the K Buoy to terminal zone, specifically including any such future safety or national security exclusion zones likely to be implemented by the U.S. Coast Guard or any other state of federal enforcement agency. ODFW recommends the DSL and Applicant consider recreational value of the Jordan Cove and Coos Bay estuary; specifically consider impacts to salmon fishery, crabbing, and other boating during construction, dredging, and LNG ship transit, specifically within the context of the above described U.S. Coast Guard restrictions likely to occur. ODFW recommends that the DSL direct the Applicant to complete an economic analysis of the shellfish (crabbing/clamming) and finfish (rockfish, salmon, steelhead) fisheries in Coos Bay, their

• Recreational use of the Bay has increased, with greater numbers of crabbers, clammers, and anglers participating. • The area from the jetties to Jordan Cove is a high-use area for crabbing and salmon angling from boats. • It is uncertain whether or not USCG security/safety measures will require boats to completely leave the area, or simply require boats to clear the navigational channel to allow the ship to pass. Applicant and DSL need to recognize Coos Bay as an important recreation area (hunting, fishing, clamming, crabbing, boating, paddle surfing, surfing, etc.). According to OSMB 2008 report, most recreational boating in Coos Bay occurs in summer--possibly more boating now in fall (salmon angling/crabbing). **Socioeconomics—**The LNG ships will be passing within 500 yards of Charleston Marina/Boat Ramp, Empire Boat Ramp, BLM North Spit Boat Ramp, and the entire Coos Bay is a recreational area. Construction, dredging, and LNG vessel transit will have impacts on recreational areas and facilities. Overcrowding currently occurs at lower Bay boat ramps during peak of salmon fishery. Displacement of boating/launches during LNG vessel transit or construction could exacerbate boat launch overcrowding.	contribution to the economics of Coos County and Southwest Oregon and address the potential impacts of the project. The economic impact to these recreational opportunities and the local businesses that depend on them is directly related to this environmental concern. ODFW recommends DSL require that any such loss of recreational access and associated economic impact to local business and the local economy from the resulting lost recreational opportunity be fully mitigated by the Applicant. ODFW recommends that JCEP allow safe harbor access to recreational boaters using Coos Bay in the event weather conditions require a boater to leave the ocean.
Kentuck Mitigation Site: The former Kentuck golf course lands have been identified by the Applicant for restoration. These lands would be reestablished as estuary in order to provide mitigation for the dredging impacts that will occur at the slip and access channel. The Kentuck golf course lands currently are degraded wetlands that were historically de-watered through diking and tidegate management,	**Kentuck Mitigation Site:** In order to maximize the ability of the Kentuck mitigation site to provide compensation for ecological and recreational resources impacted at the JCEP project area location, ODFW offers the following guidance: **Public Access:** ODFW recommends public access be made available and encouraged at the Kentuck mitigation site in order to attempt to provide

eliminating the connection with the estuary. Although there may be sufficient acreage at this site to meet the DSL 3:1 restoration ratio for dredging impacts at the site, a number of potential impacts (e.g. salinity gradient issues, changes in bay turbidity, creation of a deepwater zone) that will occur at the will not be compensated In-kind as the salinity gradients are out of the range that is present at the project location. **Public Access:** Is currently allowed at the Kentuck Mitigation site and on the water at the JCEP project area of the bay. Recreational access to the estuary and shoreline habitats of the bay is an important component of the local economy. It is expected that the security zone in the JCEP project area following construction will significantly reduce public use of the bay and adjacent uplands. The mitigation site will need to accommodate the elimination of public access at the JCEP site through allowing open public access. Saline waters will move upstream into the Kentuck mitigation site via restoration actions allowing more viability of mariculture (i.e. Pacific oyster farming). The effective area available for expansion of mariculture will not only be within the new mitigation site, but there will also be an increase in the particle range (i.e. drift of Oyster spat) of these operations up bay. Although it will likely be practical for oyster cultivation on the mitigation site, this would be counter-productive to the intended goals of mitigating for fish and wildlife.	compensatory opportunities in replacement for loss or reduction of access at the JCEP project site. ODFW recommends construction of a public parking area off of East Bay Drive as part of the mitigation site development. There is opportunity to develop parking without filling wetlands at the site. Provision for recreational opportunities at the Kentuck golf course site, although not precisely In-Kind, may partially compensate for losses at the JCEP site and should be fully investigated. ODFW recommends, specifically, that opportunities for hunting, recreational shellfish harvest and wildlife viewing be identified and implemented in collaboration with local constituents. **Restrict Commercial Oyster Cultivation:** ODFW recommends careful consideration of restricting commercial oyster cultivation from the Kentuck mitigation site as a condition of the DSL permit. The spread of the footprint of mariculture operations just down Bay (defined as within ¼ mile) from the mitigation site may retard the creation of this restored estuarine habitat in Kentuck Slough. These types of mitigation may not be effective in the context of future expansion of mariculture which would likely defeat mitigation goals. **Additional Coordination:** ODFW requests that the Applicant/affiliate coordinate during the development/construction of the Kentuck Mitigation site, so that ODFW will be able to provide the Applicant with recommendations for specific on-site adjustments and actions to maximize ecological function.

JCEP – Upland and Freshwater Concerns from ODFW Fish and Wildlife Districts

Issue Identification	Recommended Resolution
Capping Piling to Prevent Perching: Predatory piscivorous birds strategically perch around industrial facilities on piling that do not have measures to eliminate the ability of these birds to perch/roost. Ecologically the relevance is related to an increased capacity to feed within the area and impact species such as fall Chinook, coho salmon, and steelhead juveniles. If additional perch locations are created for piscivorous birds as a result of the proposed project, predation on resident and juvenile fish will likely increase along the project, and would be of particular concern in the vicinity of the project terminus at Coos Bay and near larger rivers such as the South Coos River, South Umpqua, and Rogue.	**Capping Piling to Prevent Perching:** For both the JCEP and PCGP project ODFW recommends fitting any new pilings with devices to prevent perching of piscivorous birds. This is a standard request from ODFW to Applicants on Fill/Removal permits when the Applicant installs pilings. These caps are readily available.

PCGP - Aquatic and Upland Concerns from ODFW Fish and Wildlife Districts

Issue Identification	Recommended Resolution
Subsurface Boring and Drilling Stream Crossing Methodologies: ODFW's experience with other pipeline construction projects has shown that stream crossings and overland disturbance can be damaging to watercourses if not carried out with extreme diligence. During construction of the Coos County Gas Pipeline horizontal directional drilling (HDD) was stated as being "clean and not impacting streambeds", however, "frac-outs" occurred and incurred environmental damage caused by drilling fluids leaking into fish-bearing streams.	**Recommendations Specific to Subsurface Boring and Drilling Stream Crossing Methodologies:** Pipeline crossings using HDD or other subsurface methodologies may cause frac-outs in Coos County geology and possibly throughout the project. The Applicant should be prepared for construction stoppages, cleanup, and remediation of damages caused by frac-outs. For that reason, crossings construction timing should occur during ODFW's recommended in-water timing guidance or as otherwise approved by ODFW in writing. HDD and other subsurface boring or drilling crossing design locations should pro-actively address the risks associated with the potential for a "Frac out" or inadvertent loss of drilling fluid to the extent practicable:

Drilling fluids can be water or oil-based and can include other additives. Although the bentonite base is claimed to be a benign ingredient, ODFW is unaware of what the other additives are and how harmful they can be to fish and aquatic wildlife. Between August and October of 2003 MasTec North America, Inc. was cited by DEQ for a series of water quality violations. The violations were a result of frac-outs during the horizontal drilling work for the construction of a natural gas pipeline under the North Fork of the Coquille River in Coos County. If similar frac-out related turbidity discharge impacts were to occur at the proposed Rogue River crossing, they would likely impact the significant spawning habitat for spring-run Chinook salmon in the Rogue River Basin. It is known that ESA-listed fish species and or State Sensitive species will be present at the South Coos, North Fork Coquille, and East Fork Coquille river crossings include OC Coho salmon. State Sensitive-Vulnerable species include Coho salmon (coastal coho salmon SMU/Oregon Coast ESU). Winter steelhead (Oregon Coast ESU/coastal winter steelhead SMU) are considered Sensitive-Vulnerable in the Coquille River basin, however, not in the Coos River basin. Pacific lamprey (*Entosphenus tridentata*) are considered Sensitive-Vulnerable in the Coos River, Coquille River, and Umpqua River basins making turbidity concerns heightened throughout in these watersheds, in addition to the concern within the Rouge River watershed.	ODFW recommends DSL condition the project certificate such that the Applicant is required to complete consultation with ODFW including submittal of any risk assessment and geotechnical documentation for any stream crossing which are proposed as subsurface boring or drilling stream crossing actions. Submittals should also include descriptions of alternate or contingency crossing methods should the primary method result in an inadvertent loss of drilling fluid, otherwise known as a ”frac-out” or otherwise fail as a successful crossing action. ODFW further recommends DSL condition the project certificate such that the Applicant is required to: • Conduct adequate geotechnical analysis to ensure frac-outs will not occur (e.g. identify vulnerable geologic issues, adjust the depth of drilling, etc.). • Provide a list of the additives used in drilling fluids and their potential effects on the aquatic environment. • Implement specific drilling BMPs to ensure constant monitoring of drilling fluid return volume so that drilling can cease immediately if drilling fluid is not returning at the expected/standard volume for a successful HDD attempt. • Identify measures that will be taken to minimize impacts of a frac-out if a frac-out occurs and mitigation that will be implemented if a frac-out occurs as cleanup is not feasible and attempts will create additional damage. Mitigation could include: Placement of LWD; placement of clean washed spawning gravel; road drainage improvements (cross drains, improved surfacing); road decommissioning. • Establish performance bonds and/or require performance bonds of drilling subcontractor to ensure adequate funding is immediately available to address/mitigate a frac-out or other drilling failure which

	results in damage to fish, wildlife, or the habitats they depend on. <u>HDD Actions in the Lost River Drainage.</u> The Klamath Fish District of ODFW requests that drilling any HDD activities are implemented between July 1, and October 31, or as soon as water conditions are deemed uninhabitable by fish due to poor water quality. Shortnose suckers (*Chasmistes brevirostris*), Lost River sucker (*Deltistes luxatus*) and redband trout (*Oncorhynchus mykiss*) inhabit this stretch of river from November to July; poor water quality triggers migration to upstream refuge habitats. Fish are highly sensitive to sound waves that could be caused by drilling disturbances and sound waves could act as a migration barrier.
Non-fish Bearing Stream Crossings and Other Storm Water Drainage Conveyance Structures: Although non-fish bearing stream crossings and stormwater conveyance infrastructure are not subject to the same design criteria identified above for fish bearing stream, ODFW remains concern with regard to sizing and instillation of these types of infrastructure. Culverts or other crossing infrastructure should be sized in excess of hydraulic capacity need to help facilitate wildlife connectivity between habitats and minimize potential downstream water quality impacts such as turbidity sedimentation transport resulting from scour at undersize infrastructure.	**Non-fish Bearing Stream Crossings and Other Storm Water Drainage Conveyance Structures:** ODFW recommends that all streams be considered fish bearing unless documented to be absent of fish. If a stream crossing or storm water conveyance structure is determined to be non-fish bearing, ODFW still recommends the work be completed according to the standard In-Water Work timing guidance document or if the stream or storm water conveyance structure is dry. ODFW recommends the Applicant consider oversizing the infrastructure and installing it in such a manner to maximize its performance as a suitable wildlife crossing structure and to minimize potential for downstream water quality impacts such as turbidity sedimentation transport resulting from scour at undersize infrastructure.
Site Specific River/Stream Crossing Concerns: The resource plans do not address or mitigate for all impacts associated with stream crossings under ODFW's Fish and Wildlife Habitat Mitigation Policy. ODFW encourages both the Applicant and DSL to acknowledge the potential	**Site Specific River/Stream Crossing Concerns**: ODFW recommends site specific coordination and consultation between the Applicant and ODFW staff to fully identify unique site specific resource concerns at these crossing locations. ODFW anticipates that significant resource impact avoidance and minimization can be realized through collaboration with local Department staff

for severe impacts to fish, aquatic wildlife, and the habitats they depend on by ensuring the above recommendations become conditions of any permits for the PCGP project.	throughout the crossing design, construction, and restoration/mitigation recovery phases at these river crossing locations. Lost River Crossing- See above specific timing recommendation Klamath River Crossing - ODFW does not support open trench methods at this location. In the event of a catastrophic spill or release, a contingency plan should include an evaluation of needs for dilution flows and dewatering. Flows from upstream can be manipulated by the Bureau of Reclamation and downstream irrigation canals can be manipulated by irrigation districts for dewatering. Rogue River Stream Crossing- Pacific Connector states that if HDD of the Rogue River is unsuccessful Direct Pipe (DP) methods would be a potential option. Previously wet, open-cut crossing were also proposed. ODFW does not consider a wet, open-cut to be an acceptable contingency method. South Umpqua Direct Pipe Technique Site #1 at MP 71.3), and South Umpqua Open Cut Site #2 at MP 94.73 - This proposed crossing occurs at an ecologically important site. A gravel bar is located approximately 300 m downstream. There is no information provided in resource reports for Fate Creek. The gravel bar at this site provides river complexity, high flow refugia and summer slow water habitats which are considered to provide both essential and limited habitat function for a variety ESA-listed fish, state-sensitive listed fish and aquatic wildlife.
Herbicide Use Near Streams/Wetlands: The current public notices do not address herbicide use, if applicable.	**Herbicide Use Near Streams/Wetlands:** ODFW recommends against general use of herbicides and pesticides in wetlands. ODFW recommends any use be judicious and meet federal, state, and local, regulatory requirements.

Small Stream Temperature Issues: It is unclear how the PCGP project intends to classify streams and address water temperature fluctuations associated with project work.	**Small Stream Temperature Issues:** ODFW recommends DSL condition the certificate to direct the Applicant to treat all intermittent waterbodies within the Coast, Umpqua, and Rogue basins the same as perennial streams and provide these streams the same level of protection as streams on Federally managed lands.
Large Woody Debris (LWD) as Mitigation: The public notices do not adequately describe the impacts of the project on water quality factors such as shade and nutrients or habitat factors such as predatory cover.	**Large Woody Debris (LWD) as Mitigation:** ODFW recommends a stream habitat mitigation plan be developed for every fifth field watershed crossed in order to effectively mitigate for the life-long impacts of the project. In addition the Applicant should fully mitigate for the multiple impacts at stream crossing sites including, but not limited to: • Access roads and associated sediment production to streams. • Loss of riparian canopy that increases solar input. • Elimination of much of the filtering capacity of the RMA due to removal most other lost habitat values/benefits of riparian habitat as well. • Destabilization of stream channels and streambanks. ODFW recommends that in addition to placement of LWD at stream crossing sites the following restoration and mitigation actions may greatly complement the functional habitat benefits provide by LWD placement : • Placement of forest vegetation (limbs, small woody debris, etc.) scattered on bare soils following disturbance within 50ft. of each pipeline approach to streams. This material will be readily available due to land clearing efforts • Conservation of riparian areas within the HUC 6 watershed. ODFW has a compiled list of a number of mitigation options, and welcomes the opportunity to provide those suggestions to DSL and the applicant. • Placement of washed spawning gravel at all stream crossing impact sites in the Coastal Zone and considered on a site by site basis for all other stream locations.

	Spawning gravel is often a limited quantity habitat feature in the Coastal Zone and placement will augment productive capacity of reach impacted for salmonids. • Gravels should consist of washed drain rock from an upland source (such as the Elk River Pit in Langlois, OR) • Gravels should consist of 1.5 inch diameter washed drain rock for Coho and steelhead spawning streams; 0.75 inch washed drain rock for streams where only cutthroat trout are present. • Gravels should be applied at the rate of 8.0 inch depth over the reach impacted to the width of the ACW and up the banks 2.0 feet (which will reduce bank instability). Thus if a 40 foot reach of stream channel is disturbed and the ACW is 8 feet wide, then the quantity needed would be 40.0 feet x (8.0 feet ACW+ (2x2 banks)) x 0.67 ft. (8.0 inches) or a total of 321 cubic feet or roughly 12.0 cubic yard (CY).
Sedimentation Impacts from Clearing and Grubbing Large sections of ROW: The application does not describe how vegetation adjacent to waterways would be cleared and grubbed. Lessons learned from the ODOT's Pioneer to Eddyville project (in the Coast Range Mountains) include the need to limit the amount of ground cleared of vegetation at any one time. The pipeline will cross the Coast Range, so special care should be taken to limit erosion and sediment loss in this section as well as any other areas of significant rainfall with steep slopes	**Sedimentation Impacts from Clearing and Grubbing Large sections of ROW:** Given the known instability and potential precipitation levels in the Coast Range Mountains ODFW recommends: ODFW recommends that the Applicant develop a detailed written plan that identifies the maximum amount of land cleared and grubbed at one time. The plan should also identify (1) areas of high, medium, and low levels of risk for sediment escape and impacts to water bodies. Based on slope and proximity to water bodies, and (2) include a re-vegetation section that ensures re-establishment of vegetation in high and medium risk areas prior to the fall rains. The timing of the pipeline construction should allow for ground clearing to occur after the spring rainy season and any areas opened up should be seeded and vegetation established before the fall rains. Distance and slope can be taken into account regarding the amount of land cleared and grubbed, i.e. the greater the distance from a creek and the flatter slope, the less concern for down slope

	sediment escape and erosion that can ultimately impact water bodies.
.**Pipeline Steep Slope Concerns and Roads (implications for Water Quality – turbidity, sedimentation):** A number of miles of the pipeline will be constructed on slopes that exceed 50%. Tyee sandstone geology in the Coos and Coquille River basins and the geology of the Rogue Basin to a lesser degree are highly prone to landslides if the supporting matrix is disturbed. Additionally numerous access roads will be built to harvest timber and access construction of the PCGP. Mass wasting debris torrents and general erosion are considered substantial threat to water quality and to habitat quality in waterways for ESA listed and non-ESA listed salmonids as well as amphibians. Extensive research has documented the impacts of sediments to salmonids. Work to reduce sediment input into coastal and inland streams that will be impacted by the pipeline is foundationally critical for enhancing spawning and rearing habitat for fall Chinook salmon, Oregon Coast (OC) threatened Coho salmon, Pacific lamprey (*Entosphenus tridentata*), winter steelhead (*O. mykiss irrideus)* and coastal cutthroat trout (*O. clarki clarki)* as water quality is directly linked to hatch rates and food available for these species. Sediment loading above natural background levels contributes to embedding of substrates which often results in reduced hatch rates for eggs in redds, inability of fry to emerge from redds, inhibited production of macroinvertebrates (invertebrates largely live in the interstitial spaces of gravels), and impacts on the ability of fish to obtain food due to the nature of salmonids to feed predominantly by using their sight	**Pipeline Steep Slope Concerns and Roads:** Pipeline Steep Slope Concerns: Stabilization/erosion control of upland slopes following pipeline construction will be nearly as important as stabilization/erosion control in riparian areas adjacent to streams. Some extremely steep slopes will be encountered in the Coos County portion of the pipeline. ODFW recommends the following for locations where the pipeline will traverse or the route will be placed on slopes which qualify as High Landslide Hazard Locations (HLHL as defined in *Oregon Dept. of Forestry Technical note 2.0 vers 2.0; (ODF Jan 1, 2003)*; in Tyee Sandstone over 65% slope on headwall locations and 75% ridges): ODFW recommends the pipeline construction route incorporate cross slope trenching as opposed to routing parallel to the slope whenever possible to reduce the risk of soils moving laterally in the trench downslope (mass wasting slides). Placement of erosion control matting has been outlined as an upland soil disturbance control measure. This, in combination with cross slope placed large wood, stumps, and other wood material, is considered a modestly reasonable attempt for erosion control. ODFW recognizes that pipeline corridor management strategies are not likely to allow for placement of large wood in pipeline corridors. ODFW recommends rock or other structures be placed across the pipeline trench at a 90˚ angle and be embedded in the undisturbed walls of the trench a minimum of 4ft. to prevent free movement of soil in the disturbed pipeline trench. These structures should be placed at 100ft. intervals. Steep slope pipeline locations should receive additional efforts with seeding and mulching. Additionally these segments of the pipeline route

(Burns 1970; Hall and Lanz 1969; Weiser and Wright 1988; Suttle et al. 2004; Tripp and Poulin 1992; Waters 1995).	should have cross slope structures and drainage networks to reduce failure risk. ODFW recommends the road network: • Have surfacing that is sufficient to accommodate travel loading and prevent erosion of the road surface through all months. • Have cross drains installed at a density/spacing that is equivalent or exceeds to recommendations in the ODF Forest Practices Technical Note Number 8 vers.1 (ODF Jan 2003). • Have mitigation for sedimentation/mass wasting issues clearly identified in-proximity regardless of ownership (federal or non-federal) as these locations have the greatest potential for measurable improvements in reducing sediment loading to streams impacted.
Emergency Response: Emergency plans, including immediate notification of turbidity exceedances, frac-outs, spills, and pipeline leaks for both the JCEP facility and PCGP, are considered critically important. Sensitive fish and wildlife habitats can be severely impacted by these types of occurrences. However, impacts can be greatly minimized if remediation actions are initiated quickly upon discovery of an incident.	**Emergency Response:** ODFW recommends that emergency plans include immediate notification of: • Turbidity exceedances, frac-outs, and spills and pipeline leaks for both the JCEP facility and PCGP. • ODFW recommends that emergency plans include surveys for fish and wildlife kills immediately following a frac-out, spill, or gas release. Should an incident like those described above occur, the project must contact Oregon Emergency Response System immediately (1-800-452-0311) in the case of leaks during pipeline operation or offloading or loading at the JCEP facility or along the PCGP route. **Natural Gas Pipeline Shut-Off Valves-LNG Control at Large Rivers:** ODFW recommends that options to have shut-off valves on each side of large stream crossings such as the Coos, South Umpqua, Rogue, and Klamath Rivers be evaluated.
Hydrostatic Testing:	**Hydrostatic Testing:**

ODFW understands that hydrostatic testing will be performed along the pipeline. Hydrostatic testing will have substantial impact on fish and wildlife resources, especially during periods of low flow and poor water quality. Transport of invasive species is a substantial concern with transport of water from a source basin and release at another point in an adjacent watershed. Damage and control costs of invasive species in the United States are estimated to be more than $138 billion annually and 80% of endangered species are deleteriously impacted by these species through predation or competition (Pimental et. al). Impacts from invasive fish species alone cost $6.03 billion annually (Cusack et. al.). It is ODFW's understanding that testing will immediately follow pipeline construction in late summer and early fall. Potential adult anadromous migration during these times includes fall Chinook, coho, winter steelhead, coastal cutthroat trout and Pacific lamprey. Also, this can be the period of lowest stream flow, and water for hydrostatic testing may be unavailable unless purchased from existing available water sources such as reservoirs. Inter-basin mixing of water could adversely affect migration of adult anadromous fish (salmon, steelhead and lamprey) to their natal streams through a phenomenon known as false attraction. Supplying water from an Oregon Department of Environmental Equality 303(d) TMDL Water Quality limited waterbody to a basin of higher water	ODFW recommends: • ODFW recommends an erosion control plan • In addition, the project proponents need to continue to incorporate methods to eliminate the possibility of spreading invasive species (such as New Zealand mud snails, smallmouth bass fry) especially given that the pipeline will convey water between non-hydraulically connected basins and in some instances, be "cascaded" across the landscape to be used for the next segment. Minimizing the risk, as discussed in the plan, is not adequate. Water diverted will need to be tested along with water at the nearest discharge waterbody to see if stream pathologies are similar or measures taken to ensure water released is sterilized. • NMFS-approved screening on diversions is required and fish passage at these locations must be maintained. • In addition, test water should not be allowed to drain into waters of the State and chlorinated water should not be used for the testing unless the release location will not enter a stream, wetland, or waterway. • ODFW recommends continued efforts to develop the Hydrostatic Testing Plan as well as a Hydrostatic Monitoring protocol with the intent of approval of the plan by ODFW, other state and federal agencies. The survey will monitor ramping, fish stranding, and water temperature at pumping and release sites, salvage fish, and document fish losses. The project proponents should conduct the surveys with competent biological staff. • A summary report of monitoring would be submitted to the agencies, along with compensation for losses to fish and wildlife resources.

quality may result in reduced water quality in the source watershed. Hydrostatic testing will require additional staff and noise disturbance on the pipeline route. It is uncertain if and how noises associated with this activity will impact nesting Northern Spotted Owls and other sensitive species.	
Impacts to Water Quality and Habitat Quality in Wetlands and Waterways: The project is anticipated to produce substantial turbidity to wetlands adjacent to the pipeline channel and road networks associated with the project. Major wetland functions include water storage, carbon sequestration, slow water release, maintenance of high water tables, temperature regulation, nutrient cycling, sediment retention, accumulation of organic matter, filtration, and maintenance of plant (by provision of substrate for plant colonization) and animal communities. Measures need to be taken to eliminate the risk of spreading invasive plants and noxious weeds.	**Impacts to Water Quality and Habitat Quality in Wetlands and Waterways:** ODFW recommends more detailed plans be described for addressing turbidity risk, non-native species invasion risk, and monitoring plans for mitigation sites that include contingency plans if restoration attempts are not successful.
Amphibian Direct Mortality and Long-Term Passage: The PCGP project is anticipated to incur notable mortality to amphibians resulting from proposed construction methods in riparian areas, stream adjacent wetlands, and perched wetlands. Amphibians range in mobility from highly mobile to extremely limited. Installation of crossings where there is currently stream/wetland connectivity can result in increased predation and reduced capacity of amphibians to	**Amphibian Direct Mortality and Long-Term Passage:** ODFW recommends that surveys are completed for both amphibians and reptiles. Additionally: • ODFW recommends that final constructed designs provide for amphibian passage along the pipeline route (i.e. installing cross drains under access roads that connect wetlands). Installation of culverts with stream simulation design is considered to fully provide for amphibian passage. There will be a number of locations where fish are not present that passage for amphibians may need to be provided on a case by case basis.

access needed habitats. This is critical where wetland are ephemeral. Additionally, noise from hydrostatic testing will likely impact amphibian populations, potentially disrupting breeding cycles.	• ODFW recommends the PCGP project staff consult for all wetland locations >0.1 acre in size with Department staff at least 1.0 months prior to disturbance to determine methodologies to reduce impacts to amphibians and identify if salvage is necessary.
ODFW's Scientific Take Permits: Scientific take permits are relevant to coordinate salvage and movement of fish and wildlife species impacted during a project.	**ODFW's Scientific Take Permits:** ODFW recommends a condition be included for the Applicant to apply for and comply with state scientific taking permits. • ODFW recommends that the pipeline staff report quantified known injuries and mortalities by species during construction of the project. • ODFW recommends that the PCGP staff report injuries and mortalities of fish and wildlife by species associated with operation of the pipeline or in an emergent condition.
Riparian Habitat Impact/Mitigation Concerns: Riparian vegetation within the Riparian Management Area (RMA) zone near streams, wetlands, and waterways is critically important for the health of Oregon's native fish populations, especially in the drier parts of the pipeline corridor such as the Rogue and Klamath watersheds. Fish in the state are predominantly cold water species that evolved in stream conditions that were in most cases related to climax or second growth hardwood and conifer forest, thus near maximum shade that the stand would produce. The Oregon Dept. of Environmental Quality has identified 303d temperature listed streams including numerous streams through the pipeline route. These listings relate directly to removal of riparian vegetation since the 1800's.	**Riparian Habitat Impact/Mitigation Concerns:** ODFW recommends that riparian vegetation buffers that meet or exceed State and local government requirements be implemented on non-federal lands. All disturbed areas need to be replanted with native vegetation. ODFW recognizes that the proposed crossing locations may be on lands where private landowners may not allow the full setback to be replanted. In these situations, ODFW does not object if mitigation for permanent riparian impacts occurs off-site provided that it occurs within proximity within the same HUC 6 watershed and on private lands. Thinning as Mitigation: ODFW recommends this treatment should be used only on a very limited basis with clearly defined objectives that address location specific limiting factors.
Forest and Vegetation Impacts: In the context of described limits to revegetation of the ROW, the currently	**Forest and Vegetation Impacts:** To adequately evaluate watershed activities that impact wetlands and waterways associated with

proposed impacts to riparian areas may result in net loss of habitat function. ODFW assumes some percentage of riparian stream crossings will remain in an unvegetated or low-vegetation state requiring moving/cutting maintenance.	this project, ODFW recommends DSL consider the risks of erosion along pipeline corridors associated with vegetation removal and ground construction. ODFW also recommends: • Additional development of BMP's and a robust revegetation plan be developed for pipeline disturbance areas • Encourage use of native herbaceous (grass/forb), shrub, and tree species for revegation of disturbed sites unless natives will be unsuitable for site stabilization or specific species of non-natives are recommended to wildlife forage value. The establishment of vegetation using native grasses, trees and shrubs (although preferable in most instances) may prove ineffective if there is a lack of understanding of local conditions and their influence on vegetation growth, poor plant/seed selection, inappropriate soil management practices and inadequate vegetation management plans. • Work collaboratively with ODFW and other natural resource agencies to develop a revegetation plan with robust success criteria and clearly identified remedial actions if success criteria are not met
Species Occurrence/Status Species Corrections: The application does not discuss how state listed and state sensitive species will be addressed by this project.	**Species Occurrence/Status Species Corrections:** ODFW recommends the Applicant consult with ODFW to receive best available information regarding locations of sensitive/listed species, and that plans be developed to avoid, minimize, and mitigate impacts to those species. Species of particular relevance in the wetland and waterway environment will include (but are not limited to) western pond turtle, Oregon spotted frog, bald eagle nests, great blue heron rookeries, etc..
Noxious Weeds/Invasive Plants: Invasive species (e.g. noxious weeds) have been identified as one of the seven key conservation issues (threats to conservation) in Oregon in the Oregon Conservation Strategy (ODFW 2016). Hundreds of thousands of	**Noxious Weeds/Invasive Plants:** ODFW recommends that the Applicant complete a more comprehensive noxious weed control plan to prevent spread in aquatic environments or uplands associated with waterways.

dollars are expended annually on both public and private lands to combat invasion and expansion of noxious weeds and their negative effects on fish, wildlife, and their habitats. Specific invasive concerns include: • Gorse in the Coos Bay region has had substantial negative impacts on elk production in the Coastal frontal zone. • Scotch broom is considered a substantial factor decreasing production of elk and deer forage across the Coast range and some of the interior locations of Oregon. • Himalayan blackberry will likely be a factor within the right of way • Cheatgrass and medusahead are invasive species of concern for the eastern more arid portions of the project	ODFW recommends broad scale monitoring for noxious weeds, for the life of the project. ODFW recommends that performance metrics be included in a weed control plan, and that additional mitigation be undertaken if the final state of the pipeline is not satisfactory regarding avoidance, prevention, and minimization of noxious weeds. ODFW recommends wash stations for equipment be set up to handle aquatic invasive species as well. Equipment should be cleaned between individual subbasins at the HUC 6 level or if the machinery has been in a known area with invasive/noxious weeds. ODFW recommends that DSL include conditions outlining that the noxious weed plan have specific strategies (i.e. cleaning of equipment, monitoring, and control measures) for the JCEP project and individual reaches of the PCGP project. Mowing is considered a preferential treatment to herbicides when effective. ODFW recommends the Applicant acknowledge that the risk of invasion of noxious weeds on the pipeline route and mitigation sites is likely high and ensure the following: • ODFW recommends the Applicant fund an Oregon Dept. of Agriculture (ODA) weed extraction teams within the affected counties • ODFW recommends the PCGP project include ODFW in the list of agencies consulted and include our comments for noxious weed management. • ODFW recommends the Applicant describe the experience/qualifications of the staff used to conduct noxious weed surveys. • ODFW recommends the PCGP project should provide some level of assurance that environmental inspectors will have the capacity in their schedule to ensure

	noxious weed management concerns are addressed. • ODFW recommends that EI's should inspect new equipment arriving on site. Any protections given to federal lands should also be given to non-federal lands • ODFW recommends the PCGP project develop an incentive/dis-incentive program to greatly increase the likelihood the potential for a contractor driven inspection system (with random EI investigations) to function effectively. • ODFW recommends a buffer should be applied to known noxious weed infestation areas. Accordingly soil should not be moved out of these sites. These sites should be treated to prevent spread of noxious weeds to uninfested areas. • ODFW recommends that protection measures for federal lands should also be applied to non-federal lands. • ODFW recommends the PCGP project needs to provide extended monitoring at known infestation sites, dewatering stations, and all other high-risk sites on private lands as well. Monitoring the ROW only likely inadequate. ODFW recommends that PCGP employ independent consultant noxious weed specialists to conduct periodic on-going monitoring to maintain a sufficient level of certainty that noxious weed issues are addressed. Periodic monitoring needs to be completed for the life of the project on all disturbed ground with special emphasis at known infestation, dewatering stations, and equipment cleaning locations.
Capping Piling to Prevent Perching: Predatory piscivorous birds strategically perch around industrial facilities on piling that do not have measures to eliminate the ability of these birds to perch/roost. Ecologically the relevance is related to an increased capacity to feed within the area and	**Capping Piling to Prevent Perching:** For both the JCEP and PCGP project ODFW recommends fitting any new pilings with devices to prevent perching of piscivorous birds. This is a standard request from ODFW to Applicants on Fill/Removal permits when the Applicant installs pilings. These caps are readily available.

impact species such as fall Chinook, coho salmon, and steelhead juveniles. If additional perch locations are created for piscivorous birds as a result of the proposed project, predation on resident and juvenile fish will likely increase along the project, and would be of particular concern in the vicinity of the project terminus at Coos Bay and near larger rivers such as the South Coos River, South Umpqua, and Rogue.	
Environmental Inspectors: Properly trained environmental inspectors are able to greatly increase the potential for maximizing habitat conservation measures.	**Environmental Inspectors:** ODFW recommends that the PCGP project have environmental inspectors on all active construction segments of the pipeline project.
Public Communications: There is currently a significant need for a representative of the JCEP/PCGP project to serve as a public communications specialist to the project area constituents. Additionally there is a need for planning regarding how recreational users of fish and wildlife resources in Coos Bay and along the pipeline route will obtain information concerning the project: e.g. will recreation be restricted at the JCEP site, mitigation site access, pipeline route access; access to the PCGP corridor during construction, etc.) Restrictions to recreational accessibility can result in substantial impacts to the local economic conditions of affected communities.	**Public Communications:** The JCEP/PCGP project needs to develop a project communication plan in collaboration with ODFW to consult with and inform fishing groups and other recreational users on construction actions on a real time basis. Including but not limited to: • Will recreation (clamming, crabbing, and duck hunting) be restricted at the JCEP site during construction/following construction? • Will mitigation sites be open to public recreation, hunting, and fishing access during construction/following construction? • Will the pipeline route be open to access for fishing and hunting (the route will cross major salmon and steelhead fishing streams as well as historical hunting locations) during construction/following construction? • How and where will any residual impact to public access or recreational opportunities be fully mitigated?

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Comments and Public Inquiries Received for Application No. 187-18-00153: Jordan Cove Energy Navigation and Efficiency and Reliability of the Coos Bay Deep Draft Navigation Channel.

Number	Name	Date Received	For or against	General comment or inquiry
1	Jody McCaffery	January 4, 26, 28, 2019 February 15, 2019 March 19-20, 2019		General inquiry wishing to receive notice when available. How to submit comments. view current code.
2	Jan Hodder	February 12, 2019; March 8, 19, 2019		General inquiry wishing to receive notice when available. How to participate in public hearing. Eelgrass mitigation site.
3	Jamie Fereday	February 14, 2019		General inquiry wishing to receive notice when available.
4	Sam Schwarz	March 12, 2019		General inquiry wishing to receive notice when available.
5	Sarah Ruth Crawford	March 13, 2019		General inquiry on how to find documents related to the application.
6	Debra New	March 18-20, 2019	Against	Comment. Map of proposed map amendment. Damage to estuary. Impartiality. Third party study of impacts. Prior contacts / relationships with Coos Bay Council, Planning Department, and Pembina/Jordan Cove staff.
7	Sylvia Yamada, PHD	March 20, 2019	Against	Comment. Impacts to native species, including Dungeness crab. Detriment to crabbing industry economically. Crabs found in eelgrass. Disturbance to ecosystem. Simulated dredging operation showed a 45-85% mortality rate of Dungeness crabs.
8	Heike-Marie Eubanks	March 20, 2019	Against	Comment. Opposition to any permits or zoning changes to accommodate Jordan Cove facility. Contaminated sludge. Harm to marine life, tidal flow, recreation and fishing.
9	Pamela Frazier	March 20, 2019	Against	Comment. Environmental degradation. Temporary project. Foreign project. Proposal part of larger extreme environmental destruction. Danger to wildfire and public by way of explosion or leak. Application should be denied.
10	Monique	March 21, 2019	Against	Comment. Puts at risk forests and rivers. Land taken away by a Canadian company. Unethical. Scared land being taken. Does not consent to having pipeline in Oregon.
11	Jennifer and Robert Legate	March 21, 2019	Against	Property, quality of life and enjoyment of area directly impacted. Harm Oregon's water resources, fishing, navigation and recreation. Duplicate facility being built in British Columbia. Home near surveyed pipeline is proposed. Please deny permits to alter estuary.

HEARLEY Henry O

1

From: Jody McCaffree <mccaffrees@frontier.com>
Sent: March 20, 2019 1:29 PM
To: 'Carolyn Johnson'; jodymccaffree@gmail.com
Cc: 'Jim Hossley'; HEARLEY Henry O; CALLISTER Jacob (LCOG)
Subject: RE: Jordan Cove application - new information

If the current updated version is on-line that is all I need to know.

Jody

From: Jody McCaffree [mailto:mccaffrees@frontier.com]
Sent: Wednesday, March 20, 2019 1:25 PM
To: 'Carolyn Johnson'; 'jodymccaffree@gmail.com'
Cc: 'Jim Hossley'; 'Henry Hearley'; 'Jake Callister'
Subject: RE: Jordan Cove application - new information

Is it possible to obtain a copy of code changes that have occurred as of Jan 15, 2019 under Ordinance 508?

Jody

From: Jody McCaffree [mailto:mccaffrees@frontier.com]
Sent: Tuesday, March 19, 2019 12:06 PM
To: 'Carolyn Johnson'; 'jodymccaffree@gmail.com'
Cc: 'Jim Hossley'; 'Henry Hearley'; 'Jake Callister'
Subject: RE: Jordan Cove application - new information

Never mind as I see it is listed on your website as:

> Planners Henry Hearley and Jake Callister have prepared the staff report and are available to accept your written comments at hhearley@lcog.org or jcallister@lcog.org or by US mail at 859 Willamette St #500, Eugene, OR 97401. All written comments will be provided to the Planning Commission and the City Council.
>
> Henry and Jake work for the Lane Council of Governments (LCOG); the City has contracted with LCOG for planning permit processing services related to the project. They can also be reached by phone, Henry is at 541-682-3089 and Jake is at 541-682-4114. Carolyn Johnson, Community Development Administrator, can be reached at 541-269-1181 ex 2287 or cjohnson@coosbay.org.

Jody

From: Jody McCaffree [mailto:mccaffrees@frontier.com]
Sent: Tuesday, March 19, 2019 11:50 AM
To: 'Carolyn Johnson'; 'jodymccaffree@gmail.com'
Cc: 'Jim Hossley'; 'Henry Hearley'; 'Jake Callister'
Subject: RE: Jordan Cove application - new information

Is there an e-mail address that is preferred?

Jody

From: Carolyn Johnson [mailto:cjohnson@coosbay.org]
Sent: Tuesday, March 19, 2019 11:25 AM

To: mccaffrees@frontier.com; jodymccaffree@gmail.com
Cc: Jim Hossley; 'Henry Hearley'; 'Jake Callister'
Subject: RE: Jordan Cove application - new information

Hello Jody,
Emails are welcome.
Carolyn

From: Jody McCaffree <mccaffrees@frontier.com>
Sent: Tuesday, March 19, 2019 10:54 AM
To: Carolyn Johnson <cjohnson@coosbay.org>; jodymccaffree@gmail.com
Cc: Jim Hossley <JHossley@coosbay.org>; 'Henry Hearley' <hhearley@lcog.org>; 'Jake Callister' <jcallister@lcog.org>
Subject: RE: Jordan Cove application - new information

Is it possibly to be given direction on your commenting rules. Can they be electronic or must one provide a hard copy?

Jody

From: Carolyn Johnson [mailto:cjohnson@coosbay.org]
Sent: Friday, February 15, 2019 5:01 PM
To: mccaffrees@frontier.com; jodymccaffree@gmail.com
Cc: Jim Hossley; 'Henry Hearley'; 'Jake Callister'
Subject: Jordan Cove application - new information

Hello Jody,

You can access the Jordan Cove application to the City here: http://coosbay.org/departments/community-development-department. If there are questions feel free to contact
Henry Hearley at hhearley@lcog.org or (541) 682-4283.

When the public hearing notice for the Planning Commission meeting on this project is published, Henry will notify you by e-mail.

Sincerely,

Carolyn

From: Carolyn Johnson
Sent: Monday, January 28, 2019 8:19 AM
To: mccaffrees@frontier.com; jodymccaffree@gmail.com
Cc: Jim Hossley <JHossley@coosbay.org>; 'Henry Hearley' <hhearley@lcog.org>; 'Jake Callister' <jcallister@lcog.org>
Subject: RE: Question RE: Response to Your 1.4.2018, 11.22 AM request regarding the

Here is the application number Jody: 187-18-000153-PLNG-01.

From: Carolyn Johnson <cjohnson@coosbay.org>
Sent: Saturday, January 26, 2019 1:05 PM

To: mccaffrees@frontier.com; jodymccaffree@gmail.com
Cc: Jim Hossley <JHossley@coosbay.org>; 'Henry Hearley' <hhearley@lcog.org>; 'Jake Callister' <jcallister@lcog.org>
Subject: Re: Question RE: Response to Your 1.4.2018, 11.22 AM request regarding the

Hello Jody,
I will get the file number to you on Monday.
Carolyn

Get Outlook for iOS

From: Jody McCaffree <mccaffrees@frontier.com>
Sent: Saturday, January 26, 2019 1:00 PM
To: Carolyn Johnson; jodymccaffree@gmail.com
Cc: Jim Hossley; 'Henry Hearley'; 'Jake Callister'
Subject: Question RE: Response to Your 1.4.2018, 11.22 AM request regarding the

Dear Mr. Hossley and all:

Can anyone tell me if the application that Jordan Cove has filed with the Coos Bay has any kind of File number(s) associated with it?

Thanks,

Jody McCaffree

From: Carolyn Johnson [mailto:cjohnson@coosbay.org]
Sent: Friday, January 04, 2019 1:33 PM
To: jodymccaffree@gmail.com
Cc: Jim Hossley; Henry Hearley (HHEARLEY@Lcog.org); Jake Callister (jcallister@lcog.org)
Subject: Response to Your 1.4.2018, 11.22 AM request regarding the

Hello Jody,

We are glad to provide you with the requested information. Attached please find:

- Estuary Management Plan map

- Estuarine and Coastal Shoreland Uses and Activities chapter from the Coos Bay Municipal Code (attached) This chapter was recently modified but not "codified" thus the strike outs and additions.

- The Jordan Cove Energy project L.P. application for a map amendment for approximately 1.64 acres from 52-NA to DDNC-DA, a comprehensive plan text amendment to take reasons exception to Statewide Planning Goal 16, and an Estuarine and Coastal Shoreline Uses and Activities Permit to allow dredging in DDNC-DA and temporary pipeline in 52-NA, 54-DA, and 55-CA. The City has engaged the Lane Council of Governments to process this application. You may reach LCOG staffer Henry Hearley with questions at hhearley@lcog.org or (541) 682-4283. By way of copy I'm requesting that Henry include your name and contact information on the list of individuals who will be notified of future information and public hearings.

-Comp plan chapter related to the City's Estuary Plan. See http://coosbay.org/government/codes-plans-standards#city-plans for the rest of the Comprehensive Plan.

If there is anything else you need you may contact Henry or his supervisor Jake Callister at jcallister@lcog.org at the number noted above.

Sincerely,

Carolyn Johnson

Carolyn Johnson
Community Development Administrator
City of Coos Bay Oregon 97420
541-267-1181 x2287
cjohnson@coosbay.org

From: Jody McCaffree <mccaffrees@frontier.com>
Date: January 4, 2019 at 11:22:29 AM PST
To: <jhossley@coosbay.org>
Subject: Question regarding Coos Bay Zoning requirements
Reply-To: <mccaffrees@frontier.com>

Dear Mr. Hossley:

Would it be possible to obtain a copy of the City of Coos Bay's Estuary Management Plan zoning requirements or a link to where I can download this document? An electronic copy would be preferred if possible. In addition, if there are any applications or requests that may or may have recently come before the City of Coos Bay with respect to the Jordan Cove Energy Project I would appreciate being notified concerning any of these and given ample time to review the documents. You can send an e-mail under (12MB or less preferably) to jodymccaffree@gmail.com and/or mail me a copy of the notices or information to:

Jody McCaffree
PO Box 1113
North Bend, OR 97459
(541) 756-0759

Please let me know if you will be able to fulfill this request as soon as possible.

Sincerely,

Jody McCaffree

HEARLEY Henry O

2

From: HEARLEY Henry O
Sent: March 20, 2019 10:15 AM
To: 'Jan Hodder'
Cc: Carolyn Johnson
Subject: RE: Information

Hi Jan, I'm not aware of a rezoning associated with the eelgrass mitigation site. Here are responses I got out of your initial question relating to eelgrass:

1) Does the Estuary plan identify eelgrass in the 52NA designation area?

   - Yes, eelgrass beds are identified in the NA-52 Aquatic Unit.

2) If it does, what mitigation is required by the plan for disturbance?

   - Doesn't specify only states " shall be accordingly managed to maintain these resources in their natural condition in order to protect their productivity."

3) If it doesn't, is there language in the Estuary plan requiring a bio study to identify where eelgrass is located and associated mitigations for removal ?

   - There's nothing in the Estuary plan requiring a study or mention of specific mitigation measures to be undertaken. Per Exhibit 5 of the DEA Memo, eelgrass is located to the east of Dredge Area 4, and none would be disturbed by the project (top of page 5 of 13). The temporary dredge line will be suspended where it crosses eelgrass at the entrance to APCO site 2.

Please, let us know if you have any further questions.

Respectfully,

Henry

From: Jan Hodder <jhodder111@gmail.com>
Sent: March 18, 2019 6:08 PM
To: HEARLEY Henry O <HHEARLEY@Lcog.org>
Subject: Information

Henry,
Can you tell me if Coos Bay has received an application from JCEP for rezoning associated with the proposed eelgrass mitigation site in Coos Bay that will require a rezoning of the 52NA designation.
Thank you,
Jan Hodder

HEARLEY Henry O

2

From: HEARLEY Henry O
Sent: March 8, 2019 12:13 PM
To: G-Mail
Subject: RE: CB planning meeting public hearing

Good afternoon Jan,

No, you do not need to be a resident of City of Coos Bay to participate in the hearing on March 21.

Respectfully,

Henry

From: G-Mail [mailto:jhodder111@gmail.com]
Sent: Friday, March 08, 2019 9:57 AM
To: HEARLEY Henry O
Subject: CB planning meeting public hearing

Henry,
Do you need to be a resident of Coos Bay to participate in the March 21 public hearing? I live in the county notthe city.
Thanks
Jan Hodder

HEARLEY Henry O

2

From: Jan Hodder <jhodder111@gmail.com>
Sent: February 12, 2019 3:11 PM
To: HEARLEY Henry O
Cc: Carolyn Johnson
Subject: Re: Follow-up to phone call

63840 Fossil Point Road
Coos Bay
OR 97420

Jan Hodder
541 297 0664

On Feb 12, 2019, at 2:50 PM, HEARLEY Henry O <HHEARLEY@Lcog.org> wrote:

> Hello,
>
> Thank you for your call earlier. You indicated you would like to receive notice of the pending Jordan Cove application, if so, please send me your name and mailing address.
>
> Respectfully,
>
> Henry O. Hearley
> GIS & Planning
> Lane Council of Governments
> 541-682-3089

HEARLEY Henry O

3

From: HEARLEY Henry O
Sent: February 15, 2019 7:43 AM
To: Jamie Fereday
Subject: RE: JCEP

Good morning Jamie,

Sure thing.

Respectfully,

Henry

From: Jamie Fereday [mailto:jsfmcr@frontier.com]
Sent: Thursday, February 14, 2019 8:30 PM
To: HEARLEY Henry O
Subject: JCEP

Hello,

I would like to receive notice of the pending Jordan Cove application, thank you

Jamie Fereday
1017 Elm Ave.
Coos Bay, OR 97420

HEARLEY Henry O

From: Sam Schwarz <chair@coosbay.surfrider.org>
Sent: March 12, 2019 12:50 PM
To: HEARLEY Henry O
Subject: Re: notice

4

Got it. Great! Thanks Henry.

On Tue, Mar 12, 2019 at 12:46 PM HEARLEY Henry O <HHEARLEY@lcog.org> wrote:

> Here you go, Sam.
>
> Respectfully,
>
> Henry

--
Sam Schwarz
Coos Bay Chapter
Surfrider Foundation

HEARLEY Henry O

From: Carolyn Johnson <cjohnson@coosbay.org>
Sent: March 13, 2019 4:52 PM
To: Sarahruthcrawford@yahoo.com
Cc: HEARLEY Henry O; CALLISTER Jacob (LCOG)
Subject: follow up to your phone call today, Jordan Cove application to the City of Coos Bay

5

Hello Sarah,

Information on the Jordan Cove application and Coos Bay Planning Commission staff report for their 03.21 meeting can be found at: http://coosbay.org/departments/community-development-department <https://nam01.safelinks.protection.outlook.com/?url=http%3A%2F%2Fcoosbay.org%2Fdepartments%2Fcommunity-development-department&data=02%7C01%7CHHEARLEY%40Lcog.org%7C932c8bbbb64942e17f3b08d6a80ef11a%7C9a80ddb717904782a634ef32f273169c%7C0%7C0%7C636881179476491179&sdata=FRItA1uHeQlADF6HZjYVKiUVFbSCoMcZAlnyQRCLUOg%3D&reserved=0> .

This is the City's Community Development dept web site, just scroll down to "notable projects" and you'll find the reference to the project, contact info and where to send your written comments.

Thank you,

Carolyn

Carolyn Johnson

Community Development Administrator

City of Coos Bay

500 Central Ave, Coos Bay Oregon 97420

cjohnson@coosbay.org <mailto:cjohnson@coosbay.org>

541-269-1181 ext 2287

HEARLEY Henry O

6

From: CALLISTER Jacob (LCOG)
Sent: March 20, 2019 8:32 AM
To: Deb
Cc: HEARLEY Henry O
Subject: RE: Coos bay/estuary

Good Morning Ms. New,

Your concern is understood. I took no offense at your questioning. It is clear that there are many who care deeply about this matter and it is important that all have an opportunity to weigh in and better understand the core issues.

When I review an application I do my best to approach it objectively. Applicants are required to provide evidence. Many application types (like subdivisions or conditional use permits) require studies, drawings and plans by licensed/certified professionals. Although this comprehensive plan amendment does not carry explicit requirements for such certification, the supporting materials are often generated by certified individuals. We are very mindful of the qualifications of the experts relied upon for the consultant's supporting materials. Generally speaking, the certification/licensing process assures that these firms are not willing to risk their reputation to cater to the desired outcomes of a particular applicant.

Even for larger cities (and particularly for smaller cities) it is impractical for the city to sponsor redundant studies on all related topics. LCOG was hired to review the submitted application. We have performed analysis, asked questions and been skeptical about certain elements of the proposal. Though we have significant experience in natural resources planning, we do not the expertise to independently refute the findings of engineers and biologists from an established firm like David Evans and Associates (DEA).

The public testimony process can reveal alternate perspectives from other expert sources. For example, we have received an item of testimony from a marine biologist in Corvallis who asserts that the impacts to crustaceans in the Bay will be more significant than DEA's findings in Attachment A, Exhibit 5 suggest. This is something that we can bring forward and make sure that the Planning Commission is aware of.

I hope this is helpful.
Feel free to follow up with any other questions.

Jacob L.Callister
Principal Planner
Lane Council of Governments
541-682-4114

From: Deb [mailto:quackerranch@gmx.com]
Sent: Tuesday, March 19, 2019 5:54 PM
To: CALLISTER Jacob (LCOG)
Subject: Re: Coos bay/estuary

Mr. Callister,

Thank you so very much for the clarification on the process. I'm just an ordinary person trying to figure this whole thing out. I'm wanting to make sure things are above board, so far I haven't seen this in our county. I meant no disrespect, I just want facts and not filibuster. So from what I am understanding is that your

conclusions are made by the information that is brought to you. This information that was brought to you was from the applicant, who I'm assuming is either Pembina/Jordan Cove project, and/or the city of Coos Bay planning department and/or council. The conclusions reached by your office therefore are made from information/data/studies from these applicants with a vested interest in the outcome and no third party impartial studies/information, is that correct? Thank you again for your time and responses, I do appreciate it.

6

Debra New

Sent from my iPad

On Mar 19, 2019, at 9:36 AM, CALLISTER Jacob (LCOG) <jcallister@lcog.org> wrote:

> Good Morning Ms. New,
>
> Thank you for your note. We will include your feedback in the record and speak to it at the hearing on Thursday.
>
> From what you have noted you are concerned that LCOG, although hired to provide a non-biased staff report, has not done so, as evidenced by the absence of oppositional conclusions in the staff report we have prepared. Though I will validate our reasoning, I do think your initial response is understandable.
>
> In a land use application, the onus is on the applicant to show consistency with the approval criteria. For this reason, the applicant is required to submit a significant amount of evidence and supporting material to show that their proposal is, in fact, consistent with the criteria. Our staff report uses the applicant's response/evidence as the key object of analysis. Staff have had significant back and forth with the applicant on matters within the application (including the formal "completeness" review process). In instances where criteria are more subjective in nature, we provide an analysis that we hope can be useful for evaluation and we leave to the local decision/policy makers to exercise their subjective decision making authority. We also propose conditions of approval to address, where possible, instances where we feel the application falls short or is unclear about the criteria. We often provide a "staff recommendation," in our staff reports. In this instance we were inclined to provide only our preliminary "conclusion" that the application can meet the criteria with the proposed conditions. It is important to note that the staff report can (and often does) change based on testimony from hearings, written comments and other information relevant to applicable criteria that is contributed while the record is open. These are critical steps in the process.
>
> LCOG is genuinely impartial on the matter. Neither Henry nor I, nor the Lane Council of Governments have any particular interest in the outcome of the application. LCOG is a public agency and we provide planning services to cities both within and outside of Lane County, including many in Douglas County and several in Curry County. It is not uncommon that we are asked to weigh in on more sensitive applications to provide an unbiased perspective, but also just to help over-extended staff on time-consuming applications. We barely cover costs in performing these services. Our mission compels us to help, but we do not seek out this work.
>
> Regarding how we came to work on the application: LCOG was approached by the City of Coos Bay's Community Development Director in December. We have never provided planning services to the City of Coos Bay, and it is entirely possible that we won't do it again any time soon. Neither Henry nor I have

spoken with any City of Coos Bay decision makers until this week (Planning Commissioners) – by way of responding to a few of their questions about the staff report. City of Coos Bay staff have provided no direction and have indicated no preference on the matter.

6

Our previous and current contacts with Pembina/Jordan Cove staff have only been through their representatives (Perkins Coie) and have been focused on details surrounding their current pending application.

I am happy to answer any other questions you have regarding the application.

Have a good day,

Jacob L.Callister
Principal Planner
Lane Council of Governments
541-682-4114

From: Deb [mailto:quackerranch@gmx.com]
Sent: Tuesday, March 19, 2019 8:11 AM
To: CALLISTER Jacob (LCOG)
Subject: Fwd: Coos bay/estuary

Sent from my iPad

Begin forwarded message:

> **From:** Deb <quackerranch@gmx.com>
> **Date:** March 19, 2019 at 7:40:07 AM PDT
> **To:** HEARLEY Henry O <HHEARLEY@Lcog.org>
> **Subject: Re: Coos bay/estuary**
>
> Thank you Mr. Hearley for the information. I guess my last few questions are why would we make decisions based on the "applicants" assessment of the environmental impacts to the estuary, wouldn't those conclusions obviously be in their favor? How about a third party science based study by a local university that has zero interest in the Jordan Cove project? I've read your "impartial third party responses", and have sadly come to the conclusion that you and Mr. Callister are not impartial as every one of your responses favors the dredging near/at the estuary border and/or the Pembina/Jordan Cove project. If you and Mr. Callister we're impartial I would assume there would be at least a couple negative responses along with the positive ones, that's simply common sense. The meeting on Thursday evening is therefore simply for the illusion that ordinary citizens can have any meaningful impact. I'm also curious as to if you or Mr. Callister have had any prior contact and/or personal relationships with any of the Coos Bay city council members, the Coos Bay planning department or Pembina/Jordan Cove project staff. I'm not accusing, I'm just a concerned home owner and citizen of Coos County, wanting to hope that our elected officials and their decisions are based on facts and not for sale to the highest bidder. Thank you for calling me back yesterday I very much appreciated your response. Thank you in advance for

6

any more clarity you could give me.

Sincerely,

Debra New
541-217-0278

Sent from my iPad

On Mar 18, 2019, at 3:08 PM, HEARLEY Henry O <HHEARLEY@Lcog.org> wrote:

> Hi Deborah, certainly.
>
> http://coosbay.org/departments/community-development-department
>
> I've attached the link where you can find the application and staff report (try downloading the file). I've also attached a map showing where the area is located.
>
> The applicant has submitted an assessment of environmental impacts that is included as Exhibit 5.
>
> Let me know if you have any other questions.
>
> Respectfully,
> Henry
>
> -----Original Message-----
> From: Deb <quackerranch@gmx.com>
> Sent: March 18, 2019 3:01 PM
> To: HEARLEY Henry O <HHEARLEY@Lcog.org>
> Subject: Coos bay/estuary
>
> Hi, I was wondering about any information you may have as to the location of the zoning that will be changed for the Jordan cove pipeline from estuary to improved ? Unsure as to the exact terminology used, but was interested in the place say on a map of the bay, also the science behind doing this and how much if any

damage it would do to the estuary itself. Just a concerned citizen, I live here. Thank you for your help.

6

Debra New

Sent from my iPhone

<Fig 1 CBEMP Zoning NRI Dredge Area 4.pdf>

HEARLEY Henry O

7

From: Sylvia Yamada <yamadas@science.oregonstate.edu>
Sent: March 20, 2019 8:27 AM
To: HEARLEY Henry O
Subject: RE: Impact of dredging on Dungeness crabs

Henry,
Thanks.
Syvlia

From: HEARLEY Henry O <HHEARLEY@Lcog.org>
Sent: Wednesday, March 20, 2019 8:22 AM
To: Sylvia Yamada <yamadas@science.oregonstate.edu>
Subject: RE: Impact of dredging on Dungeness crabs

Sylvia,

Thank you for your comments. We will add it to the record. We'll bring a copy of your testimony to the hearing tomorrow. Following the hearing we'll incorporate comments received after the staff report was first published last week in preparation for the next hearing in front of City Council.

Thank you.

Respectfully,
Henry

From: Sylvia Yamada <yamadas@science.oregonstate.edu>
Sent: March 20, 2019 7:59 AM
To: HEARLEY Henry O <HHEARLEY@Lcog.org>
Subject: Impact of dreging on Dungeness crabs

Dear Mr. Hearley

I have been studying crabs in Oregon estuaries, including Coos Bay, for over 20 years. My study sites include Jordan Cove and Russell Point, below McCullough Bridge (see size graph of sub-market size Dungeness crabs in attached document). I am concerned that the construction of the Jordan Cove Energy Project could impact important habitats for native species, including the Dungeness crab. The Dungeness crab fishery is the most valuable commercial fishery in Oregon. In a good year, landings yield $100 million to the Oregon economy. The highest numbers of juvenile crabs are found in soft sediments and eel grass beds of estuaries. This is where the young crabs find food and shelter from predators. In my study site along Trans Pacific Parkway, I have consistently

trapped an average of 15 young Dungeness crabs per trap. The importance of this nursery habitats has to be kept in mind when 1) a trench is dug In Haynes Inlet, 2) the Trans Pacific Parkway is expanded and 3) an upland area is cut out to create a berth for ocean-going vessels.

Not only will the turbidity during the construction phase be of concern to the ecological community, the on-going dredging to maintain the berth and shipping channels will continue to be a disturbance to the ecosystem. In a study, designed to simulated a dredging operation, between 45 to 85 % of the Dungeness crabs died. In summary, construction and maintenance of the Jordan Cove LNG Terminal will result in habitat loss for native species, including nursery habitat for the valuable Dungeness crab.

Sylvia Yamada PhD

3062 NW Snowberry Place

Corvallis, OR 97330

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Potential Impact of Jordan Cove LNG Terminal construction on the Nursery Habitat of the Dungeness crab.

Salem, Oregon, January 14, 2019

Sylvia Yamada Ph.D.
yamadas@science.oregonstate.edu

The **Dungeness crab** (***Cancer magister***) supports an important commercial and sport fishery from Alaska to California. Total annual landings in recent years exceeded 25,000 tons (55 million pounds) (FAO statistics, 2012). In Oregon, the 2014 Dungeness fishing season yielded 14.4 million pounds, $50 million to crabbers and an estimated $100 million to the Oregon economy (Oregon Dungeness Crab Commission in Fisherman's News On line). *The Dungeness fishery is the most valuable commercial fishery in Oregon (Rasmusen 2013).*

The life cycle of Dungeness crab is complex, depending on both estuarine and near-shore habitats. Typically, mating occurs in shallow water, and females migrate offshore to brood and hatch their eggs. The early larval stages feed and rear in the near-shore water column, after which the final larval stage rides tidal currents back to shore and settles out in shallow estuarine habitats. The final larval stage molts into a ~5 -7 mm wide first crab stage. *The highest densities of juvenile Dungeness crabs are found in estuaries, which provide warm water, high biological productivity and protection from predators. Sand substrate and eelgrass beds are preferred habitat for these young crabs, which bury in the sand and hide in the eelgrass to escape predators.* Size measurements of crabs trapped at Russell Point in Coos Bay (below the Highway 101 McCullough Bridge) show that Dungeness crabs in their first two years of life (100 mm carapace width and smaller) are extremely abundant in the mid-to low intertidal areas such as pools and eelgrass beds (Figure 1).

In my research documenting the status of the non-native European Green crab in Coos Bay, I encounter young Dungeness crabs in all my study sites. I selected a sub-set of my sites closest to the proposed Jordan Cove Energy Project: the north and south sides of Trans Pacific Lane and the beach adjacent to the Roseburg Forest Product watchman's booth. The results from over 600 trap-days, show that young Dungeness crabs are consistently abundant from 2002 to 2014 at all sites, with an average catch of 15 per trap (Table 1). *These trapping results confirm the findings by Emmett and Durkin (1985) that estuaries are important nursery habitats for Dungeness crabs. This fact has to be kept in mind when a trench is dug In Haynes Inlet, the Trans Pacific Parkway is to be expanded and an upland area is cut out to create a berth for ocean-going vessels. Not only will the turbidity during the construction phase be of concern to the ecological community, the on-going dredging to maintain the berth and shipping channels will continue to be a disturbance to the ecosystem. It will result in habitat loss for native species, including the valuable Dungeness crab. In one study between 45 to 85 % of the Dungeness crabs died during a simulated dredging operation (Chang and Levings, 1978).*

Sylvia Yamada is a marine ecologist who has studied native crabs and the invasive European green crab in Oregon and Washington for over 20 years.

References:

Chang, B., Levings, C. 1978. Effects of burial on the heart cockle *Clinocardium nuttalii* and the Dungenes crab *Cancer magister. Estuarine, Coastal and Shelf Scie*nce. 7, 4009-412.

Emmett, R.L. and Durkin, J.T. 1985. The Columbia River Estuary: An Important Nursery for Dungeness Crabs, *Cancer magister. Marine Fisheries Review.* 47(3), 21-25.

Fisherman's News On line Sept 24, 2014 http://fnonlinenews.blogspot.com/2014/09/oregons-crabbers-riding-market-value.html

Rasmuson, L.K. 2013. The Biology, Ecology and Fishery of the Dungeness crab, *Cancer magister.* In Michael Lesser, editor: *Advances in Marine Biology*, Vol 65, Burlington: Academic Press, pp. 95-148. ISBN: 978-0-12-410498-3 Elsevier Ltd. Academic Press.

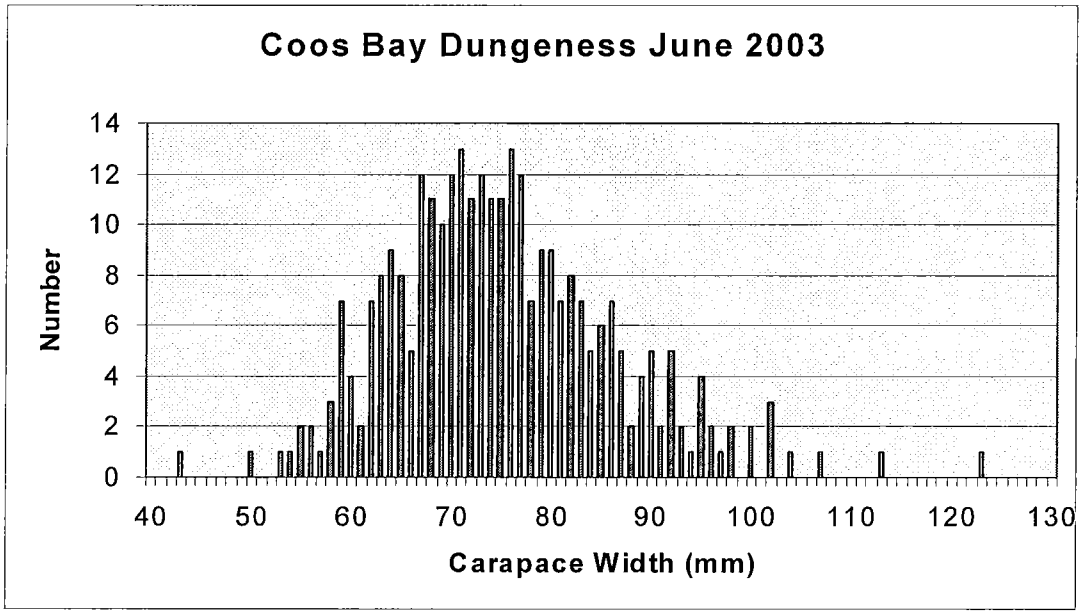

Figure 1. Size frequency distribution of Dungeness crabs trapped in pools and eelgrass at Russell Point, below the Highway 101 McCullough Bridge, in June 2003. Adult crabs are greater than 100 mm in carapace width. It is estimated that the first 2 year classes are represented.

Table 1. Trapping Data for study sites along Trans Pacific Lane and Roseburg Forest Product causeway from 2002-2014.

	Date	Trap Type	Zone	European green crab *Carcinus maenas*	Hairy shore crab *Hemigrapsus oregonensis*	Purple shore crab *Hemigrapsus nudus*	Dungeness crab *Cancer magister*	*Cancer magister* (Recruits <50mm)	Red rock crab *Cancer productus*	stag-horn sculpin	# Traps
Roseburg Lumber	6/25/2002	Fish	Site	0	0	0	45	0.5	0.1	0	10
Roseburg Lumber	6/16/2003	Fish	*low*	0	0	0	12.2	0	0.7	1.5	10
TransPacific S	7/10/2005	Fish	*low*	0	0	0	6.14	1.14	0	1.86	7
North	7/10/2005	Fish	*low*	0	0	0	0	5.7	0	1.1	10
South	3/25/2005	minnow	*Mid*	0	0	0	0	0	0	2.4	10
North	7/10/2005	minnow	*mid*	0	0.2	0	0	0.6	0	0.8	5
South	7/10/2005	minnow	*mid*	0	0	0	0	0.4	0	0.6	5
Trans-Pacific Bridge	9/1/2005	Fish	*Low*	0	0	0	6.6	0	3	1	5
	9/1/2005	Minnow	*high*	0	0	0	0.2	0	0	0.4	4
Trans-Pacific Ln.	6/8/2006	Fish	*Low*	0	0	0	4.9	0	0	2.6	10
	9/13/2006	Fish		0	0.4	0	0.2	0	0	0.2	5
	6/8/2006	Minnow	*high*	0	0	0	0.7	0	0	2.3	10
Trans Pacific Br.	9/13/2006	Minnow		0.2	0	0	0	0	0	0.2	5
TransPacific Ln. N	5/25/2007	Fish	Mid	0.5	0.2	0	1	0.1	0	0.8	10
	7/14/2007	Fish		0.4	1.47	0	23.53	0	0	0.2	15
	9/26/2007	Fish		0	0	0	4.75	0	0	0	8
TransPacific Ln. S	5/25/2007	Fish	Mid	0.09	0	0	0.82	0	0	0.36	11
	7/14/2007	Fish		0.27	0.07	0	9	0	0.07	1	15
	9/26/2007	Fish		0	0	0	2.71	0	0	0.14	7
TransPacific Bridge	5/25/2007	Fish	Mid	0	0	0	1.33	0	0	0	6
	9/25/2007	minnow	high	0	0	0	1.6	0	0	0.4	5
TransPacific Ln. N	6/18/2008	Fish	Mid	0.1	0.2	0	7.4	0	0	7.8	10
	6/19/2008	Fish		0	0	0	1.75	0	0	3.25	8
	9/18/2008	Fish		0	0.1	0	23.4	0	0	0.7	10
TransPacific Ln. S	6/18/2008	Fish	Mid	0.5	0	0	17.2	0	0	2.2	10
	6/19/2008	Fish		0.37	0	0	17.63	0	0	1.37	8
	9/18/2008	Fish		0.1	0	0	22.6	0	0	0.3	10
TransPacific Ln. N	7/8/2009	Fish	Mid	0.13	0	0	9.88	0	0	0.38	8

	7/9/2009	Fish		0.1	0.2	0	11.3	0	0	0.3	10
	07/0/09	Fish		0.1	0	0	11.7	0	0	0.5	10
TransPacific Ln. S	7/8/2009	Fish	Mid	0	0	0	24.38	0	0	0.25	8
	7/9/2009	Fish		0.1	0	0	30.2	0	0	0.9	10
	7/10/2009	Fish		0.4	0	0	16.6	0.1	0	0.5	10
	7/11/2009	Fish		0.4	0	0	13.1	0	0	2.7	10
TransPacific Ln. N	3/19/2010	Fish	Mid	0	0.4	0	0.7	0	0	0	10
	3/20/2010	Fish		0	0.1	0	0.1	0.2	0	0	10
	3/21/2010	Fish		0	0.3	0	0.3	0.4	0	0	10
	6/25/2010	Fish		0	0	0	35.7	0	0	1.1	9
	6/26/2010	Fish		0	0	0	75.9	0	0	0.4	10
TransPacific Ln. S	3/19/2010	Fish	Mid	0	0	0	1.9	0.9	0	0	10
	3/20/2010	Fish		0.1	0	0	1.7	0	0	0	10
	3/21/2010	Fish		0	0	0	2.5	0.1	0	0	10
	6/25/2010	Fish		0	0	0	90.6	0	0	0	10
	6/26/2010	Fish		0	0	0	69.9	0	0	1.6	20
TransPacific Ln. N	7/17/2011	Fish	Mid	0	0.6	0	4.73	0.27	0	0.73	15
	10/17/2011	Fish		0	0	0	5.3	0	0	0.2	10
TransPacific Ln. S	7/16/2011	Fish	Mid	0.03	0.09	0	1.5	0.06	0	1.53	34
	7/17/2011	Fish		0	0.13	0	2.07	0.47	0	1.2	15
TransPacific Ln. N	6/27/2012	Fish	Mid	0	0	0	89.2	0	0	0.4	5
TransPacific Ln. S	6/25/2012	Fish	Mid	0	0	0	9.75	0	0	0.75	12
	6/27/2012	Fish		0.11	0	0	5.2	0	0	0.67	9
TransPacific Ln. S	3/22/2013	Fish	Mid	0	0	0	1.75	0	0	0	20
	3/23/2013	Fish		0	0	0	6.79	0	0	0	19
	7/12/2013	Fish		0	0	0	7.37	0	0	1.6	30
	7/13/2013	Fish		0	0	0	5.24	0	0	1.48	25
TransPacific Ln N	7/12/2014	Fish		0	0	0	40.33	0	0	0.5	12
	7/13/2014	fish		0	0	0	24.9	0	0	0.4	12
TransPacific Ln. S	7/12/2014	Fish		0	0	0	47.27	0	0	0	15
	7/13/2014	fish		0	0	0	23.83	0	0	0	12
Average				0.068	0.075	0	14.955	0.067	0.065	0.874	
Total # Traps											649

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HEARLEY Henry O

From: Heike-Marie Eubanks <heikemarieeubanks@gmail.com>
Sent: March 20, 2019 1:48 PM
To: HEARLEY Henry O
Subject: Coastal Management Permit for Jordan Cove Natural Gas Facility.

I would like to state my opposition to any permits or zoning changes to accommodate the Jordan cove facility. The dredging would severely effect marine life and tidal flows. Contaminated sludge would be newly exposed to cause further harm. It would adversely effect fisheries and boating in the channel and recreation. Please enter my comments into the official records. Thank you

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HEARLEY Henry O

From: HEARLEY Henry O
Sent: March 20, 2019 3:53 PM
To: 'Pamela'; CALLISTER Jacob (LCOG)
Cc: 'Carolyn Johnson'
Subject: RE: Thoughts re: hearing on Pembina application

Good afternoon Ms. Frazier,

Thank you for your comments. I will add them to the record.

Respectfully,

Henry

From: Pamela <pamfrazier@hotmail.com>
Sent: March 20, 2019 3:50 PM
To: HEARLEY Henry O <HHEARLEY@Lcog.org>; CALLISTER Jacob (LCOG) <jcallister@lcog.org>
Subject: Thoughts re: hearing on Pembina application

Greetings,

I am emailing because I will not be able to attend in person the hearing to formulate recommendations to the City Council concerning Pembina's application for to alter the Coos Bay Estuary. I am sending my testimony/thoughts in writing in advance instead.

As a local professional and homeowner, I sincerely hope that the application will be denied. There is nothing more important than protecting and preserving our natural environment. The beauty and rural nature of the natural environment in Coos County is a big part of why I enjoy living here. And in the era of climate change and mass environmental destruction, there is no excuse for gratuitous environmental degradation just to create temporary jobs and a boom-bust economy. We know that the reality is that in the end we get left with the mess of a temporary project and the proceeds go to a foreign corporation. We must not be shortsighted. On top of that, if we allow this project to go forward, we put ourselves and our local wildlife in very real danger of physical harm by way of explosion or leak. This application to alter the estuary is part of a bigger picture of extreme environmental destruction which will bring permanent devastation and only temporary gain, most of which won't be ours anyway.

For these reasons, I hope the recommendation to City Council will be that the application should be denied and the Coos Bay Estuary should not be subject to the alteration that Pembina wants.

Thank you.

~ Pam Frazier

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HEARLEY Henry O

From: HEARLEY Henry O
Sent: March 21, 2019 7:44 AM
To: 'monique'; CALLISTER Jacob (LCOG)
Cc: 'Carolyn Johnson'
Subject: RE: Concerning the Pembina pipeline

Good morning Monique,

Thank you for your comment. I will included it in the record.

Respectfully,

Henry

-----Original Message-----
From: monique <monique.wootwoot@gmail.com>
Sent: March 20, 2019 11:57 PM
To: HEARLEY Henry O <HHEARLEY@Lcog.org>; CALLISTER Jacob (LCOG) <jcallister@lcog.org>
Subject: Concerning the Pembina pipeline

Hi there,

This letter is to address my concerns as a citizen regarding the Pembina pipeline. I wanted to express as a citizen of Oregon that I am deeply concerned with pipeline being put in as it would effect thousands of citizens and potentially put miles of our beautiful forests and rivers at risk. The idea that people may be taken away from their land and their homes so that a Canadian company can make millions of dollars off our land is unethical. This land is sacred to those of us who live here and I would do anything to protect it. It is wrong to let the interest of a corporation go against the wishes of the citizens of Oregon. I absolutely do not consent to having the pipeline put in here in Oregon and I know I share this view with thousand of other citizens. Thanks for your time, I hope you make the decision to keep our land ours and not the property of a corporation.
Sincerely, Monique

Jennifer and Robert Legate
93376 Hillcrest Lane
North Bend, OR 97459

February 2, 2019

Coos Bay Planning Commission and Coos Bay City Council
C/O hhearley@lcog.org and jcallister@lcog.org

Re: **Pembina Application to alter the Coos Bay Estuary**

We strongly oppose the issuing of permits for Pembina to alter the Coos Bay Estuary as part of the Jordan Cove liquid natural gas plant as homeowners whose property, quality of life, and enjoyment of the area's recreational opportunities would be directly impacted. It is our view that the proposed activities will harm Oregon's water resources, fishing, navigation, and public recreation as well as increase risks to public health and safety. We do not believe that the project has a goal of conservation, protection, or best use of Oregon's waters, and it will adversely impact water resources in the area.

With Shell Petroleum announcing they are putting $40 billion into building an LNG export facility in Kitimat, British Columbia on which ground has already been broken, we wonder why a duplicative effort is needed here. That facility will export directly to Asia, thus competing with Jordan Cove. With ground already being broken on the Kitimat, BC project, there is no need to put Oregon's waterways, estuaries, and forests at risk. This is a bad business move that will leave the taxpayers of Coos County responsible for clean-up costs should Pembina decide to pull out of the project due to profit concerns.

We have a home very near where workers have been surveying an area to build the pipeline. We are within range of the hazardous burn zone that could occur if there were an accident at the plant or a tsunami-related explosion. The area is considered wilderness and the community is considered "rural", so the quality of the pipeline being proposed is of lower safety standards than would be required in a high-density population area. Any changes to the estuary will be devastating to the plants and animals that thrive at and depend on the bay. We moved to this area for its natural beauty, opportunities to hike and enjoy the forest and marine life that currently abounds. There is a national Sand Dunes park next to the proposed site of the plant, and currently people come from all around the country to enjoy its beauty. It is difficult to imagine that anyone would want to engage in recreational activities next to an LNG plant.

Construction of the LNG export terminal and the 229-mile pipeline would impact more than 485 rivers and streams, harming habitat for fish and polluting clean water. The project would also require dredging out and fundamentally re-shaping the Coos Bay estuary. We are deeply concerned that dredging the Coos Bay for LNG ships to enter the harbor would increase risks to our community for a tsunami. There is a bar from the harbor to the ocean that boats must cross in high tide only, and it is already a dangerous crossing in inclement weather. Given the size and security issues that accompany LNG ships, we are concerned that fishing and recreational boating would be necessarily curtailed or severely limited.

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In addition, many of the forests that would be impacted by the pipeline have been in drought conditions for the past several years. A pipeline increases the risks of fires such as those seen in California this past year. Rather than increasing those risks, Oregon and Coos County should be doing what it can to prevent them.

In summary, being born and raised in Oregon, and knowing the people of Oregon, slamming a fossil fuel pipeline through the forests of Oregon, under the rivers of Oregon, and over the mountains of Oregon is so contrary to Oregon's values and the culture of our State. This is not who we are.

Please deny the permits to alter the Coos Bay Estuary and keep our community and its waterways and forests safe from the harm that the LNG project will naturally cause.

Sincerely,

Jennifer and Robert Legate

James Fereday
1017 Elm Ave.
Coos Bay, OR 97420

March 19, 2019

Concurrent Land Use Applications by Jordan Cove Energy Project L.P.
Coos Bay Estuary Navigation Reliability Improvements
City of Coos Bay File Nos. -

Dear Hearings Officer:

Please accept these comments to be included in the evidentiary record

I am a resident of Coos Bay and a retired public school science teacher, having worked in the CB school district for 24 yrs. Over that time, I have witnessed many changes to our local area, in particular, the Coos Estuary. I was involved in a land use plan amendment to build The Millicoma Marsh Trail to access a Natural Aquatic zone of the Coos Estuary, the W-shaped salt marsh in Eastside. The resulting trail allows students and residents to view a remnant of our natural wetland resources, of which, nearly 90% have been destroyed or altered in this estuary. In addition to providing economic, cultural and ecological benefits to communities, estuaries deliver invaluable ecosystem services, which are are fundamental life-support processes upon which all organisms depend, such as water filtration and habitat protection (https://oceanservice.noaa.gov/education/kits/estuaries/estuaries03_ecosystem.html).
The Jordan Cove Energy Project and Pacific Connector Pipeline is threatening to add to this negative legacy, both above and below tidal extremes. The current proposed amendment to the Coos Bay Estuarine Management Plan (CBEMP) by the applicant is just one of many components of this project that concerned citizens must address. The Coos Bay Estuary Management Plan "contains specific plan provisions - map decisions and written policies - that are designed to provide guidance necessary to assure wise use of the Coos Bay Estuary and adjacent shorelands."

The applicant, Jordan Cove Energy Project, proposes dredging at four locations in the Coos Bay channel. Among the dredging sites, referred to as Navigation Reliability Improvements (NRIs), three are within Coos County and one (NRI #4) is within the City of Coos Bay. The applicant is proposing the following:

(1) A map amendment to the Coos Bay Estuary Management Plan to change the designation of approximately 3.3 acres from 52-NA to DDNC-DA;
(2) A text amendment to the City of Coos Bay Comprehensive Plan to take a reasons exception to Statewide Planning Goal 16 Estuarine Resources to authorize the map amendment;
(3) An estuarine and coastal shoreline uses and activities permit for "New and Maintenance Dredging" in the DDNC-DA Estuarine Zone; and

(4) An estuarine and coastal shoreline uses and activities permit to allow an accessory temporary dredge transport pipeline in the 52-NA, 53-CA, 54-DA, and 55-CA Estuarine Zones.

NRI #4 is zoned 52-NA, Natural Aquatic. **Natural Aquatic zones explicitly prohibit dredging.** Natural aquatic zones are established in order to assure the protection of significant fish and wildlife habitats. Amendments to this designation should only be performed with strict adherence to the original goal of the zoning. In my judgement, this project is not worthy of such a change, as the applicant has not adequately shown a demonstrated need for the proposed activity.

The applicant bases the zoning change request in part on Oregon's Statewide Planning Goals & Guidelines #9 and #12, Economic Development and Transportation. These are the goals I will address in my comments.

Goal 9: Economic Development
To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.
Applicant's response:
The Application complies with Goal 9. The purpose of the Application is to complete the NRIs, which in turn will facilitate a broader operational window, and increase safety and efficiency of transit, in the Channel. This will be a boon to the economic prospects for the City and the state because it will make the Channel safer and more efficient for productive economic enterprises of the kind that provide opportunities to Oregonians.

Goal 12: Transportation
To provide and encourage a safe, convenient and economic transportation system.
Applicants response:
The Application complies with Goal 12. Goal 12 directs local governments to plan transportation systems that consider all modes of transportation, including water, that facilitate the flow of goods and services so as to strengthen the local and regional economy, that conserve energy, and that avoid principal reliance on one mode of transportation. The Application furthers these goals by supporting safer and more efficient use of the Channel for water transportation. This safer and more efficient use of the Channel will conserve energy that is currently wasted when, outside the Channel's operational window, vessels wait outside the Channel, using fuel and adding time and expense to transit.

The applicant shows little if any justification of measured increase in safety as well as projecting an inflated boost to commerce. In addition, the proposed dredging will result in added environmental, economic, and recreational degradation to an already degraded estuarine system.

Historically, Coos Bay has been busier, mainly with extractive industries like coal, timber and lumber exports. The export of those commodities will not again reach the rate they were in the last century. Container ships and bulk carriers of the Panamax size suggested by the applicant will unlikely come to Coos Bay as our rail and trucking capacity is less than robust to deliver goods to or from the port. The channel now serves a reasonable size of bulk and timber ships. Most bulk carriers are well within the size appropriate to our bay, should there be an increase in shipping.

In the zoning change application, JCEP asserts that:
The NRIs will allow companies to secure emerging opportunities to export products with today's larger vessels, including bulk carriers of up to 299.9 meters (983.3 feet) in length and 49 meters (160.8 feet) in beam and 11.9 meters (39 feet) in draft. Although log export vessels serving the upper bay are smaller, the proposed enhancements also benefit these vessels by broadening the tidal and environmental windows for transiting the Channel, providing an enhanced margin of safety and improved efficiency in the loaded vessel departure schedule.

The U.S. Coast Guard has already approved for safe passage LNG vessels up to 299.9 meters. According to the Coast Guard, "At this point, the waterway can accommodate the types of vessels associated with the proposed Jordan Cove LNG facility. We are working together to make sure that any resource issues are resolved through the Emergency Response Planning Process." https://coastguardnews.com/coast-guard-releases-jordan-cove-lng-letter-of-recommendation/2018/05/11/

The issue of safety begs the question of whether there has there been, in the past 40 years, significant shipping related incidents within the bay/channel? The only one I remember was when a ship hit the McCullough Bridge in 1986 - and this was not an issue with the width or depth of the channel. The applicant has included letters of support from the Coos Bay Pilots Association and Roseburg Forest Products Co. but neither has offered data to substantiate their claims of increased safety. Typically, data on incidents point to a problem. It is akin to highway safety where a road has segments which are problematic and incident records will drive improvements. I have contacted the Coast Guard with a request for information but have not received it as yet. Does JCEP have this information?

Further, the applicant has stated that they would be unable to reach their total capacity if unable to dredge the selected segments in the bay channel. The applicant states:
This dredging will allow for vessel transit under a broader weather window to enable JCEP to export the full capacity of the optimized design production of 7.8 metric tonnes per annum ("mtpa") from JCEP's liquefied natural gas ("LNG") terminal on the nearby North Spit.
From their removal and fill application, the applicant states:

Modeling showed that without the NRIs in place, the greater delays imposed by the Pilots on LNG ship transits of the channel due to environmental conditions would result in a potential annual loss of production at the facility equal to about 38,000 tonnes of LNG.
If you the math, dredging of the channel shows that it would only increase the output of the terminal by 0.48%, barely a half percent. The shipping channel exists as a safe and adequate channel and does not warrant the permanent removal of an important segment of our lower bay ecosystem.

In light of the fact that JCEP has not sufficiently addressed the statewide planning goals and has not demonstrated a need for the zone changes, I respectfully suggest that the 52-NA designation of the Coos Bay City parcel remain unchanged and enforced and this application be denied.

James Fereday

Include in Record
Individual will provide oral testimony
L823 03/21/18
Huy

March 21, 2019

Coos Bay Planning Commission

RE: 187-18-00153 (CC am18-011)

Dear Commissioners,

You are faced with a monumental task of reviewing a "comprehensive plan amendment" even before the comprehensive plan is approved. No wonder it seems impossible, because it is.

This is simply a ploy to rezone 3.3 miles of Natural Aquatic out of its protective status under State Goal 16 so the Applicant can destroy current habitat and inhabitants. As with the project north of Mc Cullough Bridge, not even a simple study was done by the applicant, which would have revealed required mitigation for the displaced lives. What have they done to show you what they are destroying in this 3.3 miles?

The Applicant has simultaneously thrown applications into different courts for decisions in a vacuum but subject is not only interdependent but completely dependent on FERC. Perhaps you should follow Department of State Lands and defer your decision until the FERC determines the route, if any, through our estuary. Also pending, is the approval of the Port's drastic dredging.

You will hear an abundance of reasoning why this violates the spirit of the law and a threat to our estuary and to us, living and enjoying a wonderful habitat, so I will forgo the subject and concentrate the Applicant's words and promises.

They said they would take the dredge spoils out of the area yet have committed to plan only a small portion of the 7.5 cubic yards of dredge spoils (26 football

fields stacked 100 feet) to a couple parcels along the river by the bridge that they bought, but also plan to use it for the pipeline, and the overused Kentuck. Both areas are in first reach of the tsunami and the spoils will suffocate the estuary. And this does not include the spoils from the tunnel under the bay, which is phenomenal but not accounted for by the Applicant but was researched by Natalie Ranker which she will share. Please get a written account of dredge spoils and the disposition of.

In closing, I wonder if you got that 110-120 ships will be coming each year. With only 356 days per year, that mean every third day we will have our river plugged up with the passage of LNG. Can we endure that? Incidentally, they will construct a "lay berth" for repairs, etc. but they will tell you about it**, after** the permitting process! Better make them cough it up in the **comprehensive plan.**

Yours truly,

Jan Dilley

1223 Winsor Ave

North Bend OR 97459

541 756-4802

Janyce.dilley@frontier.com

Janet Hodder Ph.D.
63840 Fossil Point Road
Coos Bay
OR 97420

March 18, 2019

Concurrent Land Use Applications by Jordan Cove Energy Project L.P.
Coos Bay Estuary Navigation Reliability Improvements
City of Coos Bay File Nos. ____ _

Dear Hearings Officer:
Please accept these comments from Dr. Janet Hodder to be included in the evidentiary record for the application from Jordan Cove Energy Project (JCEP) to the City of Coos Bay which includes:

1) Map Amendment to the Coos Bay Estuary Management Plan (CBEMP) to Change the Designation of Approximately 3.3 Acres from 52-NA to DDNC-DA;
(2) Text Amendment to the City of Coos Bay Comprehensive Plan to take a Reasons Exception to Statewide Planning Goal 16 to Authorize this Map Amendment;
(3) Estuarine and Coastal Shoreline Uses and Activities Permit For "New And Maintenance Dredging" in the DDNC-DA Estuarine Zone; and
(4) Estuarine and Coastal Shoreline Uses and Activities Permit to Allow an Accessory Temporary Dredge Transport Pipeline in the 52-NA, 53-CA, 54-DA, and 55-CA Estuarine Zones and an Accessory Buoy in the 52-NA Estuarine Zone.

COMMENTS ON THE NAVIGATION RELIABILITY IMPROVEMENT #4

The NRI 4 site is currently zoned 52-NA (a natural aquatic unit) which does not allow for dredging. The applicant seeks to amend the Coos Bay Estuary Management Plan to rezone to apply a DDNC-DA (a development aquatic) management unit to the NRI 4 site in order to allow dredging.

The applicant's response to several State wide planning goals are insufficient. OAR 660-004-0022(1)(a) requires the Applicant to establish a "demonstrated need" for the proposed use or activity based on the requirements of one or more of Oregon Statewide Planning Goals 3 to 19. The Applicant asserts the "demonstrated need" for the NRIs is based primarily on Goals 9 (Economic Development) and 12 (Transportation).

GOAL 9: ECONOMIC DEVELOPMENT.
To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.
***APPLICANT'S RESPONSE**: The purpose of the Application is to complete the NRIs, which in turn will facilitate a broader operational window, and increase safety and efficiency of transit, in the Channel. This will be a boon to the economic prospects for the City and the state because it will make the Channel safer and more efficient for productive economic enterprises of the kind that provide opportunities to Oregonians.*

AND

GOAL 12: TRANSPORTATION.
To provide and encourage a safe, convenient and economic transportation system.
***APPLICANT'S RESPONSE**: Goal 12 directs local governments to plan transportation systems that consider all modes of transportation, including water, that facilitate the flow of goods and services so as to strengthen the local and regional economy, that conserve energy, and that avoid principal reliance on one mode of transportation. The Application furthers these goals by supporting safer and more efficient use of the Channel for water transportation. This safer and more efficient use of the Channel will conserve energy that is currently wasted when, outside the Channel's operational window, vessels wait outside the Channel, using fuel and adding time and expense to transit.*

There are several pieces of evidence provided in the application that do not support the need for dredging the NRI4 area to make the channel safer, or more convenient, or more efficient. Page 4 of the application, when referring to the NRIs states, "*Notably, these improvements have been identified by the USCG as a required navigation risk mitigation measure for the JCEP terminal operations. See Letter of Recommendation from USCG dated May 10, 2018 in Exhibit 4.*" There is no evidence for such an identification by the USCG as to risk mitigation measure in the application. Exhibit 4 has three incidences where the US Coast Guard equivocally states that the current Coos Bay Channel is adequate for the proposed LNG ship transit.
They are:

1. The Coast Guard Letter of Recommendation to FERC signed by USCG Captain W.R. Timmons, dated May 10, 2018 in response to JCEP's Letter of Intent and based on the comprehensive review of JCEP's Waterway Suitability Assessment (WSA). It states, *"I recommend the Coos Bay Channel be considered suitable for LNG marine traffic".* This letter is appended as a reference.

2. A subsequent letter to Jordan Cove Energy project dated November 7, 2018 from USCG Commander J. C. Smith, Captain of the Port, Sector Columbia River documenting that simulated transits by Coos Bay pilots demonstrated that they could safely and successfully maneuver LNG carriers up to 299.9 meters (983.3 feet) in length and 49 meters (160.8 feet) in beam and 11.9 meters (39 feet) in draft. This is the proposed size of the LNG ships that will call at the JCEP terminal. This letter is appended as a reference.

3. An analysis supporting the letter of recommendation issued by COTP sector Columbia River on May 10, 2018. In this analysis a WSA team, which included several Coos Bay based participants, met in Coos Bay on November 1, 2017 to analyze the suitability of the Coos Bay Channel to support marine traffic. The results of this meeting are included as a supplement to the aforementioned Captain of the Port's May 10, 2018 recommendations. This analysis states on Page 9 of Exhibit 4 in the Coos Bay City application, *"Based on my review of the completed on November 1, 2017, and input from state and local port stakeholders, and taking into account previously reviewed expansion projects, I recommend to the Federal Energy Regulatory Commission that the waterway in its current state be considered suitable for the LNG marine traffic associated with the proposed project."*

Additionally, two other documents produced by JCEP have information pertinent to the adequacy of the current Federal Navigation Channel. Page 24 of Resource Report 11 for the JCEP terminal project submitted to the Federal Energy Regulatory Commission in Docket No. PF17-4-000 dated May 2017 states," *The LNG Transit Management Plan will establish a specific set of weather conditions during which the entry or departure of LNG carriers will not be allowed. JCEP has determined, with the assistance of the local harbor pilots that these conditions occur approximately* ***10 days per year*** *and when these conditions do occur, they are only in place for a period of approximately 12 hours.*

The clear majority of these conditions is caused by ebb tides and last a short duration." Page 24 of Resource Report 11 for the JCEP terminal project submitted to the Federal Energy Regulatory Commission in Docket No. PF17-4-000 dated May 2017 is appended as a reference.

The applicant recently (November 7, 2018) submitted a joint permit request to the Oregon Department of State Lands (DSL) and the US Army Corps of Engineers (ACE), who have yet to rule on the permit request. Page 2 of this permit provides further information from JCEP that refutes the "demonstrated need" for the Navigation Reliability Improvements. It notes that the Navigation Reliability Improvements were determined to be necessary by the 2015 Asian customers. This fails to demonstrate Goal 9's requirement that the economic activities are vital to the health, welfare, and prosperity of **Oregon's** citizens.

Further the JCEP DSL/ACE permit request on page 2 also states," *Modeling showed that without the NRIs in place, the greater delays imposed by the Pilots on LNG ship transits of the channel due to environmental conditions would result in a potential annual loss of production at the facility equal to about 38,000 tonnes of LNG. This would equate to a direct loss of revenue of about $8.0 million per year for the facility*". JCEP proposes to export 7.8 million tons of LNG/year. Without the NRI dredging they can export 7,762,000 tons (7,800,000 minus 38,000) which amounts to 99.51% of their anticipated output. The applicant's assertion that dredging NRI4, *" will be a boon to the economic prospects for the City and the state because it will make the Channel safer and more efficient for productive economic enterprises of the kind that provide opportunities to Oregonians*" is not supported by this detail. Page 2 of the DSL/ACE permit is appended as a reference.

JCEP has not provided sufficient evidence that the dredging of NRI4 will be a, *"boon to the economic prospects for the City and the state because it will make the Channel safer and more efficient for productive economic enterprises of the kind that provide opportunities to Oregonians*." Neither has it provided evidence for details of how NRI4 will, *"conserve energy that is currently wasted when, outside the Channel's operational window, vessels wait outside the Channel, using fuel and adding time and expense to transit."* JCEP fails to establish a "demonstrated need" sufficient to justify a Reasons Exception to Goal 16.

GOAL 16: ESTUARINE RESOURCES.

To recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and to protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity and benefits of Oregon's estuaries.

In the CBEMP the NRI 4 site is zoned 52-NA (a natural aquatic unit). Natural units are designated to assure the protection of significant fish and wildlife habitats, of continued biological productivity within the estuary, and of scientific, research, and educational needs. These shall be managed to preserve the natural resources in recognition of dynamic, natural, geological, and evolutionary processes. Thus in the development of the Coos Bay Comprehensive Plan the proposed NRI4 region was recognized as having significant fish and wildlife habitats including but not limited to crabs, clams, a large variety of juvenile fish, and a large variety of benthic invertebrates.

Goal 16 has a requirement that the proposed uses are compatible with other adjacent uses or will be so rendered through measures designed to reduce adverse impacts. The applicant fails to address this requirement as they only cite the Federal Navigation Channel (FNC) as an adjacent use, and

do not address the impacts on the 52-NA area that would be adjacent to the proposed NRI4. It is feasible to suggest that by removal of sediment as a result of the NRI4 dredging the adjacent 52-NA area will experience an alteration of the hydrological regime. This may include a change in water flow velocity which would impact habitat characteristics, or a movement of sediment from the 52 – NA area into the NRI4 dredged area thus altering the characteristic of the adjacent area and the organism that it would support. Additionally the activities associated with building the entrance slip to the JCEP terminal will take place on the western side of the FNC adjacent to the NRI4 region. The changes in the hydrographic regime and associated sediment transport associated with this activity, and any influence that it will have on the 52-NA area under consideration has not been addressed by the applicant.

The CBEMP states that," In a natural management unit, a use or activity is consistent with the resource capabilities of the area when either the impacts of the use on estuarine species, habitats, biological productivity and water quality are not significant or that the resources of the area are able to assimilate the use and activity and their effects and continue to function in a manner to protect significant wildlife habitats, natural biological productivity, and values for scientific research and education." Dredging will be the primary activity that will impact estuarine species, habitats, biological productivity and water quality. The application does not provide sufficient information about the techniques that will be used for dredging and although they state they will use best management practices associated with dredging to reduce turbidity effects, it is not possible to determine if the activity is consistent with this part of the CBEMP as insufficient information is provided in the application.

The application has a flaw in its use of Exhibit 5 Federal Navigation Channel Dredge Areas – Coos County Land Use Permit Support. Attachment 2: Responses to CBEMP Policies 4 and 5.
This document deals only with NRIs 1, 2, and 3 which are located within Coos County. There is no specific information included that pertains to the NRI4, the subject of this application. One example is on page 12 of Exhibit 5 where information on the dredging volumes and types are not included for NRI4. Thus statements such as, *"JCEP's environmental consultant has further evaluated potential adverse impacts associated with the dredging activities and describes ways by which JCEP will minimize such adverse impacts. See DEA memorandum in Exhibit 5."* and, *"As required by CBEMP Policy #5, "[i]dentification* (sic) *and minimization of impacts shall follow the procedure set forth in Policy #4. JCEP has addressed the provisions of this policy in the DEA memo included in Exhibit 5."* cannot be evaluated as the information is not provided in the application.

Information contained in the Final Report of the Estuary Inventory Project – Oregon Technical Assistance to Local Planning Staffs in Fulfilling the Requirements of the LCDC Estuarine Resources Goal – Natural Resources of the Coos Bay Estuary February 1978 – June 1979 prepared by Cyndi Roye, Oregon Department of Fish and Wildlife provides limited details of the area of the 52-NA region under consideration for NRI4 development. The most specific is that, " The large flats southwest of the North Bend airport and the Jordan Cove area should be considered major tracts and protected accordingly. " This no doubt led to the current designation of the area as Natural Aquatic.

The impact of dredging NRI4 may seem somewhat inconsequential when looked upon as an individual action. It is just because the NRI4 area is within Coos Bay's city limits that the planning commission is having to deal with this issue. It does not allow for a consideration of the cumulative impact of dredging all four of the NRI areas, the other three of which are in Coos County's jurisdiction. Although the Coos Bay planning committee cannot rule on the merits of dredging for NRI 1, 2 and 3, I encourage them to think of the "bigger picture" of the impact of dredging NRI4 has on the estuary as a whole.

Respectably submitted,

Janet Hodder Ph.D.

Attachments

1. The Coast Guard Letter of Recommendation to FERC signed by USCG Captain W.R. Timmons, dated May 10, 2018 in response to JCEP's Letter of Intent and based on the comprehensive review of JCEP's Waterway Suitability Assessment (WSA).

2. Letter to Jordan Cove Energy project dated November 7, 2018 from USCG Commander J. C. Smith, Captain of the Port, Sector Columbia River.

3. Page 24 of Resource Report 11 for the JCEP terminal project submitted to the Federal Energy Regulatory Commission in Docket No. PF17-4-000 dated May 2017.

4. Page 2 of the DSL/ACE permit

Attachment 1. Janet Hodder

U.S. Department of Homeland Security
United States Coast Guard

Captain of the Port
U. S. Coast Guard
Sector Columbia River

2185 SE 12th Place
Warrenton, Oregon 97146-9693
Staff Symbol: s
Phone: (503) 861-6211

16611
May 10, 2018

Director of Gas Environment and Engineering, PJ 11
Attn: Mr. Rich McGuire
Federal Energy Regulatory Commission
888 First Street NE
Washington, DC 20426

Dear Mr. McGuire:

This Letter of Recommendation (LOR) is issued pursuant to 33 Code of Federal Regulations (CFR) 127.009 in response to the Letter of Intent submitted by Jordan Cove Energy Project. L.P. (Jordan Cove) on January 9, 2017. Jordan Cove proposes to construct and operate the Jordan Cove LNG facility in Coos Bay, Oregon from which Liquefied Natural Gas (LNG) is proposed to be transferred in bulk to a vessel for export. This LOR conveys the Coast Guard's recommendation on the suitability of the Coos Bay Channel for LNG marine traffic as it relates to safety and security. In addition to meeting the requirements of 33 CFR 127.009, this LOR fulfills the Coast Guard's commitment for providing information to your agency under the Interagency Agreement signed in February 2004.

After reviewing the information in the applicant's Letter of Intent (LOI) and Waterway Suitability Assessment (WSA) with subsequent annual updates and completing an evaluation of the waterway in consultation with a variety of state and local port stakeholders, I recommend that the Coos Bay Channel be considered suitable for LNG marine traffic. My recommendation is based on review of the factors listed in 33 CFR 127.007 and 33 CFR 127.009. The reasons supporting my recommendation are outlined below.

On November 1, 2017, I completed a review of the WSA for the Jordan Cove Energy Project, submitted to the Coast Guard by KSEAS Consulting on behalf of Jordan Cove in February 2007. This review was conducted following the guidance provided in U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 01-2011, dated January 24, 2011. In conducting this review and analysis, I focused on the navigation safety and maritime security aspects of LNG vessel transits along the affected waterway. My analysis included an assessment of the risks posed by these transits and validation of the risk management measures proposed by the applicant in the WSA. During the review, I consulted a variety of stakeholders including the Area Maritime Security Committees, Harbor Safety Committees, State representatives, Pilot Organizations, and local emergency responders.

Based upon a comprehensive review of Jordan Cove's WSA, and after consultation with State and Local port stakeholders, I recommend that the Coos Bay Channel be considered suitable for accommodating the type and frequency of LNG marine traffic associated with this project.

The attached LOR Analysis contains a detailed summary of the WSA review process that has guided this recommendation. It documents the assumptions made during the analysis of Jordan Cove's WSA. It discusses details of potential vulnerabilities and operational safety and security measures that were analyzed during the review. The portion of the LOR Analysis which

addresses matters that affect maritime security is marked as Sensitive Security Information and is withheld from distribution.[1] The LOR Analysis sets forth the navigational safety and maritime security resource gaps that currently exist in, on, and adjacent to the waterway, including the marine transfer area of the proposed facility, and which, to the extent allowable under FERC's existing legal authority, may be addressed in its Commission Order if one is issued. To the extent implementation of specific mitigation measures fall outside the scope of FERC's legal authority, the applicant is expected to examine the feasibility of implementing such mitigation measures, in consultation with the Coast Guard and State and Local agencies as applicable.

This recommendation is provided to assist in the Commission's determination of whether the proposed facility should be authorized. This Letter of Recommendation is not an enforceable order, permit, or authorization that allows any party, including the applicant, to operate a facility or a vessel on the affected waterway. Similarly, it does not impose any legally enforceable obligations on any party to undertake any future action be it on the waterway or at the proposed facility. It does not authorize, nor in any way restrict, the possible future transit of properly certificated vessels on the Coos Bay Channel. As with all issues related to waterway safety and security, I will assess each vessel transit on a case by case basis to identify what, if any, safety and security measures are necessary to safeguard the public health and welfare, critical marine infrastructure and key resources, the port, the marine environment, and vessels. In the event the facility begins operation and LNG vessel transits commence, if matters arise concerning the safety or security of any aspect of the proposed operation, a Captain of the Port Order could be issued pursuant to my authority under the Ports and Waterways Safety Act of 1972, as amended by the Port and Tanker Safety Act of 1978, 33 U.S.C. § 1221 – 1232, among other authorities, to address those matters.

Please note that Enclosures (4) is Sensitive Security Information (SSI) and shall be disseminated, handled and safeguarded in accordance with 49 CFR Part 1520, "Protection of Sensitive Security Information."

If you have any questions on this recommendation, my point of contact is Lieutenant Commander Laura Springer. She can be reached at the address listed above, by phone at (503) 209-2468, or by email at Laura.M.Springer@uscg.mil.

Sincerely,

W. R. TIMMONS,
Captain, U. S. Coast Guard
Captain of the Port, Sector Columbia River

Enclosure (1) LOR Analysis
(2) LOR issued by Sector Portland on April 24, 2009
(3) U.S.C.G.'s Waterway Suitability Report for the Jordan Cove Energy Project
(4) LOR Analysis (SSI Portion)

[1] Documents containing SSI may be made available upon certification that the requestor has a need to know and appropriate document handling and non-disclosure protocols have been established.

Attachment 2

Janet Hodder

U.S. Department of Homeland Security
United States Coast Guard

Captain of the Port
United States Coast Guard
Sector Columbia River

2185 SE 12th Place
Warrenton, OR 97146-9693
Staff Symbol: s
Phone: (503) 861-6206
Fax: (503) 861-6355

16611

NOV 07 2018

Tony Diocee, Vice President, Projects
Jordan Cove Energy Project, L. P.
5615 Kirby, Suite 500
Houston, TX 77005

Dear Mr Diocee:

The USCG Waterways Suitability Report provided to the Federal Energy Regulatory Commission (FERC) on July 1, 2008 and a subsequent Letter of Recommendation provided to FERC on May 10, 2018 required the applicant, Jordon Cove Energy Project, L.P. (JCEP), to conduct additional ship transit simulator studies for liquid natural gas (LNG) carriers that exceed a 148,000 m^3 spherical containment class vessel or for any increase in physical dimensions.

Since the initial Waterway Suitability Analysis was submitted to the USCG in 2007 LNG Tanker technology has improved and tanker sizes and capacities have changed. As a result, additional simulator studies were required. In response, JCEP conducted additional vessel transit simulations during September 26-27, 2018 using modern ship design and carrying capacities.

The simulated transits were piloted by the Coos Bay Pilots and witnessed by the USCG. They were conducted at California Maritime Academy in Vallejo, CA using a Transas Simulator. They were conducted to demonstrate that the Coos Bay Pilots can safely and successfully maneuver LNG carriers up to 299.9 x 49m x 11.9m dimensionally while transiting the channel.

These successful simulations expand the ability for Jordan Cove LNG to use any class of LNG carrier (membrane, Moss, or SBT) with physical dimensions equal to or smaller than observed during the simulated transits. JCEP will continue development of the Transit Management Plan and work with the Coos Bay Pilots in establishing any other operating parameters.

Sincerely,

J. C. SMITH
Commander, Sector Columbia River
Captain of the Port
Captain, U. S. Coast Guard

Enclosure: 1) Jordon Cove LNG Terminal Simulation Plan, September 2018
2) TRANSAS Simulation Printouts

Copy: FERC
Commander, Coast Guard District Thirteen (dp)
Commander, Pacific Area (PAC-54)
Commandant (CG-OES), (CG-ODO), (CG-FAC), (CG-741), (CG-CVC), (CG-ENG), (LNGNCOE)
Marine Safety Center (CG MSC)

for both safety and security issues. This process has also been briefed to the projects Emergency Response Development group on a regular basis.

As part of the LNG Transit Management Plan, JCEP is proposing that LNG carriers would not be allowed to move past the 50-mile voluntary traffic lanes offshore unless all conditions are acceptable for them to continue into the LNG Terminal. LNG carriers will only be allowed to enter closer than 50 miles when all conditions are suitable to enter the Port of Coos Bay (the "Port"). JCEP is also proposing that LNG carriers will not be allowed to anchor offshore of the Oregon coast, based on the recommendation contained in the National Oceanic Atmospheric Administration's ("NOAA") United States Coast Pilot 7 (2009). Due to the lack of a safe anchorage suitable for ocean-going ships in Coos Bay, JCEP is proposing, in addition to the LNG carrier loading berth, to construct an emergency lay berth on the west side of the slip that could be utilized for the safe mooring of a LNG carrier that is temporarily disabled. Further, JCEP has committed in the WSA to providing tractor tugs to escort each LNG carrier into the Port and to the berth. This type of tug has not been previously available in the Port. These tugs are capable of fully controlling and maneuvering the LNG carriers even without ships power and will also have extensive firefighting capability, as recommended by industry best practice guidelines.

The LNG Transit Management Plan will establish a specific set of weather conditions during which the entry or departure of LNG carriers will not be allowed. JCEP has determined, with the assistance of the local harbor pilots that these conditions occur approximately 10 days per year and when these conditions do occur, they are only in place for a period of approximately 12 hours. The clear majority of these conditions is caused by ebb tides and last a short duration.

Oil Spill Contingency Plans, required by federal and state regulations, are to be submitted and approved by the USCG and Oregon Department of Environmental Quality ("ODEQ") prior to entry of the LNG carriers to the Port. Before arrival of any LNG carrier to the Port, a "Qualified Individual" will be present and will have the clear authority to perform the following duties on behalf of the ship owners:

- Have full authority to immediately implement emergency actions;
- Commit the financial resources of the company to respond to an incident;
- Communicate with the appropriate federal and state officials and the incident response teams; and
- Ensure that the response resources identified by the ERP will be allowed to commence appropriate response actions in a timely manner.

The ship traffic in the area is controlled by the harbor pilots. It is their decision when it is safe to bring ships into and out of the Port. JCEP has recommended that two systems be added to assist the pilots in making proper decisions. One system, a Vessel Traffic Information System ("VTIS"), would allow ships' agents, ships, pilots, and other harbor users to make information more readily available on very short notice. As a ship approaches the 50-mile mark, the ship's agent would communicate with the authorities, the LNG Terminal, and Pilots, and would discuss the proper timing of the ship's arrival. If necessary, a ship could increase speed or decrease speed to arrive at the proper time. Otherwise, the ship will be held in a waiting area beyond the 50-mile mark offshore. The second system, a NOAA, Physical Oceanographic Real-Time System ("PORTS"), would allow oceanographic information to be made readily available to the maritime public, ships, and pilots, thereby reducing the possibility for error in predicting tides and currents. All of the above measures will be included in the LNG Transit Management Plan. The LNG Transit Management Plan will be the operational guidance by which all LNG carrier arrivals and departures will be undertaken.

Attachment 4

Janet Holder

(2) PROJECT INFORMATION

C. Indicate the project category. (Check all that apply.)

☐ Commercial Development	☐ Industrial Development	☐ Residential Development
☐ Institutional Development	☐ Agricultural	☐ Recreational
☑ Transportation	☐ Restoration	☐ Bank Stabilization
☑ Dredging	☐ Utility lines	☐ Survey or Sampling
☑ In- or Over-Water Structure	☐ Maintenance	☐ Other:

(3) PROJECT PURPOSE AND NEED

Provide a statement of the purpose and need for the overall project.

The entities constructing the project are Jordan Cove Energy Project, LP and Pacific Connector Gas Pipeline L.P. Both together are referred to as Jordan Cove. JCEP is constructing a liquefied natural gas terminal to be located on the North Spit of Coos Bay (LNG Terminal) and PCGP is constructing a pipeline from the intersection of the GTN and Ruby pipelines to Coos Bay (the Pipeline). The LNG Terminal and the Pipeline are together referred to as the Project

The Project is a market-driven response to the burgeoning and abundant natural gas supply in the U.S. Rocky Mountains and Western Canada markets, and the growth of international demand, particularly in Asia. The overall Project purpose and need is to construct a natural gas liquefaction and deep-water export terminal capable of receiving and loading ocean-going Liquefied Natural Gas (LNG) carriers, in order to export natural gas derived from a point near the intersections of the GTN Pipeline system and Ruby Pipeline system.

The pipeline origin near the intersection of the GTN Pipeline system and Ruby Pipeline system is strategically located to give reliable and secure supplies of natural gas from two natural gas supply basins – one in the U.S. Rocky Mountains (through the existing Ruby Pipeline) and a second in western Canada (through the existing GTN Pipeline) – capable of delivering volumes of at least 1,200,000 dekatherms (a unit of energy used to measure natural gas, approximately equal to one thousand cubic feet) per day (dth/d) in order to support export of 7.8 million tonnes per annum (mtpa) of LNG.

The LNG Terminal, proposed to be located on the bay side of the North Spit of Coos Bay, would support receipt, liquefaction, storage, and loading of LNG onto ocean-going LNG carriers for delivery to export markets giving those supplies an efficient and cost-effective outlet. The Pipeline is needed to transport natural gas from near the intersection of the GTN Pipeline system and Ruby Pipeline system to the LNG Terminal. The Navigation Reliability Improvements (NRIs) enhancements that are planned as part of the Project will allow for transit of LNG vessels of similar overall dimensions to those listed in the July 1, 2008 U.S. Coast Guard (USCG) Waterway Suitability Report and as approved in the USCG Letter of Recommendation dated 10 May 2018., but under a broader range of weather conditions, specifically higher wind speeds. This allows for greater navigational efficiency and reliability to enable JCEP to export the full capacity of the optimized design production of 7.8 million metric tonnes per annum from the LNG Terminal. Although the depth of the FNC is suitable for vessel transit as determined by the USCG Waterway Suitability Assessment, without the NRIs, the LNG facility would not be able to optimize its production capacity and export 7.8 mtpa of LNG and therefore would not fully satisfy the Project purpose. JCEP conducted an extensive evaluation of the existing channel geometry with the Coos Bay Pilots Association (Pilots) and LNG navigation experts from JCEP's Asian customers during 2015 at the simulator located at the California Maritime Academy (Schisler 2015). Based on these evaluations, it was determined that without the NRIs, the number and duration of LNG carrier transits would be limited by the Pilots' environmental condition requirements for transit, such as wind speed, channel currents and fog. JCEP modeled the LNG Terminal, LNG production, and transportation throughput, both with and without the NRIs in place. Modeling showed that without the NRIs in place, the greater delays imposed by the Pilots on LNG ship transits of the channel due to environmental conditions would result in a potential annual loss of production at the facility equal to about 38,000 tonnes of LNG. This would equate to a direct loss of revenue of about $8.0 million per year for the facility.

March 21, 2019
Coos Bay Planning Commission
Re: 187018000153-PLNG-01 Jordan Cove Energy Project

Good evening to the citizens of Coos Bay. Our comments will be brief.

The Clam Diggers Association of Oregon is opposed to the building and operation of the LNG export facility at Jordan Cove for very good reasons.

The most important environmental benefit of Coos Bay is the ecological productivity of this estuary. Things like eel grass matter to a healthy bay ecology.

Construction and the day to day operation of the LNG facility will minimize the contribution that robust thriving tidal flats provide for the life cycles of the marine organisms that inhabit the bay. These include: Shellfish, Chinook, Coho, Steelhead, Dungeness and Red Rock Crab plus numerous rock and near shore fish.

Even whales and porpoises visit our bays. Numerous sea and shore birds also live in Coos Bay. Our sand and mud shrimp stocks will be harmed if construction is allowed to remove the mud flats. These shrimp are part of the food web that feeds our fisheries and other wildlife. Coos Bay sand shrimp are some of the last remaining healthy stocks in Oregon and deserve protection from habitat loss.

The scope and nature of the LNG facility requires the State to mitigate the loss of recreational opportunity. The State's remedy falls short of achieving mitigation for loss of recreational opportunity. Exchanging the loss of recreational opportunities associated for the conversion to the public property at Kentuck Golf Course does not meet the test of Mitigation. The State cannot exchange one public property for another public property. The State forced this mitigation remedy upon us without stakeholders at the table.

Will recreational boating be allowed when LNG tankers are entering or leaving Coos Bay?

In a one year period, Pembina has paid out $150,000 dollars to our elected representatives. How can the public have faith in elected representatives that accept campaign contributions that amount to nothing more than a legalized bribe for influence by a foreign country?

The planning commission should not allow Pembina to end run our current zoning regulations that protect Coos Bay.
Thank you,
William Lackner President Clam Diggers Association of Oregon
PO BOX 1083
Coos Bay, OR 97420
read by Margaret Mullen

Natalie Ranker
414 Simpson Ave
North Bend, OR 97459

City of Coos Bay Planning Commission
500 Central Ave
Coos Bay, OR 97420

Re: AM-18-011/RZ-18-007/HBCU-18-003

Dear Planning Commissioners,
I would like to address some of the many important problems with the dredging of the navigation channel for the the Jordan Cove Energy Project (JCEP).

1- Public need - This dredging will provide no benefit to the public. The only benefit will be to enrich Jordan Cove with a 1%-2% increase in LNG export from the straightening of the navigation channel as stated in their Removal Fill Application. This certainly does not satisfy a public need that outweighs harm to navigation, fishing, and recreation.

2- The dredging will cause definite harms to Coos Bay and local residents who live, work, and recreate around the Bay and navigation channel. The final distribution of 600,000-750,000 cy of dredged materials to Apco 1 and 2 sites is contingent upon slope stability, the ability to ensure adequate residence time of spoils and safe access for equipment. It will require management of discharge positions and rates to ensure water quality standards and side slope stability. What contingencies will be met? JCEP has made no assurances of how they will guarantee the stability of the massive piles of spoils. JCEP Removal Fill Ap. states above.

3- What will be the composition of the spoils? JCEP has stated that they are required to test them but have not stated how. From years of industry, there are deposits of heavy metals and toxic contaminants, including arsenic. Will these and other contaminants be safe to deposit on Apco 1 and 2, which is less than 1/2 mile from Simpson Heights, a neighborhood of more than 750 people according to Nextdoor Neighborhoods? And if the spoils are proven to be toxic, what will JCEP do with them.? They have provided no informationabout makeup or contamination levels.

4- This from JCEP's Removal Fill Application, 6.0, p.59
5,700,000 cy will initially be dredged from the slip and access channel. Periodic maintenance will occur every 3 years for the first 10 years and every 5 years sfter. This will result in 115,000 cy of spoils every 3 years and 160,000 cy every 5 years thereafter. Along with the problem of where to deposit more spoils, there will be a constant re-silting problem that will cauce damage to oyster beds, crab larvae, and salmon fry. Coos Bay is dependent on these resources to bring millions of dollars into our local economy. Our Coho salmon are endangered, which is admitted in the JCEP application along with 8 other species that they do not name, steelhead and water fowl among them.

5- There will be subsurface blasting required at several sites along the navigation channel. ~~This~~ will kill numerous salmonid species through barotrauma, which affects the inner ear and leads to immediate or delayed mortality. with sound greater than 218 d B

6- The noise from blasting, dredging, pile driving and other activities will drive away tourists staying at the North Spit and Empire campgrounds as well as creating great discomfort for people fishing, clamming, recreating along the channel. In 2017, Coos County brought in $271 million

from tourism. This is far greater than JCEP will ever provide to our residents, and we can't afford to lose it.

There are also many problems with the horizontal directional drilling (HDD) pipeline that will pass 100 - 200 ft under the bay.

1- Coos Bay has thousands of years of silt making up its base structure. In their removal fill ap. JCEP stated they have only attempted two bores, and they did not reach bedrock. Years ago when Williams was in charge of the pipeline, they attempted many unsuccessful bores due to the fact that the walls collapsed after 35 ft. They concluded that the soils in the bay and channel will not hold up to building an HDD pipeline.

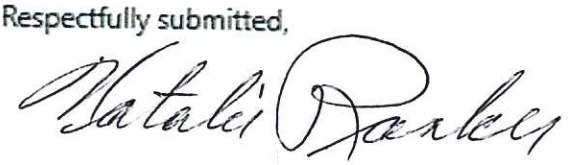
2- As previously stated, JCEP is required to test and dispose of offsite all dredging materials. The same is true of all of the spoils from the 3000 ft. HDD pipeline from the Jordan Cove facility to the Apco site just below the McCullough Bridge. These spoils are drilling mud which is made up of bentonite, polymers, fresh water, and drill cuttings from the bottom of the channel. They must be contained, tested, and shipped offsite. To provide a reference, a 300 ft bore for a 4" gas pipeline will require 1320 gal. of drilling mud.*1 This computes to 13,200 gal of mud for a 3000 ft (10 X longer) 4" pipeline and 118,800 gal for a 36" (9 X wider) pipeline.

To calibrate weight...I was unable to find the weight o drill mud filled with drilling cuttings. However, one gallon of water weighs 8.33 lbs, and a gal. of water filled sand weighs 16.04 lbs *2 I have given a low estimate of 10 lbs/gal. Thus, the weight of 118,800 gal of mud and cuttings would weigh 1,888,000 lbs. This material must be transported in water tight containers, so there will be no leakage. Most drillers use 20 cy roll off containers, which, due to the weight of this material can only be filled half way. At 10 lb/gal, a 20 cy container will hold 20,200 lbs plus the additional weight for the container.*3 Therefore, the 1,888,000 lbs of HDD spoils will require a minimum of 59 trips carrying the 20 cy watertight containers. And where will these spoils be disposed of? Depending on the contents, which will only be discovered after the required testing, JCEP may not be able to use Beaver Hill, and they may have to find other sites at perhaps long distances. None of this can be predicted until JCEP starts boring, and they may end up with a massive amount of spoils and nowhere to dispose of them.

Due to all of the above mentioned unknowns, I believe it to be right to demand more study of the contents of dredge/HDD spoils and where they will be taken for disposal. JCEP should provide this information before they are allowed to start dredging or boring. More time is required for these reports.

1-https://trenchless technology.com/drilling-fluids-critical-hdd-jobs/
2-https://aqua-calc.com/calculate-volume-to-weight
3-https://convertto.com/conversion-weight-volume-/convert-ydofwater-to-us-gal-of-water-volume

Respectfully submitted,



Natalie Ranker

OREGON SHORES
CONSERVATION COALITION

March 21, 2019

City of Coos Bay Planning Commission
c/o Mr. Henry Hearley
Assistant Planner
Lane Council of Governments (LCOG)
859 Willamette Street, Suite 500
Eugene, OR, 97401

Via Email to: hhearley@lcog.org; jcallister@lcog.org

Re: City of Coos Bay Land Use Application #187-18-000153
Concurrent Land Use Applications by Jordan Cove Energy Project L.P.
Coos Bay Estuary Navigation Reliability Improvements
Comments of Oregon Shores Conservation Coalition

Dear Chair Coles and Planning Commission members:

Please accept these comments from the Oregon Shores Conservation Coalition and its members (collectively "Oregon Shores") to be included in the evidentiary record for Land Use Application #187-18-000153. Oregon Shores is a non-profit organization dedicated to protecting the natural communities, ecosystems, and landscapes of the Oregon coast while preserving the public's access to these priceless treasures in an ecologically responsible manner. Our mission includes assisting local residents in land use matters and other regulatory processes affecting their coastal communities, and engaging Oregonians and visitors alike in a wide range of stewardship activities that serve to protect our state's celebrated public coastal heritage. For nearly half a century, we have been a key public interest participant in legal and policy matters related to land use and shoreline management at the local and state level. Oregon Shores has been tracking and working to address the numerous adverse environmental and social impacts likely to arise from the proposed Jordan Cove LNG facility, the Pacific Connector Gas Pipeline, and the construction activities associated with the two in the Coos Bay estuary and its surrounding communities for over a decade.

Oregon Shores requests that the Planning Commission leave the record open to allow for submission of additional information and rebuttal of information presented for at least seven days. Please notify us of any further decisions, reports, or notices issued in relation to these concurrent applications. Oregon Shores will provide further comments as appropriate and allowed within the open record periods.

I. Background of the concurrent land use applications before the City of Coos Bay

A. Coos Bay

Coos Bay is the extensive estuary of the Coos and Millicoma rivers. Occupying approximately 20 square miles, the bay is the second largest drowned river valley on the Oregon Coast, and largest entirely within Oregon. Tidelands cover approximately 4,569 acres including 2,738 acres of tidal marsh and 1,400 acres of eelgrass beds. Its primary features include the main, expansive bay, an extensive arch of water around a peninsula, and major arms including South Slough, near the entrance of the bay, and Haynes Inlet, which extends northeasterly from the main body of the bay. Jordan Cove, site of the proposed Liquefied Natural Gas export facility of the same name, is an embayment on the western (North Spit) side of the outer bay.

The natural environment of the Coos Bay estuary hosts a diversity of plants and animals. The extensive shallow tidal flats provide habitat for fish and shellfish species. The estuary is critical nursery habitat for the commercially important Dungeness crab. It supports the life-cycle of iconic salmonid species, including Oregon Coast Coho (Oncorhynchus kisutch), winter steelhead (Oncorhynchus mykiss irideus), fall Chinook salmon (Oncorhynchus tshawytscha), and coastal cutthroat trout (Oncorhynchus clarki clarki). Coos Bay is also home to ESA-listed species, including but not limited to Oregon Coast Coho and green sturgeon.

Coos Bay also supports a variety of beneficial uses as designated in the South Coast region as a whole, including fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, and commercial navigation and transportation. Coos Bay is central to Oregon's commercial fishing industry—especially the consistently lucrative Dungeness crab fishery. Economic contributions from commercial fishing and crabbing go beyond harvesting and seafood-processing, and include tourism and visitors, boat-building and gear manufacturing, safety, research and education. Recreational fisheries, including shellfish harvest and crabbing, are also important economic drivers in Coos Bay. Several of the most important shellfish beds are located in close proximity to the Pipeline route along the edge of the North Spit (western side of lower Coos Bay).

B. The Proposed "Navigation Reliability Improvements," Generally

Jordan Cove Energy Project L.P. ("JCEP" or "Applicant") proposes to develop a natural gas liquefaction facility and export terminal (LNG Terminal) on the North Spit of Coos Bay. The LNG Terminal would receive a maximum of 1.2 million dekatherms[1] per day of largely fracked natural gas via the proposed Pacific Connector Gas Pipeline ("PCGP" or "Pipeline") and cool it into its liquid form in preparation for export to overseas markets. The proposed Pipeline is a 36-inch subsurface interstate natural gas pipeline extending 229 miles from Malin, Oregon to

[1] A dekatherm is a unit of energy used primarily to measure natural gas.

the coast at Coos Bay's North Spit in North Bend, Oregon. Its sole purpose is to transport natural gas extracted from locations in Western Canada and possibly locations in the western United States to the proposed LNG Terminal facility. The LNG Terminal will produce a maximum of 7.8 million tons of LNG for export each year. The proposed Project—including the LNG Terminal, Pipeline, and related components—is known as Jordan Cove.

Over the past decade, Jordan Cove has failed to garner many of the required approvals, permits, and compliance determinations from local, state, and federal agencies. In some cases, authorizations were denied on the basis of the Applicant's inability to demonstrate a public need for its proposed activities and/or inability to demonstrate that proposed activities could be implemented without serious adverse impacts on protected conservation, environmental, recreational, and public safety uses.

Should the proposed LNG Terminal be developed, it will increase vessel traffic in the Coos Bay Deep Draft Navigation Channel ("DDNC" or "Channel) in the form of large LNG export tankers. To accommodate this type of vessel, JCEP proposes to make "navigation efficiency and reliability improvements" to the City of Coos Bay ("City")-designated DDNC by dredging three submerged areas lying adjacent to the existing Channel.[2] The Applicant asserts that the dredging "will allow for vessel transit under a broader weather window to enable JCEP to export the full capacity of the optimized design production of 7.8 metric tonnes [*sic*] per annum ("mtpa") from JCEP's liquefied natural gas ("LNG") terminal on the nearby North Spit."[3] At issue for the purposes of this public hearing are the following four concurrent land use applications (together, "Application) submitted by JCEP seeking local land use authorization to make these substantial Channel modifications:[4]

1. Post-acknowledgment amendments to the Coos Bay Estuary Management Plan ("CBEMP") map to change the zoning designation of approximately 3.3 acres located approximately 2,700 feet from the end of the North Bend airport runway within the Coos Bay estuary ("Navigation Reliability Improvement Site" or "NRI Site") from 52-NA (Natural Aquatic) to DDNC-DA (Development Aquatic);

2. A post-acknowledgment text amendment of the CBEMP, which is part of the City of Coos Bay Comprehensive Plan ("CBCP"), to take a reasons exception to Statewide Planning Goal 16 ("Goal 16") to authorize the rezone of the NRI Site to DDNC-DA;

[2] Jordan Cove Energy Project L.P. ("JCEP"), "In the Matter of Requests to Improve the Navigation Efficiency and Reliability of the Coos Bay Deep Draft Navigation Channel Pursuant to the Following Applications: (1) Map Amendment to the Coos Bay Estuary Management Plan to Change the Designation of Approximately 3.3 Acres from 52-NA to DDNC-DA; (2) Text Amendment to the City of Coos Bay Comprehensive Plan to take a Reasons Exception to Statewide Planning Goal 16 to Authorize this Map Amendment; (3) Estuarine and Coastal Shoreline Uses and Activities Permit For "New And Maintenance Dredging" in the DDNC-DA Estuarine Zone; and (4) Estuarine and Coastal Shoreline Uses and Activities Permit to Allow an Accessory Temporary Dredge Transport Pipeline in the 52-NA, 53-CA, 54-DA, and 55-CA Estuarine Zones and an Accessory Buoy in the 52-NA Estuarine Zone," 1-2, City of Coos Bay Land Use Application #187-18-000153, (Feb. 21, 2018) [hereinafter *JCEP Appl. Narrative*].
[3] *JCEP Appl. Narrative* 2.
[4] *JCEP Appl. Narrative* 2.

3. Estuarine and Coastal Shoreline Uses and Activities Permit in the DDNC-DA estuarine zone to allow new and maintenance dredging at the rezoned NRI Site;

4. Estuarine and Coastal Shoreline Uses and Activities Permit in the 52-NA, 53-CA, 54-DA, and 55-CA estuarine zones to allow a temporary pipeline to transport the dredge spoils from the NRI Site to approved disposal sites and a buoy as accessory uses to the primary dredging activity. The Applicant states that it is not seeking approval of the dredged materials disposal (DMD) activity in conjunction with the present Application.[5]

The City has engaged Lane Council of Governments ("LCOG") to process this application.[6] In addition to the proposed NRI request presently before the City, the Applicant is concurrently seeking to rezone three other estuary management units within Coos County's ("County") jurisdiction.

Oregon Shores provides these comments in order to underscore the apparent deficiencies in the concurrent application request. Upon the current record, the Applicant has not demonstrated compliance with the applicable approval criteria set forth in the Statewide Planning Goals ("Goals"), the Oregon Revised Statutes ("ORS"), the CBEMP, the CBCP, and the City of Coos Bay Development Code ("CBDC"). Our comments support the view that the Applications fail to provide the minimum information necessary to be evaluated for compliance with applicable standards and criteria.

II. The Applicant fails to meet applicable criteria under Chapter 17.360 of the CBDC and the Statewide Planning Goals to justify its proposed CBEMP Map amendments.

It appears that the Applicant first submitted its Application to the City at some time prior to Feb. 2, 2017.[7] The Application currently before the Planning Commission is dated Feb. 4, 2019, and constitutes an "amended and restated application submittal" which the Applicant has requested that the LCOG "accept in place of [its] original submittal."[8] JCEP seems to be referencing an older version of CBDC in its amended discussion of applicable approval criteria for the proposed Comprehensive Plan Map Amendment.[9] Oregon Shores' discussion of CBDC requirements with respect to JCEP's proposed map amendment relies on the applicable CBDC criteria listed in the LCOG's Mar. 14, 2019 Staff Report, which makes reference to CBDC provisions as updated pursuant to Ordinance 508 (passed Jan. 15, 2019). The Applicant bears the responsibility for stating and addressing all applicable decision criteria. To the extent the Applicant is relying on 2017 criteria, it has not demonstrated why the City's code allows this 2019 Application to be deemed accepted as of 2017.

JCEP's overall proposed project seeks to change the designation of more than 20 total acres of the Coos Bay estuary to DDNC-DA, including highly valuable estuarine areas currently designated "natural" and "conservation" management units pursuant to Goal 16 (Estuarine

[5] *Id.*
[6] City of Coos Bay Planning Comm'n, *Notice of Public Hearing: Land Use application 187-18-000153*, 1 (Mar. 1, 2019).
[7] *See* LCOG Staff Report, (Mar. 14, 2019).
[8] *See JCEP Appl. Cover Letter*.
[9] *JCEP Appl. Narrative* at 5-7.

Resources). The proposal presently within the jurisdiction of the City seeks to change the designation of 3.3 acres located in the 52-NA (Natural Aquatic) management segment to DDNC-DA, along with a corresponding CBEMP map amendment to reflect the change. To justify this rezone and map amendment, the Applicant must demonstrate compliance with requisite provisions in the CBDC and the Goals. Each are discussed following a description of the 52-NA management segment.

A. The 52-NA Management Segment

The Coos Bay Comprehensive Plan ("CBCP") is the highest authority for all land use development within the City of Coos Bay. It incorporates the requirements of the Statewide Planning Goals, and is further implemented by the CBDC. The review authority must refer to and rely upon the Coos Bay comprehensive plan (CBCP) for guidance "above all other city texts or maps" should any ambiguity or conflict arise. Under the CBEMP, which is incorporated as Volume 3 of the CBCP, the proposed NRI site is located in a management segment currently zoned as 52-NA (Management Classification: Natural Aquatic). All uses and activities allowed within each management segment must be consistent with the direction set forth in a respective segment's "Management Objectives" statements.[10]

The 52-NA management segment is located in the Lower Bay. This unit extends north to the deep-draft navigation channel beginning at a line extending northwest from the configuration change in the shoreline that parallels Runway 4-22. 52-NA ends at a line extending west from a point at the approximate center of Section 17 and surrounds the disposal islands southwest of Runway 4-22. Its current Management Objective statement is as follows:

> This aquatic unit contains extensive eelgrass beds with associated fish and waterfowl habitat, and shall accordingly be managed to maintain these resources in their natural condition in order to protect their productivity.
>
> Dredging of a small channel on the north side of the proposed airport fill shall be necessary as a form of mitigation to maintain tidal currents.
>
> Maintenance only of the existing sewage treatment plant outfall shall be permitted. [11]

New and maintenance dredging in 52-NA as currently zoned are prohibited uses, apart from "as a form of mitigation to maintain tidal currents."[12] Given this prohibition, JCEP proposes to rezone a highly productive portion of 52-NA to DDNC-DA (a Development Aquatic segment which does allow new and maintenance dredging activities) in order to allow LNG tankers to commence their turn from the Lower Jarvis Range to Jarvis Turn Range channels "sooner."[13] Under Goal 16, dredging is a prohibited activity in "Natural" management units, which are meant to be managed to preserve natural resources and dynamic natural processes with an absolute minimum of development. As such, a Goal 16 exception is required for the Applicant's proposed rezone of 52-NA. Absent an exception, JCEP's proposed rezones would not comply with the CBCP.

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[10] *Id.*
[11] CBCP Vol. 3, 3-142 (emphasis added).
[12] CBCP Vol. 3, 3-143 (emphasis added).
[13] *See JCEP Appl. Narrative* 4.

B. CBDC Provisions – Ch. 17.360.010-Comprehensive Plan Amendment.

Title 17 of the Coos Bay Municipal Code contains the City's Development Code.[14] In relevant part, it states that no structure "shall be constructed, improved, altered, enlarged or moved[…]after the effective date of the ordinance codified in [Title 17], except in conformity with conditions prescribed by this [Title 17]."[15] Ch. 17.110.070(1) sets forth a general hierarchy by which the City's review authority is required to interpret land use plans, policies, maps, and standards. "In case of ambiguity or conflict, the review authority shall refer to and rely upon the Coos Bay comprehensive plan (CBCP) for guidance above all other city texts or maps."[16]

The Applicant is requesting an amendment of the CBCP map to change the CBCP designation of the NRI Site from 52-NA to DDNC-DA. Hence, CBDC Chapter 17.360, which governs Plan Amendments and Zone Changes, establishes the approval criteria for Applicant's proposed amendment of the CBEMP map to change the zoning designation of NRI Site at issue. Further, the Application will be subject to a Type III process with Council Approval.[17]

Ch. 17.360.010-Comprehensive Plan Amendment

Pursuant to CBDC Ch. 17.360.010(1), the boundaries of the comprehensive plan map designations and the comprehensive plan text may be amended as provided in CBDC 17.360.020 (Initiation of Amendment).[18] 17.360.010(2) states that the City may amend its comprehensive plan and/or plan map. Specifically:

> The approval body shall consider the cumulative effects of the proposed comprehensive plan and/or map amendments on other zoning districts and uses within the general area. Cumulative effects include sufficiency of capital facilities services, transportation, zone and location compatibility, and other issues related to public health and safety and welfare the decision-making body determines to be relevant to the proposed amendment.[19]

The Applicant asserts that "the cumulative effects" of its proposed amendment would be "to facilitate an increase in safety and efficiency of navigation in the Channel." It further states that the cumulative effect of the Application is to "augment transportation in the Bay." As discussed throughout, JCEP fails to provide evidence sufficient to evaluate the claim that its proposed activities would "facilitate an increase in safety and efficiency of Navigation in the Channel." First, the Application materials omit any data regarding the safety issues and Channel constraints facing the commercial fleet currently using the Lower Bay, and whether the Channel modifications would improve navigational hazards for the typical vessel in the fleet. In fact, evidence suggests that any benefit of the proposed Channel modifications would accrue solely to the LNG Tanker vessels the Applicant proposes to operate. The Applicant asserts that the Channel modifications would enable LNG tankers (which are significantly larger than any that

[14] *See* Ch. 17.110.010 Title.
[15] *See* Ch. 17.110.020 Applicability.
[16] 17.110.070(1) Hierarchy of plans and regulations – General Hierarchy.
[17] *See* Ch. 17.130.100 Type III procedure; *See also JCEP Appl. Cover Letter* 2.
[18] Ch. 17.360.010(1) Comprehensive plan amendment.
[19] Ch. 17.360.010(2) Comprehensive plan amendment.

currently operate within the estuary) to navigate the DDNC in windier conditions. As discussed in Part III of these comments, the JCEP fails to establish on the basis of the current Application that modifications enabling LNG vessels to transit under windier conditions would actually result in safer navigation in the Lower Bay. Second, JCEP fails to include information relevant to analyzing the impact its proposed new and maintenance dredging may have on adjacent zoning districts and uses, especially with regard to the Federal Navigation Channel (FNC) abutting the 52-NA management segment.

The Applicant further asserts that its proposed activities "will not have cumulative effects on the sufficiency of capital facilities services, or health and welfare." Similarly, JCEP fails to provide evidence sufficient to evaluate this claim. To the contrary, the very nature of the Applicant's proposed dredging, maintenance dredging, and accessory activities tends to suggest the opposite conclusion. As discussed in the analysis of Goal 9 and Goal 12 below, the singular apparent purpose of these proposed activities is to enable the Applicant to operate LNG tankers in the Lower Bay. The increase LNG vessel traffic, associated exclusion zones, and timing restrictions have the potential to cause death or serious bodily harm to the crew of the vessels with the commercial fleet currently operating out of the City of Coos Bay and Charleston. Additionally, each activity risks increasing turbidity, water temperature, fatalities to benthic organisms, and threats to vital eelgrass beds—each of which has the potential to negatively affect commercially valuable estuarine organisms that presently serve as economic drivers to the region.

Absent further information, the Planning Commission cannot consider the cumulative effects of the proposed activities as required by CBDC 17.360.010. Therefore, the City cannot conclude that the Application satisfies this criterion.

C. CBCP Policies

Chapter 17.360.060(1) contains the applicable Approval Criteria for a Type III review such as the matter at issue. For a Type III review, the City Council shall approve the proposal upon finding that:

(a) The proposed amendment is consistent with the applicable policies of the comprehensive plan or that a significant change in circumstances requires an amendment to the plan or map;

(b) The proposed amendment is in the public interest; and

(c) Approval of the amendment will not result in a decrease in the level of service for capital facilities and services identified in the Coos Bay capital improvement plan(s).[20]

Each of the three criteria for approval is discussed below.

[20] Ch. 17.360.060(1)(a)-(c) Approval criteria.

1. Approval Criteria (a): The proposed amendment is consistent with the applicable policies of the comprehensive plan or that a significant change in circumstances requires an amendment to the plan or map.

The Applicant does not demonstrate that a "significant change in circumstances" exists such that its proposed amendment would be justified pursuant to Chapter 17.360.060(1)(a). Hence, it must demonstrate that its proposed amendment is consistent with applicable policies contained in Sec. 7.1, 7.5, and 8.3 of the CBCP.

Section 7.1 Natural Resources and Hazards Strategies

Sec. 7 of CBCP Vol. 1 (Identification Of Problems, Planning Issues, Goals, and Plan Implementation Strategies) identifies general community problems and specific planning issues related to nine basis topics that range from "natural resources and hazards" to "housing" and "economic development."[21] These problem statements are followed by the City's adopted strategies to solve these specific needs.[22] "The strategies are policy; moreover, they are written to cite the reasons and justification of the policies and how they will be put into effect."[23]

CBCP Sec. 7.1 identifies two problems. First, Community growth and development has the potential for infringing upon and impacting the area's natural resources. Second, natural hazards, which are known to occur in the Bay area, may threaten existing development and pose a constraint to future growth. The Goal of CBCP Sec. 7.1 (Natural Resources and Hazards) requires the City of Coos Bay to "exercise sound land use practices to conserve and protect the quality of all its natural resources and safeguard the life and property of its citizens from natural hazards and disasters."[24] The LCOG has indicated that NRH Strategies 8 and 9 are applicable to the present matter.

NRH.8 Coos Bay shall encourage the preservation and protection of riparian vegetation as an important fish and wildlife habitat and as a viable means of flood control by enactment of appropriate property development ordinances providing protection by establishing buffer strips along waterways, along designated HUD floodways, with the exception of navigable waterways. This strategy recognizes that such land use practices are necessary (1) to preserve the area's natural resources, and (2) to eliminate unnecessary drainage and erosion problems often accompanying development.

JCEP discloses that it anticipates "possible temporary, but not permanent, impacts to shoreline habitat, including to riparian vegetation, where JCEP plans to offload dredged material for processing."[25] It provides no data to meaningfully evaluate this claim. Further, the opposite conclusion is likely to be true. As discussed throughout these comments, the Applicant's new and maintenance dredging activities will increase turbidity, water temperatures, and noise pollution in Coos Bay, all of which have the potential to impose serious and potentially

[21] CBCP Vol. 1, Sec. 7 – Introduction.
[22] *Id.*
[23] *Id.*
[24] CBCP Vol. 1, Sec. 7.5 – Natural Resources and Hazards.
[25] *JCEP Appl. Narrative* 8.

irreparable harm on estuarine organisms not only during the construction of the NRI but also on an ongoing basis during the eventual operation of the LNG Terminal. The Applications at issue do not contain an up-to-date construction or projected maintenance dredging schedule for the proposed LNG Terminal. Publicly available data suggests that the average lifespan of an LNG Terminal such as one the Applicant's proposed new and maintenance dredging activities are meant to facilitate is about twenty years—making the adverse impacts of maintenance dredging to allow LNG Tanker transit both significant and possibly permanent.

The Applicant further states that "these temporary impacts would be limited to a corridor approximately 10 feet wide," and asserts that locating this corridor "in the field (location by the dredging contractor)" would "minimize impacts to vegetation and aquatic resources." The Applicant's materials similarly lack sufficient data to meaningfully evaluate the aforementioned methods JCEP proposes to use during NRI construction to "minimize impacts to vegetation and aquatic resources." There are a number of different types of dredging methods (including mechanical and hydraulic dredging), and each pose different adverse impacts to natural resources.[26] Further, because the Applicant has not identified the methods to be used in the removal of 505,500 cubic yards of rock and 53,900 cubic yards of sand, the Applicant's explanation of methods to minimize adverse impacts is inadequate. For example, if blasting is required for rock removal, it will have significant impacts that differ from those resulting from dredging. The Planning Commission should require the Applicant to disclose the proposed removal methods to allow for analysis of the possible adverse impacts including acoustic, water quality, and benthic habitat loss. Additionally, although JCEP states that it is not requesting approval for DMD within the Applications at issues, the materials lack sufficient data to evaluate JCEP's plan to contain potential spills when offloading dredged materials for processing.

Finally, the Applicant contends that "NRH.8 does not affirmatively obligate JCEP to take any action, but rather obligates the City to 'encourage' preservation of riparian vegetation." But the strategies accompanying Sec. 7 "Problem Statements" are "written to cite the reasons and justification of the policies and how they will be put into effect." As such, the Applicant should demonstrate that its proposals are consistent with the City's implementation of Policy NRH.8—especially with respect to the preservation of riparian vegetation and the elimination of unnecessary drainage and erosion problems related to its activities—prior to any recommendation of approval by the Planning Commission.

For the reasons discussed above, the Planning Commission cannot conclude that the Applicant's proposed activities comply with strategy NRH.8. As such, the City cannot find that the Application complies with NRH.8.

NRH.9 **Coos Bay shall cooperation with local, state, and federal agencies in conserving and protecting fish and wildlife habitat, open spaces, and aesthetic and scenic values encompassed by areas enclosed by the Coos Bay-North Bend Water Board, Empire Lakes, and Mingus Park. This strategy is not intended to prohibit development in these areas, but rather to ensure that if development occurs it takes into consideration the ability of the land to support such development, i.e., soils, topography, habitat, natural processes, etc. This strategy**

[26] *See JCEP Appl. Narrative* 5.

recognizes that these areas are particularly sensitive and valuable resources.

The Planning Commission should take into consideration the potential adverse and irreparable harms the Applicant's proposed activities pose to the highly sensitive and valuable nature of estuarine resources in 52-NA prior to any recommendation of approval to the City Council, discussed throughout these comments.

Section 7.5 Economic Development

Sec. 7.5's Vision recognizes that the City of Coos Bay "is developing a vibrant, dynamic economy capitalizing on its waterfront and proximity to a geographically unique area" and "is poised as the region's hub to support industrial growth."[27] The City's commercial and industrial economic development is a "balance of increasing the amount and occupancy of useable industrial land and *maintaining a focus* on services, hospitality, the retirement community and related support services."[28]

Goal #1, Policy 1.5 Support and cooperate with community and regional partners to encourage economic growth.

JCEP discloses that its navigation reliability improvements for the Channel "will primarily benefit large vessels that are navigating to and from the International Port of Coos Bay ("Port")."[29] The Applicant contends that the Port "is an important regional entity that facilitates mass export and import of goods and commodities overseas and thus serves as a key driver of economic development throughout southwest Oregon."[30] While it may be true that the Port serves as a key economic driver in Southwest Oregon, the Applicant fails to provide sufficient information to evaluate whether its proposed activities would encourage economic growth in the City of Coos Bay in accordance with the vision of Policy 7.5. In fact, the fact that its improvements would primarily benefit LNG tanker transit suggests the opposite conclusion. Publicly available information exists to suggest that the average LNG vessel is significantly larger than the average vessel making up the current commercial fleet operating out of the City. As discussed below, the exclusion zones and timing restrictions associated with the Applicant's proposed operation of LNG tankers have the potential to impose negative economic impacts on commercial crabbing and fishing boats, thereby hampering the growth of these consistently lucrative economic drivers in the region. Hence, approval of JCEP's proposed uses and activities would seem to undermine the objectives of Sec. 7.5 Goal #4 ("work to retain, expand, and strengthen existing local businesses").

For these reasons and those discussed in the analysis of Goal 9 below, the Applicant fails to provide sufficient information to establish that approving the Application and facilitating the NRI would "support community and regional partners and encourage economic growth."

Goal #6, Policy 6.1, 6.2 Maximize the potential uses and benefits the waterfront and deep-water port offers to the city and region as a

[27] CBCP Vol. 1, Sec. 7.5 Economic Development.
[28] *Id.*
[29] *JCEP Appl. Narrative* 8.
[30] *Id.*

whole; Support the Port of Coos Bay in its development efforts for transportation linkage and to develop a deep-draft channel to accommodate large cargo vessels and increase shipping activities and water-dependent uses.

As discussed throughout these comments, the Applicant fails to provide sufficient evidence to evaluate its claim that its proposed uses and activities will "facilitate increased navigational safety and efficiency for large vessels." Further, evidence suggests that the exclusion zones and timing restrictions associated with LNG vessel transit will cause severe delays to the commercial crabbing fleet operating out of Coos Bay, risking significant harm to economic prospects and even vessel fatalities. As such, the Planning Commission cannot conclude that the Application materials comply with Sec. 7.5, Goal 6 of the CBCP.

Section 8.3 Land Use and Community Development Planning Strategies

Section 8.3's Problem Statement makes the following observations:

> Municipal land use and community development strategies are serious public decisions that can have far-reaching fiscal, social, and environmental impacts. The appropriateness, effectiveness, and public acceptability of the strategies depend largely upon the rationale for and justification of the strategies. *Strategies are most easily justified when they are the culmination of a logical, defensible planning process. Yet, human nature sometimes makes short-term, superficial solutions more attractive than well-thought-out, justified community strategies.*[31]

The Goal of Sec. 8.3. requires the City to "continue to utilize the land use and community development planning process which culminated in the creation of this comprehensive plan."[32] Tracking the language of Goal 2 (discussed below), it recognizes that this planning process "provides for a rational policy framework – supported by an adequate factual base – that functions as the basis for all decisions and actions related to the use of land."[33]

LU.4 Coos Bay shall not make major revisions to this Comprehensive Plan more frequently than every two years, if at all possible. "Major revisions" are those that have widespread and immediate impact beyond the subject area under consideration. The city recognizes that wholesale approval of frequent major revisions could ruin the integrity of this Plan.

The Applicant asserts, without sufficient supporting evidence, that its Application does not request "major revisions" to the CBCP. As discussed in the below analysis of LU.5, the opposite conclusion is likely correct. The purpose of the Applicant's proposed text amendment is to change the designation of a Natural Aquatic management unit. Natural Aquatic management units are meant to be managed to preserve natural resources and dynamic natural processes with an absolute minimum of development. The CBCP as presently acknowledged recognizes 52-NA as having significant fish and wildlife habitats including but not limited to

[31] CBCP Vol. 1, Sec. 8.3 – Land Use and Community Development Planning (emphasis added).
[32] *Id.*
[33] *Id.*

crabs, clams, a large variety of juvenile fish, and a large variety of benthic invertebrates. Contrary to the Applicant's characterization of 52-NA as "isolated," it is a highly productive segment of the Coos Bay estuarine ecosystem that has purposefully been left undeveloped in accordance with the requirements of Goal 16 (discussed below). Any change in designation warrants careful consideration of the numerous potential adverse impacts the Applicant's proposed uses will impose on protected commercial and recreational uses by the City of Coos Bay. For these reasons, the Application's proposal to rezone 52-NA to DDNC-DA arguably constitutes a major revision as envisioned by LU.4.

LU.5 Coos Bay may make minor changes to this Comprehensive Plan on an infrequent basis as need and justification arises. "Minor changes" are those which do not have significant impact beyond the immediate area of the property under consideration. The city recognizes that wholesale approval of frequent minor changes could ruin the integrity of this Plan.

The Applicant asserts, without sufficient supporting evidence, that "approval of the Application will not…have a widespread, immediate, or significant impact beyond the NRI Site, and it will not require additional changes to the Plan." As discussed above in part II.A. of these comments, 52-NA is a highly valuable estuarine district that provides vital eelgrass habitat to important estuarine organisms. As stated above, the CBCP as presently acknowledged recognizes 52-NA as having significant fish and wildlife habitats including but not limited to crabs, clams, a large variety of juvenile fish, and a large variety of benthic invertebrates. The Applicant has not provided the data required to evaluate the extent of the harms (increases in turbidity, water temperature, salinity, etc.) its proposed dredging activities will impose on this district. In fact, the very aquatic nature of this district means that any adverse impact arising from the Applicant's proposed activities could accrue to the larger estuarine ecosystem. Further, as discussed below, the Applicant has not justified the need for its proposed amendment sufficient to warrant adoption of a reasons exception to Goal 16.

For the reasons stated above, the City should find that the Applicant's amendment constitutes a "major revision" of the CBCP, as described in LU.4.

LU.7 Coos Bay shall anticipate that conflicts may arise between the various plan implementation strategies contained in the plan when applying the policies to specific situations. To resolve these conflicts, if and when such may occur, Coos Bay shall consider the long term environmental, economic, social, and energy consequences expected to result from applying one strategy in place of others, then to select and apply the strategy that results in maximum public benefit as supported by findings of fact. This strategy is based on the recognition that a viable conflict resolution process is essential to the success of any comprehensive plan.

JCEP does not provide sufficient evidence to support its claim that approval of the Application will not cause any conflicts between various CBCP implementation strategies. Further, as discussed in part II and III of these comments, the Application is inconsistent with all applicable policies of the CBCP and the Goal exception criteria of the OAR.

Because the proposal to amend the CBCP designation of management segment 52-NA to DDNC-DA is inconsistent with the applicable policies of the CBCP, the City should deny the Application.

2. Approval Criteria (b): The proposed amendment is in the public interest.

As discussed throughout these comments, the Applicant fails to demonstrate that it proposed amendment will result in "increased navigational safety and efficiency for large vessels in the Channel." Further, publicly available evidence suggests that the proposed NRI may substantially interfere with the navigational safety and efficiency of the average vessel in the commercial fleet currently operating in the Lower Bay. Finally, as discussed in part II.D. of these comments, the Applicant fails to evidence its claim that its proposal will result in an "economic boon" to the City and the region. Again, given the harm its proposed activities will likely impose on commercial crabbing vessels, the opposite conclusion is likely to be true. Far from being in the public's interest, it is unclear from the Application how the proposed amendment will provide a benefit to any use or activity outside of the proposed operations of the Applicant—a private corporation based in Calgary, Canada whose object is to export goods overseas. As such, the City cannot conclude that the Application complies with this criterion.

3. Approval Criteria (c): Approval of the amendment will not result in a decrease in the level of service for capital facilities and services identified in the Coos Bay capital improvement plan(s).

The Applicant fails to provide evidence sufficient to evaluate its claim that approval of its Application "will not result in a decrease in the level-of-service for any identified capital facilities and/or services identified in the Coos Bay capital improvement plan."[34] Absent such data, the City cannot find that the Application complies with this criterion.

For the above reasons, the Applicant fails to demonstrate consistency with the applicable approval criteria contained in Chapter 17.360.060(1). As such, the City should deny its proposed requests.

D. Statewide Planning Goals.

The Applicant correctly notes that post-acknowledgement plan amendments ("PAPAs"), such as the present proposed rezoning of the NRI site and associated CBEMP map amendment, must comply with Oregon's Statewide Planning Goals under ORS 197.175(2)(a).[35] The Applicant bears the burden of proof in showing that its proposed rezoning of the three NRI Sites complies with all applicable criteria and standards. The Planning Commission's recommendation to approve the proposed rezoning must either explain why the rezoning is consistent with the Goals or adopt findings explaining why the Goal is not applicable.

[34] *JCEP Appl. Narrative* 11.
[35] ORS 197.175 – Cities' and counties' planning responsibilities

The Applicant asserts that Goals 1, 2, 6, 7, 9, 11, 12, 13, 14, and 16 are applicable to its proposed rezoning of the NRI Sites. It argues that Goals 3, 4, 5, 8, 10, 15, 17, 18, and 19 are not applicable. Oregon Shores will provide additional comment on the Goals as appropriate and allowed. General comments are provided for the purposes of clarity and preservation.

Goal 1: Citizen Involvement

"To develop a citizen involvement program that insures the opportunity for citizens to be involved in all phases of the planning process."

Consistent with the objective of Goal 1, Oregon Shores stresses the need to keep the evidentiary record open following the hearing in order to allow for meaningful community input on the Concurrent Applications currently before the Planning Commission and throughout the full Type III review including City Council consideration and final decision-making.

Goal 2: Land Use Planning

"To establish a land use planning process and policy framework as a basis for all decision and actions related to use of land and to assure an adequate factual base for such decisions and actions."

Goal 2 outlines the basic procedures of Oregon's statewide planning program: land use decisions must be made in accordance with an acknowledged comprehensive plan, comprehensive plans must be based on factual information to be acknowledged, and proper implementation ordinances must be adopted to effectuate plan policies. Further, it requires that local plans and ordinances be coordinated with those of other jurisdictions and agencies, and that plans be reviewed periodically and amended as needed.[36]

The sections of the CBDC and ORS discussed in these comments both implement and effectuate the policies of the CBCP. Hence, the Applicant correctly asserts that the standards and limitations contained therein provide the applicable policy framework and land use planning process to assess the appropriateness of its proposed rezones and map amendments. Goal 2 also contains the rules and procedures for taking exceptions to the goals. As discussed throughout these comments, the Concurrent Application materials fail to demonstrate that the proposed rezone of the NRI site and associated CBEMP map amendment satisfy the applicable criteria. These deficiencies show that the proposed rezoning and associated CBEMP map amendment is inconsistent with the objectives of Goal 2.

Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces.

"To protect natural resources and conserve scenic and historic areas and open spaces."

The Applicant asserts that the NRI Site does not include any inventoried Goal 5 resources and approval will not impact any Goal 5 inventoried resources. But the Applicant fails to provide any information to support this assertion. In fact, publicly available evidence suggests the

[36] *Id.*

opposite conclusion to be true. There are known inventoried Goal 5 resources, including the Henderson Marsh (a Goal 5 Major Marsh) and the Coos Head (an outstanding scenic resource) in the vicinity of the Coos Bay estuary which could be impacted by the Applicant's proposed uses and activities. The Applicant should address consistency with Goal 5. Proposed general condition of approval #5 is insufficient to address compliance with Goal 5.

Goal 6: Air, Water, and Land Resources Quality

"To maintain and improve the quality of the air, water and land resources of the state."

Goal 6 states that "[a]ll waste and process discharges from future development, when combined with such discharges from existing developments shall not threaten to violate, or violate applicable state or federal environmental quality statutes, rules and standards."[37] It further requires that:

> With respect to the air, water and land resources of the applicable air sheds and river basins described or included in state environmental quality statutes, rules, standards and implementation plans, such discharges shall not (1) exceed the carrying capacity of such resources, considering long range needs; (2) degrade such resources; or (3) threaten the availability of such resources.

In short, Goal 6 instructs local governments "to consider protection of air, water and land resources from pollution and pollutants when developing comprehensive plans."[38] For the purposes of Goal 6, waste and process discharges refer to "to solid waste, thermal, noise, atmospheric or water pollutants, [industry-related] contaminants, or products therefrom."[39]

JCEP asserts, without sufficient supporting evidence, that its proposed map amendments do not alter existing City protections provided by the CBEMP restricting dredging activities. The proposed rezoning of the NRI Site and corresponding CBEMP map amendment require a Goal 16 exception prior to approval. In other words, JCEP is contending that its proposed Goal 16 exception "will not undermine the CBCP's implementation of [Goal 6] guidelines." However, JCEP's ensuing discussion, as well as statements it has made in other applicable forums on the NRI, appear to suggest that the opposite conclusion is more probable. The Applicant has stated that it anticipates that completing the NRI will have effects upon air, water and land resources in the County. Similar to the materials before the City, the Applicant concluded absent relevant data that "these effects will be temporary, insignificant, or both, and JCEP will complete the NRI using methods to protect these resources" or to otherwise minimize broad harmful impacts. As discussed above, the Applicant's new and maintenance dredging activities will increase turbidity,[40] water temperatures, and noise pollution in Coos Bay, all of which will impose serious and potentially irreparable harm on estuarine organisms during the

[37] Full text of Goal 6 available at https://www.oregon.gov/lcd/OP/Documents/goal6.pdf.
[38] DLCD, *Goal 6: Air, Water, and Land Resources Quality*, https://www.oregon.gov/lcd/OP/Pages/Goal-6.aspx (last accessed Feb. 18, 2019).
[39] *See* Goal 6; *See also* DLCD, *Goal 6: Air, Water, and Land Resources Quality*, https://www.oregon.gov/lcd/OP/Pages/Goal-6.aspx (last accessed March 1, 2019).
[40] Turbidity is the cloudiness or haziness in water caused by an increase in particulate sedimentation akin to smoke in the air. It is a key test of water quality.

construction and operation of the LNG Terminal. The Applications at issue do not contain an up-to-date construction or projected maintenance dredging schedule for the proposed LNG Terminal. The Applicant's materials also lack sufficient data to meaningfully evaluate the methods JCEP proposes to use during NRI construction to "protect these resources." There are a number of different types of dredging methods, and each pose different adverse impacts to natural resources. Additionally, the Applications lack sufficient data to evaluate JCEP's plan for dredged material transport and processing. Absent additional evidence and analysis of the potential adverse impacts associated with new and maintenance dredging, the Planning Commission cannot conclude the proposed rezoning request is consistent with Goal 6.

Goal 6 requires local comprehensive plans and implementing measures to be consistent with applicable state and federal regulations.[41] As such, the proposed rezone of the NRI site within the City's jurisdiction, the associated CBEMP map amendment, and the Goal 16 exception required to effectuate them must similarly be consistent with applicable state and federal regulations. The Applicant asserts, "In a post-acknowledgment plan amendment proceeding, the Planning Commission is only required to find that it is reasonable to expect that federal and state environmental standards will be met in the future when permits for the dredging are sought."[42] Because the Application materials provide no further discussion on this standard, it is unclear whether the Planning Commission could find that it is reasonable to expect that JCEP's proposed dredging activities will satisfy the applicable federal and state environmental standards. Although JCEP may not be precluded as a matter of law from obtaining the requisite state and federal approvals of dredging activities at the NRI sites, the Planning Commission should take into consideration the fact that JCEP has consistently failed for over a decade to demonstrate that it qualifies for such approvals to the satisfaction of the Federal Energy Regulatory Commission (FERC), the Oregon Department of Environmental Quality (DEQ), and most recently, the Oregon Department of State Lands. As a result, proposed condition of approval #3 is insufficient to address compliance with Goal 6.

Goal 7: Areas Subject to Natural Hazards

"To protect people and property from natural hazards."

The proposed NRI site is located within the Coos Bay Estuary. The Coos Bay Estuary is subject to known natural hazards, including earthquakes, tsunamis, and flooding. The Applicant correctly states that Goal 7 requires local governments to identify and plan for natural hazard areas, and coordinate their natural hazard plans and programs with state agencies. However, JCEP asserts that its Application complies with Goal 7 "because it will not increase the likelihood of damage to people or property within the City from natural hazards," without any meaningful discussion of the aforementioned inventoried hazards or the applicable CBMC provisions themselves. Absent such an analysis, the Planning Commission cannot on the basis of the current record conclude that the proposed map amendment is consistent with Goal 7.

Goal 8: Recreational Needs

[41] *Goals Summary* – Goal 6.
[42] *JCEP Appl. Narrative* 10 (citing *Nicita v. City of Oregon City*, 74 Or LUBA 176 (2016)).

"To satisfy the recreational needs of the citizens of the state and visitors, and where appropriate, to provide for the siting of necessary recreational facilities including destination resorts."

The applicant asserts that Goal 8 does not apply because the application does not involve recreational needs. But the Coos Bay estuary, where the NRI Site is located, is of critical importance to the recreational needs of citizens and visitors to Coos Bay. Recreational fishing, crabbing, and shellfishing, as well as general recreational boating and other outdoor activities would likely suffer significant impacts as a result of the construction and ongoing operations proposed in the application. The Applicant should demonstrate consistency with Goal 8.

Goal 9: Economic Development

"To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens."

It is unclear from Applicant's analysis which Goal 9 policy objectives are applicable to its proposed development, and how said development goes about fulfilling the criteria outlined in Goal 9. Given JCEP's reliance on Goal 9 to establish "demonstrated need" per the requirements of a "reasons" exception to Goal 16, it must provide the Planning Commission sufficient information to evaluate its consistency with Goal 9 prior to any approval of the proposed NRI.

Setting aside the very real likelihood that the proposal to construct that the Pipeline may be denied other necessary permits to go forward (eliminating the need for the LNG Terminal itself), the Applicant provides no specific details to substantiate its claims that the NRI site will be "a boon to the economic prospects for the City of Coos Bay and the state." Its proposed new and maintenance dredging activities pose significant adverse impacts to commercially important estuarine organisms such as Dungeness crabs and oysters. Evidence exists to suggest that the construction and operational activities of the proposed LNG Terminal will adversely impact the Estuary's lucrative Dungeness Crab fishery, commercial oyster production, and other aquaculture as well as other important economic opportunities that presently serve as economic drivers for the Coos Bay region and the State of Oregon.

The Applicant asserts that completion of its proposed NRI site will "increase safety and efficiency of transit" in the DDNC. Even if the assertion may be true that the NRI will enable transiting LNG tankers to operate in windier conditions, the Applicant fails to demonstrate that the new and maintenance dredging associated with the NRI site will improve navigation conditions for commercial vessels other than those JCEP is proposing to operate. Additionally, the Application does not include data relevant to estimating the timing restrictions that transiting LNG tankers would impose on other commercial vessels. Both the exclusion zone and timing restrictions associated with LNG vessels have the potential to cause extreme delays for the commercial crabbing and fishery fleet, and negatively impact their economic prospects. Finally, there is no evidence that the current Channel is limiting the economic opportunities for City of Coos Bay as a whole, rather than for the Applicant's own self-interest. On the current record, the proposed amendment is inconsistent with the objectives of Goal 9.

Goal 12: Transportation

"To provide and encourage a safe, convenient and economic transportation system."

It is unclear from Applicant's analysis which Goal 12 policy objectives are applicable to its proposed development, and how said development goes about fulfilling the criteria outlined in Goal 12. Given JCEP's reliance on Goal 12 to establish "demonstrated need" per the requirements of a reasons exception to Goal 16, it must provide the Planning Commission sufficient information to evaluate its consistency with Goal 12 prior to any approval of the proposed NRI.

As discussed in the above analysis of Goal 9, the information on the current record does not support a conclusion that the NRI itself will increase efficiency and reduce delay for vessels other than the LNG tankers the Applicant proposes to operate. The Applicant does not provide sufficient information to evaluate how much energy is "currently wasted when when…vessels wait outside the Channel" outside the Channel's present operational window, and whether the proposed NRI would tend to reduce such wait times for vessels currently in the commercial fleet (i.e. those other than LNG tankers). In fact, the Application tends to show that the all of the proposed NRIs (before the County and the City) are a response to JCEP's singular private need for channel dredging, and would not generally improve navigation for the commercial fleet and recreational boats currently operating in the Lower Bay. Exclusion zones and timing restrictions associated with LNG vessel transit have not been addressed the Applicant. Hence, LNG vessel traffic itself could cause the very delays and inefficiencies for the commercial and recreational fleet based in Charleston harbor the Applicant purports to avoid with its proposed NRI. Far and above the negative impacts to economic prospects discussed in relation to Goal 9, these delays and inefficiencies could cause death or serious bodily harm to the crews of commercial and recreational vessels while navigating across the bar. Finally, the Applicant fails to address the impacts to City and regional transportation networks (both on land and in the Channel) from the construction associated with the proposed activities. On the current record, the Planning Commission cannot conclude that the proposed development is consistent the objectives of Goal 12.

Goal 13: Energy Conservation

"To conserve energy."

Goal 13 directs local governments to manage land use so as to maximize the conservation of all forms of energy. The Applicant's proposal itself is inherently inconsistent with the aims of Goal 13. The completion of the proposed NRI would substantially increase vessel traffic in Coos Bay, resulting in an overall increase in consumption of fossil fuels. Further, the primary purpose of the proposed NRI is to enable large LNG tankers to navigate out of Coos Bay and export LNG (a non-renewable fuel resource) to consumers in foreign markets.

Setting aside this inherent inconsistency, the Applicant fails to demonstrate compliance with the standards set by Goal 13. JCEP asserts that the NRI will "facilitate maximal energy conservation by increasing the safety and efficiency of vessel transit of the Channel, and by increasing the Channel's operational window." The evidence contained in the Concurrent Applications is insufficient to evaluate these claims. As discussed in the analyses of Goal 9 and

Goal 12 above, there is no evidence to suggest that an increase in "efficiency in material transportation" and corresponding reduction in "energy waste" will be a benefit shared by any vessel operator other than the Applicant. Additionally, JCEP does not provide an analysis of the potential adverse impacts LNG tanker transit will impose on the crabbing and fishing boats which currently travel across the bar. Evidence suggests that crabbing boats will be substantially delayed by transiting LNG vessels. As the Applicant itself acknowledges, causing commercial crabbing and fishing vessels to wait outside the Channel will use fuel as well as add time and expense (in the form of opportunity costs to recovering landings) to overall transit.

All of the activities associated with the construction and completion of the proposed NRI would tend to increase the consumption of energy, rendering the proposed amendment inconsistent with the objective of Goal 13.

Goal 16: Estuarine Resources

"To recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and to protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity and benefits of Oregon's estuaries."

The proposed activity is inconsistent with Goal 16, and therefore a Goal 16 exception is required to rezone the proposed NRI site located with 52-NA to DDNC-DA. For the reasons detailed in Part III of these comments, the Applicant's proposed rezone fails to meet the criteria required to warrant an exception to Goal 16.

For the above reasons, the City cannot find that the Application complies with the Goals.

III. The Applicant fails to meet the criteria required for an amendment of the CCCP in order to take a "reasons" exception to Goal 16.

The Application seeks to amend the CBEMP to apply the DDNC-DA (development aquatic) management unit to the proposed NRI site located within 52-NA in order to allow dredging necessary for LNG vessel passage. Goal 16 allows dredging for such purposes in development management units ("water transport channels where dredging may be necessary"). However, such dredging activities are prohibited in natural or conservation management units. Hence, an exception to this goal is required. Applicant proposes a "reasons" exception to Goal 16 exception to rezone NRI site #4 to DDNC-DA.

OAR 660-004-0020 details the criteria applicant must meet before the Planning Commission can recommend that the City Council adopt an amendment to the CBCP in order to take a reasons exception to Goal 16. ORS 197.732 contains Oregon's statutory guidelines for the Goal 2 exception process and its criteria parallel the criteria set forth in OAR 660-004-0020. The four requirements for a goal exception are:

(a) Reasons justify why the state policy embodied in the applicable goals should not apply.

(b) Areas that do not require a new exception cannot reasonably accommodate the use.

(c) The long-term environmental, economic, social and energy consequences resulting from the use at the proposed site with measures designated to reduce adverse impacts are not significantly more adverse than would typically result from the same proposal being located in areas requiring a goal exception other than the proposed site.

(d) The proposed uses are compatible with other adjacent uses or will be so rendered through measures designed to reduce adverse impacts.

Because the proposed exception fails to demonstrate compliance with applicable provisions of OAR 660-004-0020, it cannot demonstrate compliance with OAR 197.732.

In order to find that reasons justify a goal exception, there must be sufficient information provided in the record and reasoning to support each of the criteria. As the Oregon Court of Appeals explained: "an exception must be just that – exceptional."[43] The Applicant's proposal that the City of Coos Bay set forth within the CBCP the justification for a Goal 16 exception at the proposed NRI site warrants careful consideration to assess consistency with this "exceptional" standard. As shown below, the Applicant's proposal falls short of meeting this bar.

A. First Goal Exception Requirement: Reasons Justify Why the State Policy Embodied in the Goals Should not Apply.

OAR 660-004-0020. Goal 2, Part II(c), Exception Requirements

(2) The four standards in Goal 2 Part II(c) required to be addressed when taking an exception to a goal are described in subsections (a) through (d) of this section, including general requirements applicable to each of the factors:

(a) "Reasons justify why the state policy embodied in the applicable goals should not apply." The exception shall set forth the facts and assumptions used as the basis for determining that a state policy embodied in a goal should not apply to specific properties or situations, including the amount of land for the use being planned and why the use requires a location on resource land;

OAR 660-004-0020(2)(a) requires the Applicant identify "reasons" as to why Goal 16 criteria regarding estuarine resources should not apply to the NRI Site. OAR 660-004-0022 identifies the types of "reasons" that may be used to justify the exception.

[43] *1000 Friends of Oregon v. LCDC*, 69 Or App 717, 731 (1984).

OAR 660-004-0022(1). Reasons Necessary to Justify an Exception Under Goal 2, Part II(c)

Under OAR 660-004-0022(1), if a use is not specifically provided for, the reasons shall justify why the state policy embodied in the applicable goals should not apply. Acceptable reasons include:

> (a) There is a demonstrated need for the proposed use or activity, based on one or more of the requirements of Goals 3 to 19; and either
>
> (A) A resource upon which the proposed use or activity is dependent can be reasonably obtained only at the proposed exception site and the use or activity requires a location near the resource. An exception based on this paragraph must include an analysis of the market area to be served by the proposed use or activity. That analysis must demonstrate that the proposed exception site is the only one within that market area at which the resource depended upon can reasonably be obtained; or
>
> (B) The proposed use or activity has special features or qualities that necessitate its location on or near the proposed exception site.

OAR 660-004-0022(1)(a) requires the Applicant to establish a "demonstrated need" for the proposed use or activity based on the requirements of one or more of Goals 3 to 19. The Applicant asserts the "demonstrated need" for the NRI is based primarily on Goals 9 (Economic Development) and 12 (Transportation). As discussed in Part III.B. of these comments, the Applicant fails to explicitly identify policy criteria in Goals 9 and 12 applicable to its proposed development, and fails to provide sufficient information to evaluate the proposed NRI project's consistency with the primary objective of each Goal. A general desire to "boost the local economy" or a vague statement about reducing traffic delays do not establish "demonstrated need" sufficient to warrant a "reasons" exception to Goal 16.

It is unclear from the evidence presented whether the proposed NRI will reduce delays for the average vessel currently navigating the DDNC. JCEP states that "minimizing delay is a pressing need because companies that utilize the port of Coos Bay have identified potential new customers in Asia that desire to export cargo using bulk carriers that are slightly larger than the ships typically calling today." It further states that "various marine terminal businesses within Coos Bay require assurances that terminals can efficiently accommodate larger dimension bulk carriers in the future." Given that the Port already supports a variety of shipping customers, JCEP must provide details about which companies require export via bulk carries and which marine terminal businesses require assurances before any robust evaluation can be made regarding the demonstrated need for the proposed NRI.

JCEP states that the "NRI will allow companies to secure emerging opportunities to efficiently export products with today's larger vessels, including bulk carriers of up to 229.9 meters (983.3 feet) in length, 49 meters (160.8 feet) in beam, and 11.9 meters (39 feet) in draft." This is a reduction in parameters from the vessel size the Applicant previously stated would be enabled by the proposed NRI. It is unclear which studies and simulations support this reduction.

Such information must be provided prior to an evaluation of whether reasons justify seeking an exception to Goal 16.

With respect to the Liquefied Natural Gas ("LNG") facility that JCEP proposes to develop in the lower bay, JCEP and the Coos Bay Pilots Association believe the NRI is essential to achieve the required number of LNG vessel transits needed to lift the JCEP design annual LNG production volume. The Applicant asserts that "excessive delays in LNG carrier transit in the Channel, to and from the LNG terminal, could result in a shore storage tank topping situation, requiring JCEP to curtail LNG production."[44] JCEP estimates that dredging to complete navigation efficiency and reliability improvements at the NRI Sites "will allow JCEP to export the full capacity of the optimized design production of 7.8 mtpa from JCEP's LNG terminal on the North Spit." However, the application does not state why the design capacity of the proposed LNG liquefaction plant must produce 7.8 mtpa in order to attain the project purpose. For a previous version of the LNG facility in Coos Bay with the same purpose as the present proposal, the Applicant considered 6.8 mtpa of LNG a sufficient quantity to satisfy the need and purpose of the project. A permit to excavate the proposed NRI should not be issued unless the Applicant adequately demonstrates the project's purpose and need could not be met by constructing a facility with a production capacity that does not require modifications to the DDNC.

No evidence presented by the Applicant suggests the conclusion that continuing existing shipping and commercial activities in the Bay would be unduly constrained absent the proposed NRI. Further, the Applicant fails to show that the NRI will fulfill a "demonstrated need for…enhanced shipping within the Bay." There is insufficient evidence on the basis of this record to assess compliance with the policy objectives of Goals 9 and 12. For these reasons, JCEP fails to establish a "demonstrated need" sufficient to justify a reasons exception to Goal 16.

OAR 660-004-0022(8). Goal 16 – Other Alterations or Uses.

> (8) Goal 16 – Other Alterations or Uses: An exception to the requirement limiting dredge and fill or other reductions or degradations of natural values to water-dependent uses or to the natural and conservation management unit requirements limiting alterations and uses is justified, where consistent with ORS chapter 196, in any of the circumstances specified in subsections (a) through (e) of this section:

The Application seeks an exception to allow proposed new and maintenance dredging in areas that are currently designated, in accordance with Goal 16, as natural and conservation management units. None of the reasons set forth in OAR 660-004-0022(8) apply to the Applicant's proposed use. The applicant does not propose maintenance of an existing dike (per OAR 660-004-0022(8)(a)), maintenance dredging of the existing navigation channel (per OAR 660-004-0022(8)(b)), fill for a new navigational structure necessary for the continued functioning of the Channel (per OAR 660-004-0022(8)(c)), construction of a boat ramp or public fishing pier (per OAR 660-004-0022(8)(d)), or expansion of an existing public non-water-dependent use or a nonsubstantial fill for a private non-water-dependent use (per OAR 660-004-0022(8)(e)). In sum, the proposed deviation from currently acknowledged natural aquatic

[44] *JCEP Appl. Narrative* 24.

management unit requirements to allow dredge and fill is not justified under OAR 660- 004-0022(8).

OAR 660-004-0022(8)(b). Dredging to maintain adequate depth to permit continuation of the present level of navigation in the area to be dredged.

Applicant cites OAR 660-004-0022(8)(b) as a reason justifying its proposed NRI. As discussed above, the Applicant fails to establish a "demonstrated need" for what it previously termed "enhanced navigation" pursuant to OAR 660-004-0022(1)(a)(A). OAR 660-004-0022(8)(b) is a reason justifying dredging to maintain adequate depth to permit *continuation* of the *present level* of navigation in the area to be dredged.[45] This provision is only applicable to maintenance dredging, not to an expansion of a channel into new areas presently designated for natural aquatic management. Additionally, there is no evidence that the current Channel is inoperable without dredging in the adjacent natural management areas or that the proposed NRI is required for continued use of the existing Channel. As such, JCEP's proposed dredging to "permit continuation of the *presently authorized level*" of navigation (as opposed to the "*present level*" of navigation as allowed by OAR 660-004-0022(8)(b)) in the 3.3-acre area located within 52-NA does not qualify for the reason described by OAR 660-004-0022(8)(b) sufficient to justify a reasons exception under Goal 16.

Further, even with respect to navigation for potential future LNG tankers, it is not clear that dredging the deeper channel wider at the turns will increase safety margins for pilots. Should the proposed NRI be approved, Pilots would make crossings using the same margins of safety as are presently used in the Channel. The sole difference is that those margins could potentially be achieved in higher wind conditions than would be possible in the Channel's current state. In other words, while the turns are wider, they will be taken at higher wind speeds, resulting in the same margin of safety from the pilot's perspective. Without additional data, the Planning Commission cannot evaluate whether allowing bar crossings by LNG vessels under windier conditions would actually result in safer navigation.

Inherent in the project's purpose, however, is that the proposed dredging will result in new and extensive LNG tanker traffic. As discussed above in the analysis of Goal 12, the precise location and extent of NRI and channel dredging in the Coos Bay estuary will have immediate and direct implications for shipping safety. Vessel routing from the open ocean over the bar, up the estuary to the marine slip is a hazardous maneuver that impairs navigation for the current commercial fleet under the best circumstances. The route itself contains numerous important turns and components, and there is very little room for error. The entrance and first river bend, as well as the entrance to the marine slip, are both precise maneuvers. The Applicant does not provide sufficient information to assess whether its proposed expansion of the Channel would ease the difficulty of these turns. As discussed above, one notable omission appears to be the precise length and width of their proposed design vessel—the LNG tanker itself. Given the average length of a typical LNG tanker, it would appear that even with the proposed Channel modifications, design vessels will still be required to make their turns in a shorter distance than normal industry guidance. Without further information, the Planning Commission cannot assess whether the proposed NRI would actually improve shipping safety.

[45] *See* OAR 660-004-0022(8)(b) (emphasis added).

OAR 660-004-0022(8)(f). In each of the situations set forth in subsections (7)(a) to (e) of this rule, the exception must demonstrate that the proposed use and alteration (including, where applicable, disposal of dredged materials) will be carried out in a manner that minimizes adverse impacts upon the affected aquatic and shoreland areas and habitats.

As discussed above, the Goal 16 exception is not justified under OAR 660-004-0022(8). Even if it were deemed to fall within one of these reasons, more information regarding potential adverse impacts arising from its proposed NRI, as well as on the methods that Applicant will use to minimize such impacts on affected aquatic and shoreland areas and habitats, must be provided before any conclusion can be made regarding the criterion contained within OAR 660- 004-0022(8)(f). Specifically, more details regarding what JCEP asserts are "best management practices" (including cutter head suction, clamshell, and hopper dredging) associated with dredging to reduce turbidity effects, an assessment of the potential risk of oil spills and any other toxic discharge related to its dredging and accessory activities, and techniques for "localizing" noise pollution associated with dredging to the "immediate dredging area" are crucial to a robust evaluation of whether the Applicant's proposed uses and activities comply with the applicable standards. Deferring this analysis through proposed condition of approval #1 is insufficient absent evidence that these measure will be adequate to protect aquatic resources.

For these reasons, the City cannot find that the Application satisfies this standard.

B. Second Goal Exception Requirement: Areas that Do Not Require a New Exception Cannot Reasonably Accommodate the Use.

OAR 660-002-0020(2)(b) requires a showing that areas that do not require an exception cannot reasonably accommodate the use. As discussed in detail above, the Applicant has not demonstrated a need for the proposed NRI. Because the current Channel is functional for navigation, the existing Channel can accommodate the use and the Applicant cannot meet the requirements of subsection (2)(b).

C. Third Goal Exception Requirement: The Long-Term Environmental, Economic, Social and Energy Consequences Resulting from the Use at the Proposed Site are Not Significantly More Adverse than Would typically Result from the Same Proposal Located in Other Areas that Would Require A Goal Exception.

OAR 660-002-0020(2)(c) requires the applicant to demonstrate "the characteristics of each alternative area considered by the jurisdiction in which an exception might be taken, the typical advantages and disadvantages of using the area for a use not allowed by the Goal, and the typical positive and negative consequences resulting from the use at the proposed site with measures designed to reduce adverse impacts." Further,

> "The exception shall include the reasons why the consequences of the use at the chosen site are not significantly more adverse than would typically result from the same proposal being located in areas requiring a goal exception other than the proposed site. Such reasons shall include but are not limited to a description of: the facts used to determine which resource land is least productive, the ability to sustain resource uses near the

proposed use, and the long-term economic impact on the general area caused by irreversible removal of the land from the resource base.

For the same reasons set forth above, the Applicant has not demonstrated compliance with this criterion. Furthermore, absent more detailed information regarding the proposed methods of dredging, blasting, or other removal within the NRI zone, the Planning Commission cannot complete an analysis of the comparative adverse impacts.

D. Fourth Goal Exception Requirement: The Proposed Uses are Compatible with Other Adjacent Uses or Will Be So Rendered through Measures Designed to Reduce Adverse Impacts.

As discussed above, there are significant existing recreational and commercial uses adjacent to the NRI sites including shellfish beds and crabbing areas. The Application addresses only the Channel as an adjacent use, and does not address any of the other adjacent uses of the areas in the Coos Bay estuary adjacent to the Channel and the proposed NRI sites including those designated for natural and conservation uses. The Application fails to meet this criterion.

For the reasons stated above, the Applicant has not demonstrated that a Goal 16 exception is justified for the proposed uses and activities.

IV. The Applicant's request for Estuarine and Coastal Shorelands Uses and Activities Permit fails to demonstrate compliance with the requisite criteria.

Because the Concurrent Application fail to demonstrate that the comprehensive plan amendment is permissible, its Estuarine and Coastal Shorelands Uses and Activities Permits to (1) allow new and maintenance dredging at the rezoned NRI site and (2) allow a temporary pipeline to transport the dredge spoils from the NRI Site to approved disposal sites and a buoy as accessory uses to the primary activity are both unjustified. Oregon Shores will submit further comment regarding the Uses and Activities Permits, applicable CBDC provisions contained with Chapter 17.352, and applicable CBEMP policies once the plan map amendment and zoning change have been resolved. General comment is provided here for preservation purposes. Applicant provides evidence insufficient to meaningfully evaluate the impacts of the proposed NRI on the adjacent Federal Navigation Channel (FNC). Of specific concern is the impact of the proposed dredging on the use of the FNC by large vessels. Dredging will be located immediately adjacent to the FNC and dredge plans involving cables crossing the whole channel are proposed. While large vessels may be able to routinely navigate around active dredging, active dredging is an additional hazard and strain on resources that must be comprehensively assessed prior to any conclusion about the appropriateness of the DDNC-DA designation in areas adjacent to the FNC. Accommodations for smaller vessels are burdensome for mariners, especially recreational users and commercial fisheries. If the Planning Commission reaches consideration of the Uses and Activities Permits, it should conclude that additional information and study of the proposal is necessary.

V. Conclusion

On the basis of the present record, the Planning Commission should recommend denial of these applications.

Sincerely,

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Document	**Pages**
Sylvia Yamada, *Potential Impact of Jordan Cove LNG Terminal Construction on the Nursery Habitat of Dungeness Crab*, Jan. 2016.	4
Erik Knoder, *Oregon's Commercial Fishing in 2017*, Or. Emp't Dep't, May 2, 2018.	6
NATIVE OYSTERS IN THE COOS ESTUARY (CLW DATA SOURCE)	8
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Potential Impact of

Jordan Cove LNG Terminal construction on

the Nursery Habitat of Dungeness crab.

January 2016

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The **Dungeness crab** (***Cancer magister***) supports an important commercial and sport fishery from Alaska to California. Total annual landings in recent years exceeded 25,000 tons (55 million pounds) (FAO statistics, 2012). In Oregon, the 2014 Dungeness fishing season yielded 14.4 million pounds, $50 million to crabbers and an estimated $100 million to the Oregon economy (Oregon Dungeness Crab Commission in Fisherman's News On line). The Dungeness fishery is the most valuable commercial fishery in Oregon (Rasmusen 2013).

The life cycle of Dungeness crab is complex, depending on both estuarine and near-shore habitats. Typically, mating occurs in shallow water, and females migrate offshore to brood and hatch their eggs. The early larval stages feed and rear in the near-shore water column, after which the final larval stage rides tidal currents back to shore and settles out in shallow estuarine habitats. The final larval stage molts into a ~5 -7 mm wide first crab stage. The highest densities of juvenile Dungeness crabs are found in estuaries, which provide warm water, high biological productivity and protection from predators. Sand substrate and eelgrass beds are preferred habitat for these young crabs, which bury in the sand and hide in the eelgrass to escape predators. Size measurements of crabs trapped at Russell Point in Coos Bay (below the Highway 101 McCullough Bridge) show that Dungeness crabs in their first two years of life (100 mm carapace width and smaller) are extremely abundant in the mid-to low intertidal areas such as pools and eelgrass beds (Figure 1).

In my research documenting the status of the non-native European Green crab in Coos Bay, I encounter young Dungeness crabs in all my study sites. I selected a sub-set of my sites closest to the proposed Jordan Cove Energy Project: the north and south sides of Trans Pacific Lane and the beach adjacent to the Roseburg Forest Product watchman's booth. The results from over 600 trap-days, show that young Dungeness crabs are consistently abundant from 2002 to 2014 at all sites, with an average catch of 15 per trap (Table 1). These trapping results confirm the findings by Emmett and Durkin (1985) that estuaries are important nursery habitats for Dungeness crabs. These need to be kept in mind when a trench is dug In Haynes Inlet, the Trans Pacific Parkway is be expanded and an upland area is cut out to create a berth for ocean-going vessels. Not only will the turbidity during the construction phase be of concern to the ecological community, the on-going dredging to maintain the berth and shipping channels will continue to be a disturbance to the ecosystem. It will result in habitat loss for native species, including the valuable Dungeness crab. In one study between 45 to 85 % of the Dungeness crabs died during a simulated dredging operation (Chang and Levings, 1978). Marine habitat modification by construction of the Jordan Cove Energy Project could impact the important Oregon Dungeness fishery.

Sylvia Yamada is a marine ecologist who has studied native crabs and the European green crab in Oregon and Washington for over 20 years.

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Emmett, R.L. and Durkin, J.T. 1985. The Columbia River Estuary: An Important Nursery for Dungeness Crabs, *Cancer magister*. *Marine Fisheries Review*. 47(3), 21-25.

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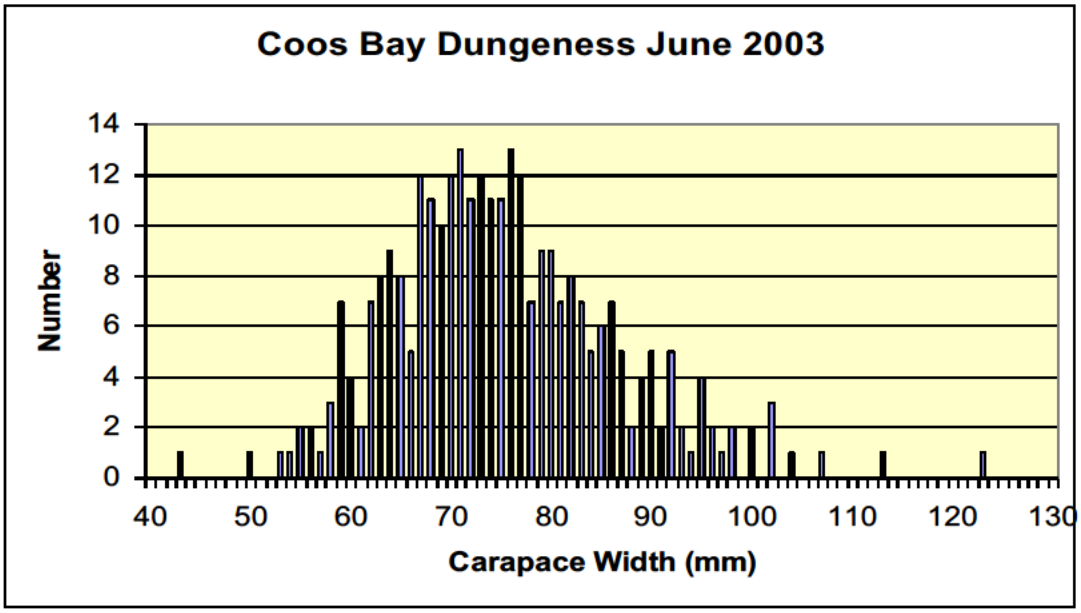


Figure 1. Size frequency distribution of Dungeness crabs trapped in pools and eelgrass at Russell Point, below the Highway 101 McCullough Bridge, in June 2003. Adult crabs are greater than 100 mm in carapace width. It is estimated that 2 year classes are represented.

Table 1. Trapping Data for study sites along Trans Pacific Lane and Roseburg Forest Product causeway from 2002-2014.

	Date	Trap Type	Zone	European green crab *Carcinus maenas*	Ha ry shore crab *Hemigrapsus oregonensis*	Purp e shore crab *Hemigrapsus nudus*	Dungeness crab *Cancer magister*	*Cancer magister* (Recru ts <50mm)	Red rock crab *Cancer productus*	stag horn scu p n	# Traps
Roseburg Lumber	6/25/2002	Fish	Site	0	0	0	45	0.5	0.1	0	10
Roseburg Lumber	6/16/2003	Fish	*low*	0	0	0	12.2	0	0.7	1.5	10
TransPacific S	7/10/2005	Fish	*low*	0	0	0	6.14	1.14	0	1.86	7
North	7/10/2005	Fish	*low*	0	0	0	0	5.7	0	1.1	10
South	3/25/2005	minnow	*Mid*	0	0	0	0	0	0	2.4	10
North	7/10/2005	minnow	*mid*	0	0.2	0	0	0.6	0	0.8	5
South	7/10/2005	minnow	*mid*	0	0	0	0	0.4	0	0.6	5
Trans-Pacific Bridge	9/1/2005	Fish	*Low*	0	0	0	6.6	0	3	1	5
	9/1/2005	Minnow	*high*	0	0	0	0.2	0	0	0.4	4
Trans-Pacific Ln.	6/8/2006	Fish	*Low*	0	0	0	4.9	0	0	2.6	10
	9/13/2006	Fish		0	0.4	0	0.2	0	0	0.2	5
	6/8/2006	Minnow	*high*	0	0	0	0.7	0	0	2.3	10
Trans Pacific Br.	9/13/2006	Minnow		0.2	0	0	0	0	0	0.2	5
TransPacific Ln. N	5/25/2007	Fish	Mid	0.5	0.2	0	1	0.1	0	0.8	10
	7/14/2007	Fish		0.4	1.47	0	23.53	0	0	0.2	15
	9/26/2007	Fish		0	0	0	4.75	0	0	0	8
TransPacific Ln. S	5/25/2007	Fish	Mid	0.09	0	0	0.82	0	0	0.36	11
	7/14/2007	Fish		0.27	0.07	0	9	0	0.07	1	15
	9/26/2007	Fish		0	0	0	2.71	0	0	0.14	7
TransPacific Bridge	5/25/2007	Fish	Mid	0	0	0	1.33	0	0	0	6
	9/25/2007	minnow	high	0	0	0	1.6	0	0	0.4	5
TransPacific Ln. N	6/18/2008	Fish	Mid	0.1	0.2	0	7.4	0	0	7.8	10
	6/19/2008	Fish		0	0	0	1.75	0	0	3.25	8
	9/18/2008	Fish		0	0.1	0	23.4	0	0	0.7	10
TransPacific Ln. S	6/18/2008	Fish	Mid	0.5	0	0	17.2	0	0	2.2	10
	6/19/2008	Fish		0.37	0	0	17.63	0	0	1.37	8
	9/18/2008	Fish		0.1	0	0	22.6	0	0	0.3	10
TransPacific Ln. N	7/8/2009	Fish	Mid	0.13	0	0	9.88	0	0	0.38	8

	7/9/2009	Fish		0.1	0.2	0	11.3	0	0	0.3	10
	07/0/09	Fish		0.1	0	0	11.7	0	0	0.5	10
TransPacific Ln. S	7/8/2009	Fish	Mid	0	0	0	24.38	0	0	0.25	8
	7/9/2009	Fish		0.1	0	0	30.2	0	0	0.9	10
	7/10/2009	Fish		0.4	0	0	16.6	0.1	0	0.5	10
	7/11/2009	Fish		0.4	0	0	13.1	0	0	2.7	10
TransPacific Ln. N	3/19/2010	Fish	Mid	0	0.4	0	0.7	0	0	0	10
	3/20/2010	Fish		0	0.1	0	0.1	0.2	0	0	10
	3/21/2010	Fish		0	0.3	0	0.3	0.4	0	0	10
	6/25/2010	Fish		0	0	0	35.7	0	0	1.1	9
	6/26/2010	Fish		0	0	0	75.9	0	0	0.4	10
TransPacific Ln. S	3/19/2010	Fish	Mid	0	0	0	1.9	0.9	0	0	10
	3/20/2010	Fish		0.1	0	0	1.7	0	0	0	10
	3/21/2010	Fish		0	0	0	2.5	0.1	0	0	10
	6/25/2010	Fish		0	0	0	90.6	0	0	0	10
	6/26/2010	Fish		0	0	0	69.9	0	0	1.6	20
TransPacific Ln. N	7/17/2011	Fish	Mid	0	0.6	0	4.73	0.27	0	0.73	15
	10/17/2011	Fish		0	0	0	5.3	0	0	0.2	10
TransPacific Ln. S	7/16/2011	Fish	Mid	0.03	0.09	0	1.5	0.06	0	1.53	34
	7/17/2011	Fish		0	0.13	0	2.07	0.47	0	1.2	15
TransPacific Ln. N	6/27/2012	Fish	Mid	0	0	0	89.2	0	0	0.4	5
TransPacific Ln. S	6/25/2012	Fish	Mid	0	0	0	9.75	0	0	0.75	12
	6/27/2012	Fish		0.11	0	0	5.2	0	0	0.67	9
TransPacific Ln. S	3/22/2013	Fish	Mid	0	0	0	1.75	0	0	0	20
	3/23/2013	Fish		0	0	0	6.79	0	0	0	19
	7/12/2013	Fish		0	0	0	7.37	0	0	1.6	30
	7/13/2013	Fish		0	0	0	5.24	0	0	1.48	25
TransPacific Ln N	7/12/2014	Fish		0	0	0	40.33	0	0	0.5	12
	7/13/2014	fish		0	0	0	24.9	0	0	0.4	12
TransPacific Ln. S	7/12/2014	Fish		0	0	0	47.27	0	0	0	15
	7/13/2014	fish		0	0	0	23.83	0	0	0	12
Average				0.068	0.075	0	14.955	0.067	0.065	0.874	
Total # Traps											649

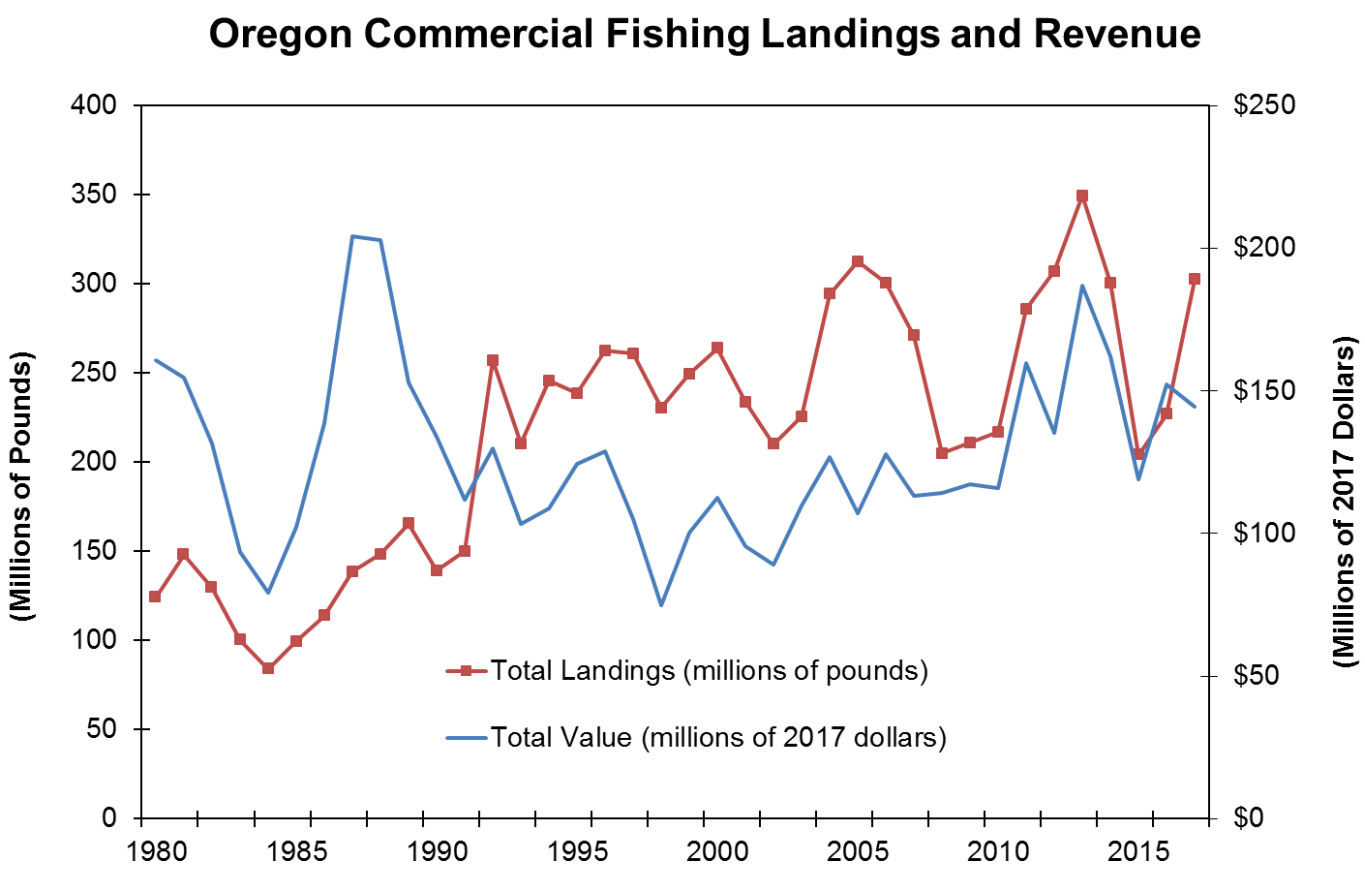
Oregon's Commercial Fishing in 2017

May 2, 2018 *by Erik Knoder*

Oregon's commercial fishing industry fell to about an average level in 2017. Harvests have been averaging $147 million (2017 dollars) per year since 2010 – after adjusting for inflation. Total landed value was $144 million in 2017. This was down from $152 million in 2016. The decrease was mainly due to the drop in the pink shrimp harvest, and the salmon harvest also fell. The pacific whiting (hake) harvest rose, and the crab and groundfish harvest also increased in 2017. Other fisheries combined for a modest decrease. Overall revenue dropped even though landed volume was up for the year.

Crab harvests in 2017 rose to 19 million pounds, the best harvest since 2013. A late start to the season and lower prices worked to offset some of the gain from higher populations, but the crab harvest was worth $58.7 million in 2017 versus $55.7 million the year before. Dungeness crab is usually Oregon's most valuable fishery, and it was again in 2017.

Salmon landings fell sharply in 2017 to 1.2 million pounds. This was less than 40 percent of the average of recent years. Prices increased slightly to $4.65 per pound, but the total landed value was only $5.6 million, a drop of $2.8 million from the previous year.



Source: PacFin and the Oregon Department of Fish and Wildlife

The pink shrimp season was hit with a double whammy in 2017. The harvest was only 23 million pounds, a decrease of 12 million pounds from 2016. On top of that, shrimp prices fell by 16 cents per pound, so total value landed dropped 49 percent to $12.7 million. Oregon pink shrimp was certified as a sustainable fishery by the Marine Stewardship Council in 2007 and reassessed as sustainable in 2011.

The amount of whiting landed rose 78 percent in 2017 to 201 million pounds. Whiting accounted for about two-thirds by weight of all wild seafood landed in Oregon. Prices stayed at eight cents per pound so total landed value for this fishery increased to $16.4 million total. Much of Oregon's whiting is made into surimi for use in making artificial crab meat.

The value of groundfish landed increased 11 percent in 2017 to $35.7 million. The amount landed actually increased 36 percent, but a drop in prices limited revenue.

The albacore tuna harvest fell for the third straight year. The harvest fell about 35 percent, but the price climbed to $2.28 per pound, so the total value dropped by only 14 percent in 2017 to $10.8 million. Albacore has become an important fishery in recent years, especially for smaller boats that depended on salmon.

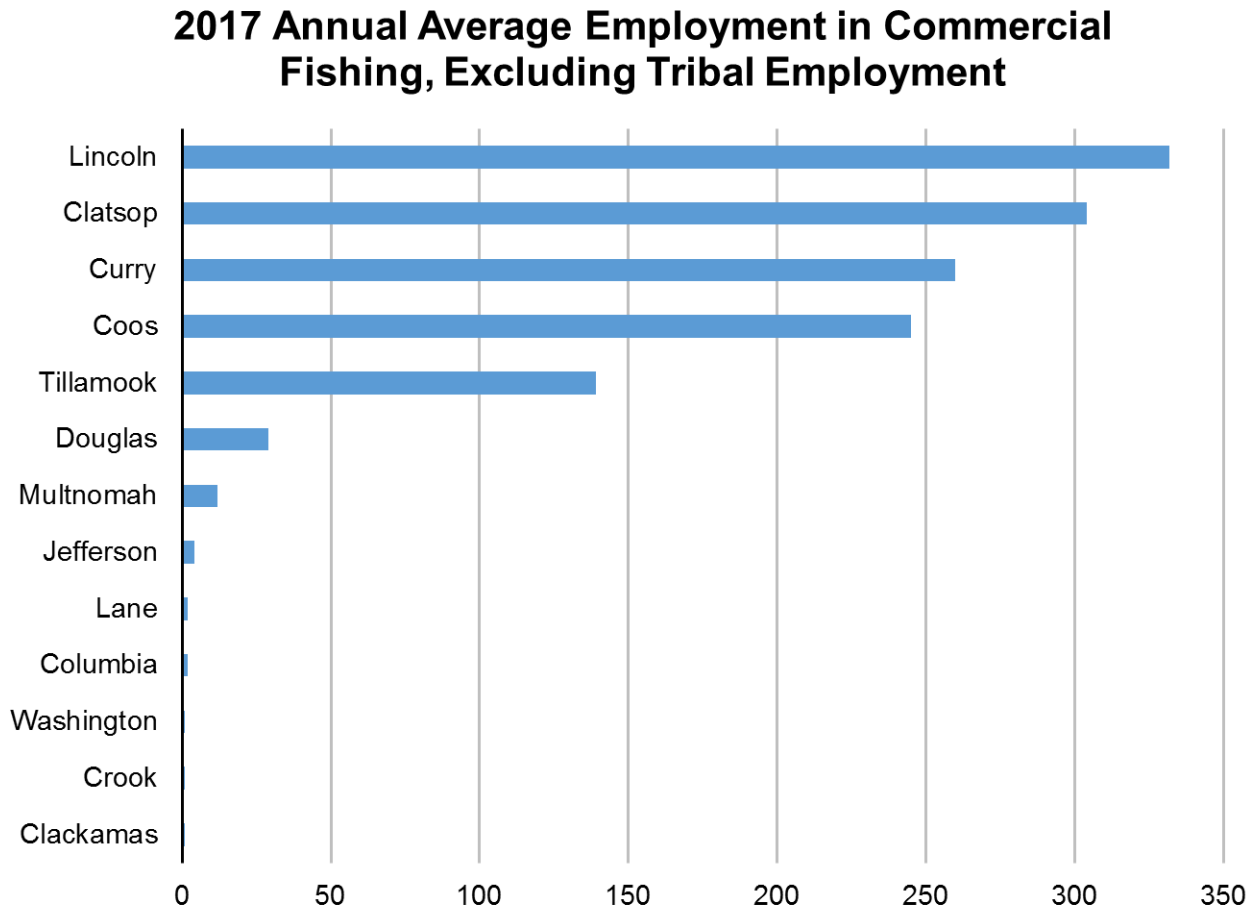
Some smaller fisheries had notable changes. The anchovy harvest decreased from $1.2 million in 2016 to zero after ODFW limited harvests to protect the stock. The sardine fishery remained closed in 2017. Squid harvests also went to zero in 2017 from $1.1 million in 2016. This fishery is usually very small or nonexistent. The Pacific cod harvest dropped by $440,000 and razor clams were down by $350,000. Slime eels (hagfish) harvests rebounded by $273,000 in 2017. Much of

the harvest is exported. Sea urchin harvests were up by $213,000 and gaper clam harvest rose by $95,000.

Employment

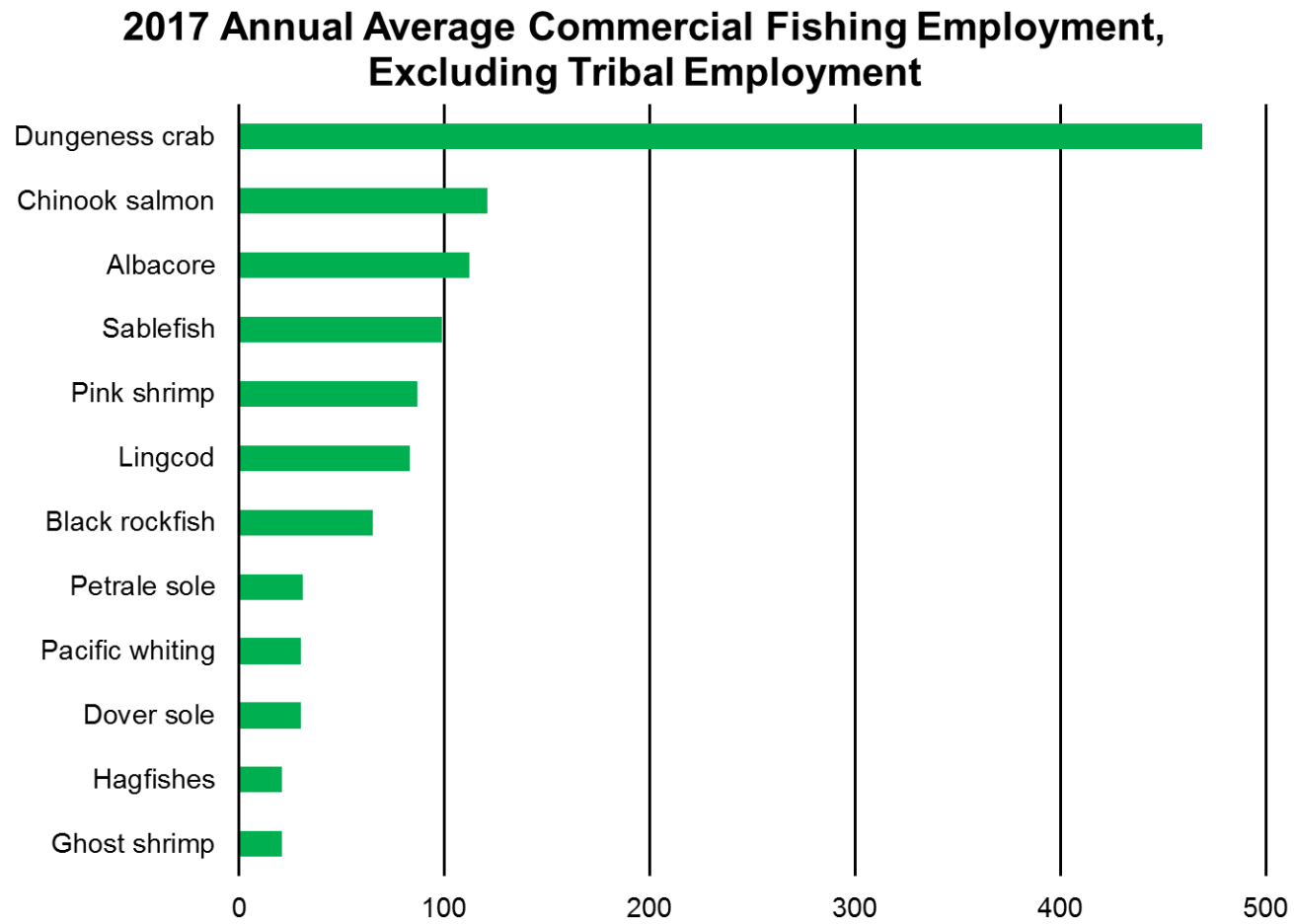
There were an estimated 1,330 commercial fishers in Oregon on an annual average basis in 2017. This was down from 1,438 in 2016, and was not too surprising given the decrease in harvests.

Estimating employment in fishing is more difficult than measuring the harvests. Legislation in 1999 allowed most fishermen to be exempt from unemployment insurance coverage – the primary source of employment data. The Oregon Employment Department now estimates the number of fishers based on a combination of survey data and the number of commercial fish landings made. This method was new for 2014 and resulted in a lower employment estimate than before.



Source: Oregon Department of Fish and Wildlife, Oregon Employment Department

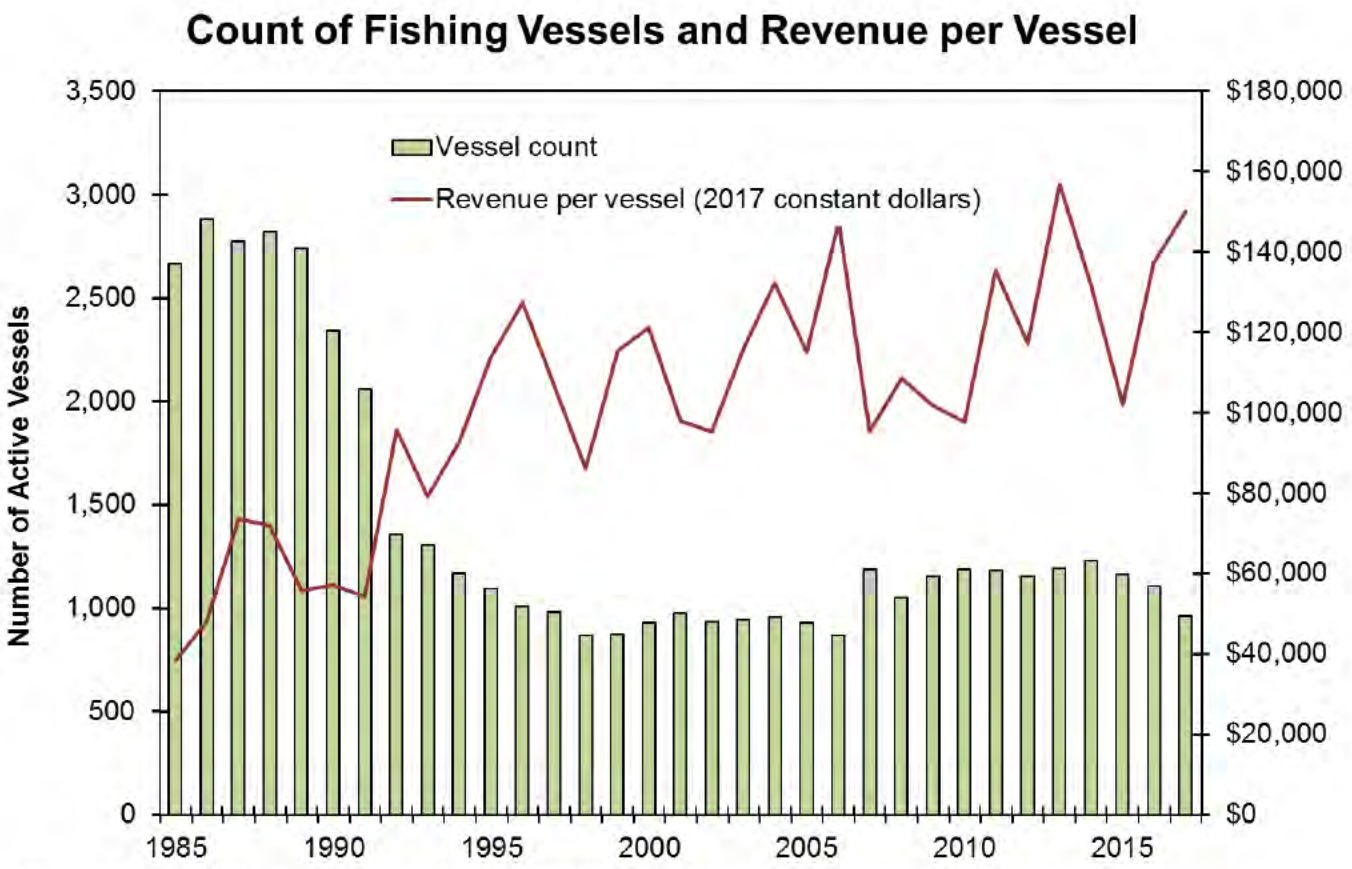
The estimated number of fishers varied from a high of 1,784 in July to a low of 520 in November. Five coastal counties – Clatsop, Lincoln, Coos, Curry, and Tillamook – had 96 percent of the total employment, based on where landings occur. Perhaps even more surprising is that some interior counties, such as Jefferson and Washington, had any commercial fishing employment. These jobs are often based on crayfish harvests. The most important fisheries for employment are crab, salmon, and albacore tuna. Commercial fishers harvested more than 100 different species in 2017.



Source: Oregon Department of Fish and Wildlife and Oregon Employment Department

Revenue

Although the number of fishing vessels has declined from historic highs, it has become more stable over the past decade. Fishing is slowly generating more revenue per boat, with plenty of fluctuations. There were 963 vessels with at least one landing in 2017, down from 1,108 in 2016. They averaged about $150,000 each in landed value in Oregon, up 9 percent from the previous year. Each vessel supported about 1.4 fishers on an annual average basis; many vessels have landings only part of the year.



Source: PacFin and Oregon Department of Fish and Wildlife

In addition to direct employment, commercial fishing provides the resource for seafood processors. There were 32 seafood processors in Oregon that had employees in 2017, two more than in the previous year. The annual average direct employment for the entire industry was 1,172. Some processors also use temporary help firms to round out their staffing, but these employees are counted in the business services industry. The processing industry paid more than $40 million in wages in 2017, which clearly shows the benefit of adding value to raw natural products.

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Native Oysters in the Coos Estuary

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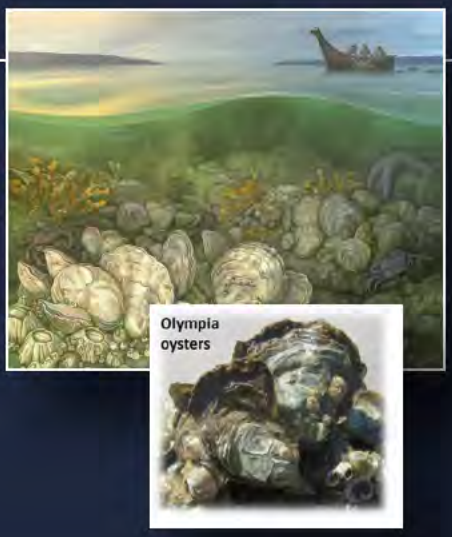


Summary:

- *Olympia oyster populations appear to be stable and even increasing. A 2006 survey shows native oysters present in multiple Coos estuary subsystems including particularly dense patches in the Upper Bay.*
- *However, native oysters are present in much smaller numbers today than in the early 20th century.*
- *Researchers are re-introducing adult oysters in the Coos estuary and investigating the biology and ecology of naturally occurring Olympia oysters.*

(Source: Groth and Rumrill 2009)

Figure 1. Status of native oysters in the Coos estuary in the South Slough, Lower Bay, North Slough, Haynes Inlet, Upper Bay and Isthmus Slough subsystems.

Evaluation

Status of Native Oysters is stable and improving and should continue to be monitored.

What's happening?

The Olympia oyster (*Ostrea lurida*) is the only oyster native to the U.S. West Coast, and was once abundant in estuaries from Baja California to Sitka, Alaska. Interestingly, the oyster was not present in Coos Bay at the time Europeans settled in the area, but shells found in dredge spoils and shell middens indicate that they were present in the area historically and were harvested by Native Americans. One hypothesis is that a tsunami and/or fire caused a huge input of sediment into the bay, smothering the oyster population.

In the 1980s, Olympia oysters were discovered growing in Coos Bay once again. Genetic similarities between Olympia oysters in Coos Bay and those in Willapa Bay, WA suggest that the local reappearance of this species was likely the result of an introduction event from Willapa (Stick 2011). It is likely that they arrived as juveniles attached to the shells of (non-native) Pacific oysters grown commercially in Willapa Bay and transported to Coos Bay. These juvenile Olympia oysters may have then spawned and their larvae settled elsewhere in the bay, setting up a new population.

Presently, the Olympia oyster population here appears to be stable and even increasing. A 2006 survey shows the oyster to be present mainly in the upper part of the bay, with particularly dense patches along the waterfront of Coos Bay, North Bend, and Eastside (Figures 1 and 2). An increasing number of researchers have become interested in restoring Olympia oyster populations (Figure 3). Researchers at the South Slough Reserve are attempting to recreate an oyster population in the South Slough estuary. They are also partnering with the Oregon Institute of Marine Biology (OIMB) to conduct research into the biology and ecology of the oysters in Coos Bay (see below).

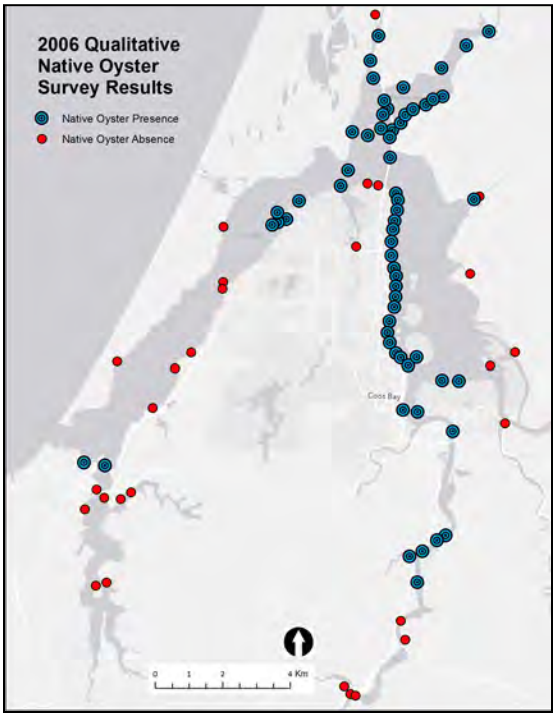


Figure 2. 2006 qualitative native oyster survey results Data: Groth and Rumrill (2009)

Figure 3. Volunteers aid in the restoration of native populations of Olympia oysters (*O. lurida*) in Coos Bay

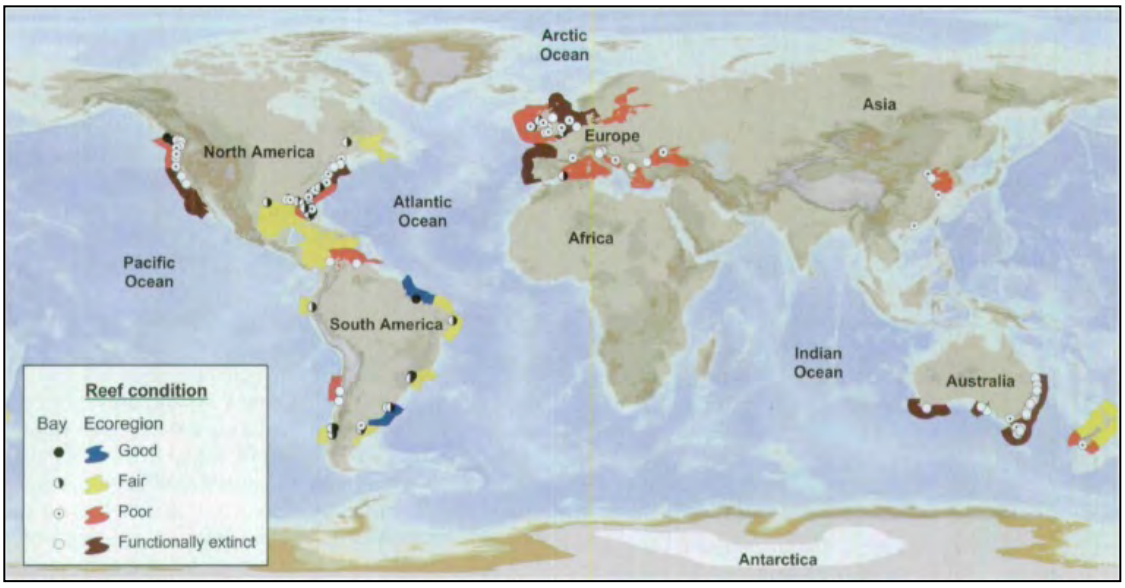
Why is it happening?

The disappearance of Olympia oysters in Coos Bay is most likely the result of a natural disaster. One hypothesis is that a tsunami and/or fire caused a huge input of sediment into the bay, smothering the local oyster population. In recent history, populations of Olympia oysters outside the Coos Bay area have also experienced a pattern of decline. Around the turn of the 20th century, Olympia oysters were heavily harvested along the West Coast, mainly for the San Francisco market. This overharvesting, as well as the increased development of estuarine areas, loss of hard substrate, sedimentation, and pollution caused the Olympia oyster population to decline dramatically.

The decline of oyster populations on the West Coast in the 20th century is indicative of a larger global trend (Figure 4). Several factors have contributed to the decline of oyster reefs across the globe. The extensive harvest of wild oyster populations has commonly led to the loss of reef structure, which exacerbates the impact of additional stresses such as anoxia, sedimentation, disease, and non-native species (Beck et al. 2011). Other anthropogenic influences including the modification of coastlines, changes to freshwater inflow regimes, sedimentation, nutrient loading, and pollution have further contributed to the decline of oysters across the globe (Beck et al. 2011; NRC 2004). A loss of 85 percent of the world's oyster reefs relative to historic abundance levels is estimated, and over a third (37 percent) of existing oyster reefs in bays across the globe are considered functionally extinct (Beck et. al. 2011).

The conservation of oysters on a global as well as local scale is important, because oysters provide many ecosystem services, including water filtration, shoreline stabilization, and habitat for many animals (e.g., fish, crabs, and birds)(Beck et al. 2011). There

Figure 4. Condition of the world's oyster reefs. < 50% lost = Good; 50% to 89% lost = Fair; 90% to 99% lost = Poor; > 99% lost = functionally extinct. GRAPHIC: Beck et al. (2011)



are also beneficial secondary effects that are associated with these ecosystem services. For example, water filtration can serve to remove excess nutrients, thereby reducing likelihood of harmful algal blooms that have many ecological as well as economic consequences (Beck et al. 2011). In order to protect these valuable ecosystem services and promote biodiversity in the Coos estuary, two main oyster restoration projects have been spearheaded. These projects are supported by NOAA's Community-based Restoration Program (CRP) and the National Estuarine Research Reserve System (NERRS) Science Collaborative program.

What's being done?

The CRP has supported several research projects investigating the biology and ecology of native oysters, many of which were led or assisted by community members and college student interns. One project involved collecting oyster juveniles, or spat, on shell bags in Coos Bay and then transferring these bags to South Slough (see Figure 3). Researchers then monitored the growth and survival of these juveniles for about a year. The juveniles survived well and grew, on average, about 10 mm between January and July.

Although the CRP projects were completed in 2009, South Slough Reserve science staff members continue to monitor these shell bags, and are currently in the process of moving them from their current location at Younker Point to a more suitable area near Long Island Point. Monitoring living adults in South Slough will provide data on the feasibility of restoring oysters to this area; the adults may also serve as local sources of natural occurring Olympia oyster larvae for use in future restoration efforts, if needed.

A thorough understanding of the reproductive development of Olympia oysters in Coos Bay is a critical component of the advancement of local restoration efforts. As a means towards that end, the South Slough Reserve and OIMB are partners in several Olympia oyster research projects supported by the NERRS Science Collaborative program. Graduate students at OIMB are currently investigating sexual development and timing of oyster larval brooding and release; mechanisms of oyster larval retention in the bay; oyster larval abundance vs. settlement throughout Coos Bay; and oyster growth and survival throughout the bay.

The results of this research have provided important insights into the life history of native oysters in the Bay. Oates (2013) found that intertidal oysters in Coos Bay have a reproductive period of approximately three to four months, and reproduction corresponds to water temperatures of approximately 15-19° C (59-66° F). These findings corroborate previously conducted research (Hori 1933; Hopkins 1937; Imai et al. 1954). In addition to temperature, brooding closely corresponds to high chlorophyll-a concentrations, suggesting a positive relationship between food availability and reproductive output of oysters (Oates 2013).
Temperature and chlorophyll-a concentrations alone, however, fail to completely explain the timing of reproductive events of

native oysters in Coos Bay. Oysters exposed to low salinity regimes in Coalbank Slough experienced repressed levels of gametogenesis, suggesting that the reproductive success of native oysters in Coos Bay may be critically dependent on salinity parameters (Oates 2013). Further research suggests that other abiotic factors such as tidal mixing and changes in precipitation regimes may also affect recruitment patterns and larval distribution in juvenile Olympia oysters (Prichard 2013). More research is required in order to fully understand the effects of salinity and other ambient parameters (e.g., dissolved oxygen or pH) on the reproductive success of native oysters in Coos Bay.

Additional research provides restoration practitioners with guidelines concerning the settlement preferences of native juvenile oysters in Coos Bay. Sawyer (2011) found that juvenile Olympic oysters were generally non-selective in their settlement preference when provided with a variety of hard substrata, including both live and dead species of native Olympic oysters and non-native Pacific oysters (*Crassostrea giggas*). However, juveniles did demonstrate a clear preference for settlement on the bottom of shells.

These findings indicate that the type of substrate provided for settlement is unlikely to limit the success of local restoration efforts. They further indicate that restoration efforts may benefit by suspending settlement substrata in the water column in order to allow for easy access to bottom of shells. Interestingly, the non-selective settlement tendencies of Olympic oysters implies that the commercial harvest of Pacific oysters represents a potential "recruitment sink" in that juvenile Olympic oysters that have settled on mature Pacific oysters become, in effect, bycatch upon the harvest of these individuals (Sawyer 2011).

Restoration decisions involving the placement of settlement substrata relative to the location of existing adults will benefit from a further understanding of the spatial preferences of juvenile Olympia oysters. As a means to this end, Prichard (2013) has studied recruitment patterns and larval distributions in Coos Bay. Her research suggests that juvenile Olympia oysters tend to settle in close proximity to previously established populations of adults, suggesting that these oysters have relatively limited larval distributions. Research investigating the timing of settlement of Olympia oysters in Coos Bay is on-going, and restoration efforts will also benefit from a well-developed understanding of the temporal settlement preferences of these oysters (R. Rimler, pers. comm., Nov. 2013).

The genetic practices of restoration projects are likely to directly affect the degree to which native oysters may successfully reestablish themselves in Coos Bay. The genetic distance between populations of Olympia oysters is a function of the geographic distance between those populations; that is to say that Olympia oysters in California, for example, are genetically distinct from oysters of the same species in Coos Bay (Stick 2011). The marked exception to this finding is the

population of Olympia oysters in Willapa Bay, WA, which is genetically very similar to the population of oysters in Coos Bay despite the geographic distance between these two sites (Stick 2011). As previously mentioned, this is likely the result of a previously occurring introduction event from Willapa Bay to Coos Bay. In order to assure the long-term viability of restoration efforts in Coos Bay, the implications of collecting broodstock from geographically distant sources should be carefully considered until it can be determined whether these populations are locally adapted (Stick 2011).

Work to further understand the status of contaminants in the Bay that may be harmful to native oyster stocks has also been undertaken by the Oregon Department of Environmental Quality (ODEQ). Butyltins, which are chemicals found in anti-fouling boat bottom paints, are of particular concern because they have been shown to cause shell deformities and decreased reproductive capacity in oysters (Wolniakowski et al. 1987). In the late 1980s, ODEQ documented high concentrations of Butyltins in the waters of Coos Bay as well as in the tissues of locally produced Pacific oysters (Wolniakowski et al. 1987). Research has documented steady declines in local Butyltin levels since the late 1980s, suggesting that the on-going management and regulation has been relatively effective in abating this pollutant in Coos Bay (Elgethun et al. 1999). The local distribution of detected Butyltins did not closely correspond to the locations of their origin, suggesting that concentration of Butyltins may be more a function of estuary bathymetry and tidal flushing patterns than proximity to point sources (Elgethun et al. 1999).

Peteiro and Shanks (2014) have studied migratory patterns in larval Olympia oysters. Their findings suggest that larval oysters in Coos Bay have some capacity to perform tidal-timed migrations, but their swimming ability is usually overcome by current speeds. These results indicate that the effectiveness of tidal-timed migrations in the estuary may be limited by local hydrology, and strategies for maximizing larval retention may benefit from detailed studies on local hydrodynamics.

Background

Oysters are bivalves, a type of mollusk characterized by two opposing shells, or valves. They are related to clams, mussels, and other commonly known and often edible mollusks. They feed by filtering small particles from seawater. Many oysters, like other bivalves, release sperm and eggs separately in the water, where they meet and fertilize to form

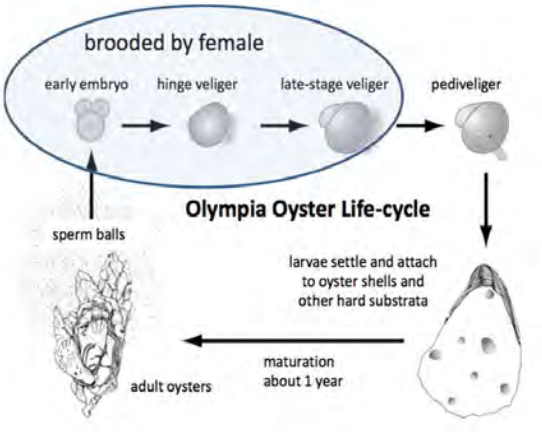


Figure 5. Life history of the Olympia oyster. GRAPHIC: Swanson n.d.

embryos outside the body of the mother. But Olympia oysters retain eggs within the mother's shell. They "brood" their embryos for several weeks before releasing the young, now called larvae, into the water column (see Figure 5).

All oysters and most bivalves produce larvae, which are generally less than a millimeter in length. The larvae swim, eat, and develop in the water for several weeks to several months. They then search for a hard surface on which to settle and metamorphose into a juvenile oyster.

Young oysters tend to settle near other oysters, forming large aggregations, or beds. These beds help stabilize the muddy bottom of the estuary and may improve habitat conditions for eelgrass, an important estuarine plant. Once settled, oysters are cemented to the substrate and remain attached to the substrate for the rest of their lives. The hard, complex surfaces provided by groups of oysters provide a unique habitat in which other estuarine animals can hide, settle, or lay eggs. In this way, a substantial oyster population could increase species diversity.

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HISTORY OF OLYMPIA OYSTERS (*OSTREA LURIDA* CARPENTER 1864) IN OREGON ESTUARIES, AND A DESCRIPTION OF RECOVERING POPULATIONS IN COOS BAY

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ABSTRACT Historical evidence indicates that Olympia oysters (*Ostrea lurida*)† are indigenous to at least three of Oregon's estuaries. Populations of *O. lurida* occur in Yaquina Bay, Netarts Bay, and Coos Bay, although only the population in Yaquina Bay seems likely to have been continuous since prewestern settlement. The historical occurrence of Olympia (native) oysters in Yaquina and Netarts Bays is confirmed by numerous records of fishery landings. In contrast, historic populations in Coos Bay are inferred by the presence of large shell deposits buried in sediments throughout the polyhaline (salinity >18 30) region of the estuary. Other Oregon estuaries (such as Tillamook, Alsea, and Umpqua/Winchester Bay) may have had ambient environmental conditions suitable to support self sustaining populations of *O. lurida*, but none of these estuaries are currently inhabited by natural populations, nor do they exhibit clear historical records of occupation in the past. We conducted searches of background information on many estuaries to summarize knowledge about the status of *O. lurida* populations in Oregon. The information presented here is based on a literature search, analysis of internal agency documents, and personal contacts with individuals most familiar with specific estuaries. As a case study, the Oregon Department of Fish & Wildlife (ODFW) repeated intertidal field surveys previously conducted in 1997 in an effort to document changes in *O. lurida* populations within Coos Bay. Field surveys conducted in 2006 followed methods that were similar to the 1997 intertidal surveys. Using previously published results as a baseline, we found that populations of native oysters exhibited spatial expansion throughout the mesohaline and polyhaline regions of the estuary, and that the intertidal oysters occurred at increased densities, over a wider range of sizes, and over a broader range of habitats. Further recovery of *O. lurida* populations in other regions of Coos Bay is most likely limited by the availability of suitable substratum for attachment and growth of the juvenile oysters.

KEY WORDS: Olympia oyster, Native oyster, Yaquina Bay, Coos Bay, Netarts Bay, Oregon, *Ostrea conchaphila*, *Ostrea lurida*, oyster populations

INTRODUCTION

Olympia oysters (*Ostrea lurida*) were once abundant and ecologically important components of estuarine communities throughout the Pacific Northwest biogeographic region. Living beds of oysters occurred within the lower intertidal and subtidal regions of the estuaries where they most likely provided several key ecosystem services including: (a) maintenance of a hardened substratum that served as benthic habitat for many species; (b) biofiltration of phytoplankton and sediment particles from the water column; (c) pelagic benthic coupling resulting in the secondary production of molluscan tissue and other organic materials; and (d) increased biotic diversity and foraging areas for invertebrates, fish, and shorebirds. In addition, the dense beds of Olympia oysters also provided local indigenous people with an important source of food, and larger scale harvests of *O. lurida* constituted an economically valuable commercial fishery in Washington, California, and parts of Oregon (Gordon et al. 2001, Baker 1995). Regional popularity of the native oysters as a targeted fishery species led to massive removal of shells from the benthic substratum and over harvests in the late 1800s, and these practices contributed to a region wide collapse in many Pacific coast estuaries during the late 19th and early 20th centuries.

Upon the arrival of European settlers to coastal Oregon (1850s), populations of Olympia oysters were only found in Yaquina Bay and Netarts Bay (Marriage 1954, Baker 1995). Extensive shell deposits were observed in Coos Bay, however, and provide clear evidence that large populations of *O. lurida* occurred in the past. No living oysters were found in Coos Bay at the time of European settlement (Dall 1897). Based on water quality parameters and proximity to larval supply, other bays such as Tillamook, Alsea, Siletz, Siuslaw, Umpqua, Coquille, and others may have, over the course of geologic history, been suitable for *O. lurida* populations. However, conclusive evi dence of the historical presence of *O. lurida* in these other estuaries is lacking. The overall purpose of this project was to document the historical and recent occurrence of *O. lurida* in Oregon estuaries, and to describe the spatial extent and recovery of Olympia oyster populations within Coos Bay.

HISTORICAL AND RECENT OCCURRENCE OF OLYMPIA OYSTERS IN OREGON ESTUARIES

Estuaries with Confirmed Populations of Olympia Oysters

Netarts Bay

Netarts Bay is a small (930 ha), marine dominated, bar built estuary located along the northern shoreline of Oregon (Fig. 1). The mouth of the estuary has not been stabilized by jetties, and the shallow tidal basin contains extensive sand flats, mudflats, and eelgrass beds as well as primary and secondary tidal channels. The watershed drainage basin for Netarts Bay is

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†The taxonomy of the Olympia oyster has been in dispute since Harry (1985) proposed synonymy of *Ostrea lurida* Carpenter 1864 and *Ostrea conchaphila* Carpenter 1857. Polson et al. (2009) provide molecular evidence that the Olympia oyster refers to the nominal species, *Ostrea lurida* Carpenter 1864. In view of their genetic data, and for consistency, the original taxon, *Ostrea lurida*, is used throughout this volume to refer to the Olympia oyster, which is distributed from approximately Baja California (Mexico) to southeast Alaska.

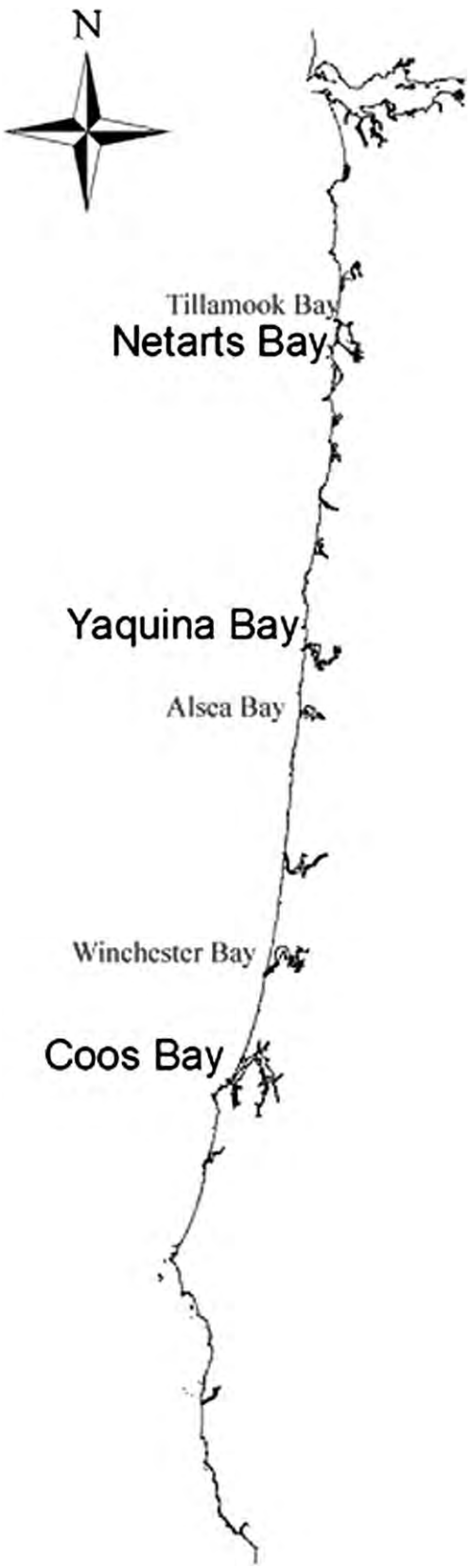

Figure 1. Map of Oregon estuaries indicating the location of confirmed populations of *O. lurida* in Netarts Bay, Yaquina Bay, and Coos Bay. The map also indicates the location of other estuaries (Tillamook Bay, Alsea Bay, Winchester Bay) that may be suitable for populations of Olympia oysters.

approximately 3,626 ha, and input of freshwater occurs through numerous small creeks.

Netarts Bay historically supported a commercial fishery for *O. lurida* beginning in the 1860s, but overall landings and duration of the fishery were always substantially lower than that of Yaquina Bay. Commercial harvest of Olympia oysters took place in the upper region of Netarts Bay where water quality parameters are most favorable (Stout 1976, Bonacker et al. 1979). In the 1930s native oysters were believed to exist in low numbers in Netarts Bay, and the remaining populations may have been affected by localized introduction in 1957 of *Oce nebra japonica* (Dunker 1860), a nonindigenous gastropod predator, (Stout 1976) concurrent with the introduction of Pacific oysters (*Crassostrea gigas*) from Japan. Olympia oysters were found to be "present in very small numbers upbay" in the mid century (Marriage 1954), and the oysters were considered to be "locally extinct" by 1979, although many areas of the upper bay where oysters would be expected to survive were not surveyed (Kraeg 1979). Qualitative surveys of Netarts Bay conducted by the Oregon Department of Fish and Wildlife in 1992 did not discover any living oysters (J. Johnson, pers. comm.). An attempt was made by ODFW to re establish the oysters in Netarts Bay over the period from 1993 1998. The reintroduction effort included establishment of approximately 9 million spat set on 150 sacks of nonindigenous Pacific oyster (*C. gigas*) cultch (ODFW, unpublished records). This effort likely re established ephemeral populations of *O. lurida* that were detected in 2004 during surveys carried out by The Nature Conservancy (TNC). A field experiment was undertaken within Netarts Bay in 2005 to 2006 to investigate the ecological effect of cultch (i.e., *O. lurida* juveniles on nonliving *C. gigas* shell) on native oyster survival, growth, and eelgrass abundance (Archer 2008). Currently, TNC is continuing their efforts to restore populations of Olympia oysters in Netarts Bay (D. Vander Schaaf, pers comm.).

Yaquina Bay

Yaquina Bay is a moderately sized (1,700 ha), drowned river mouth estuary located along the central Oregon coast (Fig. 1). The mouth of the bay is protected by rock jetties and rip rap, and the estuarine tidal basin contains a primary navigational channel, extensive sand flats and mudflats, sub sidiary sloughs, and an elongated riverine region. The water shed drainage basin for Yaquina Bay is about 65,526 ha, and the Yaquina River provides the primary source of freshwater inputs.

Environmental conditions within Yaquina Bay have been suitable over long time periods to allow for persistent popula tions of *O. lurida*. The most productive commercial harvests of native oysters were limited to a three mile stretch of polyha line (salinity >18 30) and mesohaline (salinity >5 18) waters (Fasten 1931). Oyster stocks within this confined region of the estuary were considerable in the past, and success of the oyster harvest contributed to colonization of the Newport area by European settlers (Dimick 1939). Harvests of Olympia oysters began to decrease in the 1890s, and significant commercial operations ended in the 1940s. Populations of *O. lurida* were not supplemented in Yaquina Bay throughout the years of the commercial fishery. The eventual decline of Olympia oysters in Yaquina Bay is attributed primarily to over fishing, although other factors such as pollution and habitat loss were also factors

(Dimick et al. 1941). Various habitat enhancement efforts have taken place in Yaquina Bay from the early years of the fishery to the present. Like many habitat enhancement projects related to *O. lurida*, they focused on the addition of cultch as a means to replace habitat loss associated with harvest and removal of shell rubble.

The presence of *O. lurida* in Yaquina Bay is well documented in historical accounts to the present, indicating adequate larval supplies and the persistence of self sustaining populations (Dimick et al. 1941, Baker 1995). Occurrence of natural popu lations of *O. lurida* has recently been confirmed by a coast wide survey to document peak densities of Olympia oysters in the intertidal zone (M. Polson, pers. comm.). Efforts to enhance populations of *O. lurida* in Yaquina Bay have been undertaken by the United States Army Corps of Engineers (mid 1990s) and by the Confederated Tribe of Siletz (2005 2006, S. Van De Wetering, pers. comm.).

Coos Bay

Coos Bay is a large (5,383 ha), drowned river mouth estuary located along the shoreline of south central Oregon (Fig. 1). The mouth of the bay is protected by a rocky headland, rock jetties, and rip rap. The estuarine tidal basin contains a primary navigational channel, extensive sand flats and mudflats, several subsidiary inlets and sloughs, and an elongated riverine region. The watershed drainage basin for Coos Bay is about 157,470 ha, and the Coos and Millicoma Rivers provide the primary source of freshwater inputs.

The shoreline and bottom of Coos Bay contain massive shell deposits of *O. lurida*. However, no live *O. lurida* were observed at the time of European settlement (1850s). Absence of living oysters has been attributed to a local extinction event (Baker 1995, Baker et al. 2000); the Olympia oysters were most likely decimated by the excessive inputs of sediments that resulted from a "big fire" in 1846 (Dimick et al. 1941), and/or because of sedimentation associated with a subduction zone earthquake and tsunami in 1700 (Nelson et al. 1996). Contemporary re establishment of Olympia oysters in Coos Bay has been described by Baker (1995) and Baker et al. (2000).

A few living individuals of *O. lurida* were found in 1986 in Haynes Inlet (northern region of Coos Bay) near commercial aquaculture plats (*Crassostrea gigas*). Small individuals of *O. lurida* were commonly observed on the bottom of Isthmus Slough (southern region of upper Coos Bay) in 1988 (Carlton 1989, Baker 1995). By 1997, self sustaining populations of *O. lurida* had also become established within the East Arm of Coos Bay (Baker et al. 2000). Because that time, the populations of *O. lurida* in Coos Bay have expanded in spatial distribution and abundance. To date, these populations have reached intertidal densities of $>60/m^2$ (documented by quantitative surveys along transect lines), although higher localized densities have been observed during qualitative surveys (S. Groth, pers. obs.).

No deliberate attempts to further establish or enhance populations of *O. lurida* have occurred in Coos Bay subsequent to their recent return. Anecdotal evidence exists for unsuccess ful introductions of *O. lurida* in the early 1900s (Baker et al. 2000) and mid 1960s. These attempts have not been quantified or fully substantiated. A new project supported by the NOAA Community Based Restoration Program will investigate fac tors that contribute to recovery of Olympia oysters in the South Slough estuary (S. Rumrill, pers. obs.). The project will evaluate the survivorship, growth, and ecological interactions for an experimental population of *O. lurida* in the polyhaline region of the South Slough tidal channel.

Estuaries with Potential for Populations of Olympia Oysters

We are confident that populations of *O. lurida* occurred historically within Netarts Bay, Yaquina Bay, and Coos Bay (Baker 1995). Given the tendency of *O. lurida* populations to undergo localized extinction followed by re establishment, it is clear that further evaluation is needed to provide diagnostic evidence of oyster presence or absence for other Oregon estuaries. Many other Oregon estuaries were examined for possible existence of historic populations of *O. lurida*, based on a review of their characterization and suitability for aqua culture of *C. gigas* (Osis & Demory 1976). Contradictory information was discovered for some estuaries. In particular, it is possible that Olympia oysters were historically harvested from Tillamook Bay. The close proximity of Tillamook Bay to Netarts Bay may be responsible for documented exportation of Olympia oysters during the period of intensive commercial harvest of *O. lurida* in Oregon. It is known that oysters were harvested from Netarts Bay, and then transported and shipped through Tillamook Bay, thereby providing a logical avenue for their documented records of export through Tillamook Bay (Stout 1976). No evidence of the natural presence of *O. lurida* populations was found for any estuaries other than Yaquina, Netarts, and Coos Bays (Baker 1995, this study).

SPATIAL EXTENT AND RECOVERY OF OLYMPIA OYSTERS IN COOS BAY

Description of Study Sites in Coos Bay

The Coos estuary (Coos Bay) is the sixth largest estuary along the Pacific coast of the contiguous United States (Proctor et al. 1980). As the largest estuary located completely within Oregon state lines, the Coos estuary is an important coastal industrial center and shipping port with direct commercial ties to San Francisco, the Columbia River, Puget Sound, and other major port facilities throughout the Pacific rim (Fig. 1). The Coos estuary is classified by the Oregon Department of Land Conservation and Development as a Deep Draft Development Estuary (Cortright et al. 1987; Jennings, et al. 2003) and its entrance is stabilized and protected by a pair of 1 km rock jetties. The navigational channel within the Coos estuary is routinely dredged to maintain adequate depths for commercial shipping, and the shoreline contains special zoning units for: (a) urban and industrial development, (b) conservation of natural resources, and (c) natural management of significant fish and wildlife habitats. Like many other Pacific northwest estuarine systems, the Coos estuary is a drowned river mouth that was inundated by tidal waters during the most recent transgression of sea level (beginning *ca.* 20,000 y ago; Thompson et al. 1993; Rumrill 2006).

Pony Point

The Pony Point study site (43°25′26.16″N/124°14′20.74″W) is located in the polyhaline region of the estuary near the lower bay range extent of Olympia oysters in Coos Bay (Fig.2, Fig. 3). The upper intertidal substratum is characterized by large basalt rip rap that secures adjacent fill deposited to form the runway

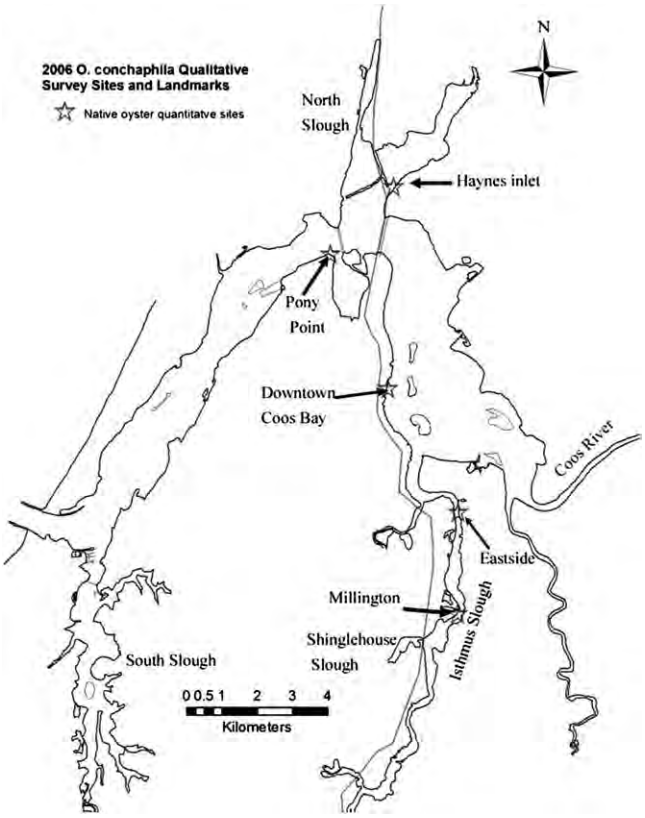

Figure 2. Coos Bay estuary, OR. Map indicates the location of local landmarks and five study sites examined in 2006 during quantitative surveys of *O. lurida* populations.

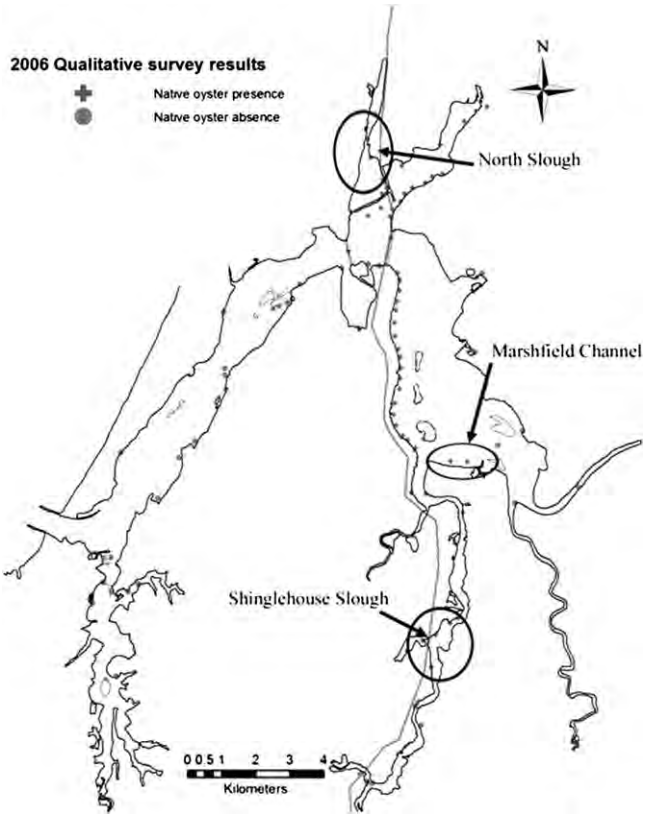

Figure 3. Coos Bay estuary, OR. Map indicates the distribution of *O. lurida* noted during qualitative surveys conducted throughout the bay in 2006. Circles indicate locations where substantial changes in distribution were observed in North Slough, Marshfield Channel, and Shinglehouse Slough.

for the local airport. Dense eelgrass beds (*Zostera marina*) occur in muddy sand in the lower intertidal area north of the airport. Rocky rip rap is the primary substrate used by *O. lurida* at this location and a diverse community of invertebrates co occurs, including arthropods (*Cancer magister, C. productus*, *Carcinus maenas*, *Hemigrapsus oregonensis*, *Neotrypaea californiensis*, and *Pachygrapsus crasspes*), bivalves (*Tresus capax, Clinocar dium nuttallii*, *C. gigas*, *Mya arenaira*, *Macoma* sp., *Mytilus* sp.), and gastropods (*Euspira lewisii*, *Nucella* sp.).

Haynes Inlet

The Haynes Inlet study site (43°26′38.79″N/124°12′48.85″W) is located in the polyhaline region of the estuary within a subestuary at the northern bend of Coos Bay (Fig. 2, Fig. 3). The intertidal substratum is characterized by sandstone and rip rap along the shoreline adjacent to tide flats used for commer cial oyster production. Hard surfaces (shell rubble, gravel, rip rap and rock) that are the preferred substratum for settlement of *O. lurida* in Coos Bay are not readily available in Haynes Inlet. Macro invertebrates common to this area include arthro pods (*C. magister, C. productus*, *C. maenas*, *H. oregonensis*, and *N. californiensis)*, bivalves (*C. nuttallii*, *C. gigas*, *M. arenaira*, *Macoma* sp., *Mytilus* sp.), and gastropods (*Nucella* sp.).

Downtown Coos Bay

The Coos Bay study site (43°23′30.17″N/124°13′2.42″W) is located in the mesohaline/polyhaline region of the estuary near the City of Coos Bay (Fig. 2,Fig. 3). The intertidal zone is characterized by steeply sloped rip rap banks adjacent to a deep (>30′ deep) dredged navigational channel. The preferred sub stratum for settlement of *O. lurida* at this site is primarily rip rap, and the narrow lower intertidal area below the rip rap is extremely soft mud and likely not suitable to support Olympia oysters. Invertebrates common to this area include arthropods (*C. magister, C. maenas*, *H. oregonensis*, and *N. californiensis)*; bivalves (*C. gigas*, *M. arenaira*, *Macoma* sp., *Mytilus* sp.); and gastropods (*Nucella* sp.).

Eastside

The Eastside study site (43°21′38.98″N/124°11′33.28″W) is located in the mesohaline/polyhaline region of the estuary near the municipality of Eastside (Fig. 2, Fig. 3). The narrow intertidal zone is characterized by a shallow gradient slope between the banks and deep channel where the substratum is a mixture of gravel, rock, and mud. The preferred substratum for settlement of *O. lurida* at this site is primarily gravel discarded from an adjacent quarry storage area. Invertebrates common to this area include arthropods (*C. magister, C. maenas*, *H. oregonensis*, and *N. californiensis)*; bivalves (*C. gigas*, *M. arenaira*, *Macoma* sp., *Mytilus* sp.); and gastropods (*Nucella* sp.).

Millington

The Millington study site (43°19′56.69″N/124°11′31.59″W) is located in Isthmus Slough (mesohaline region of the estuary)

near the municipality of Millington (Fig. 2, Fig. 3). This site, and nearby Shinglehouse Slough, establish the upper bay range limit for Olympia oysters in Coos Bay. The narrow intertidal zone is characterized by soft sediments and woody debris that transitions quickly to the deep navigational channel. The preferred substratum for settlement of *O. lurida* at this site is primarily wood bark and other wood materials discarded from local lumber operations. Invertebrates common to this area include arthropods (*C. magister, C. maenas*, *H. oregonensis*, and *N. californiensis)*; bivalves (*C. gigas*, *M. arenaira*, *Macoma* sp., *Mytilus* sp.); and gastropods (*Nucella* sp.).

Survey Methods

We used three survey methods to document changes in the distribution, abundance, and size of *O. lurida* in Coos Bay.

Qualitative Surveys

The goal of this sampling effort was to revisit previous study sites to determine any changes in the distributional range of *O. lurida* populations in Coos Bay. Study sites were chosen strategically throughout Coos Bay based on previously described oyster habitat and areas that offered potentially suitable habitats. During each qualitative survey, the intertidal zone was thoroughly examined at times when the low tides were below 0′ Mean Lower Low Water (MLLW). In addition to the study sites described above, we also included 20 sites examined in previous surveys to establish the baseline distribution of oysters in Coos Bay (Baker et al. 2000).

Quantitative Surveys

The goal of this sampling effort was to re examine the abundance of *O. lurida* at different locations throughout Coos Bay. Quantitative surveys of oyster densities were conducted in the intertidal zone following previous methods (Baker et al. 2000) at the five study sites described above (Pony Point, Haynes Inlet, Downtown Coos Bay, Eastside, and Millington; Figure 2). At each site a 10 m transect line was laid out along the intertidal zone, parallel to shoreline, and six 0.25 m^2 quadrats were placed at random intervals along the line. All adult oysters (shell length $\geq$ 20 mm) that occurred within the quadrats were counted and measured. Juvenile oysters (<20 mm) were omitted from the quantitative surveys because of the lack of comparability based on time of year and because of time constraints required to complete the surveys within a single low tide event. Notably, juvenile oysters, (<20 mm) were a significant component (~97% of total) of the oyster population surveyed in 1997 and were excluded from 2006 surveys because of time constraints.

Index Survey

The goal of this sampling effort was to establish a repeatable index of oyster density in an area of high abundance for future monitoring. The oyster index area was established at the Eastside (Isthmus Slough) study site where populations of *O. lurida* occur consistently on the gravel substrata (Fig. 2). A 50 m section of the eastern shoreline of Isthmus Slough was examined and identified as suitable oyster habitat. Randomly chosen transects (0.5 m width) were run perpendicular to the 50 m line beginning at the highest oyster found and ending at the water line. All field surveys were performed at tides lower than 1.0 MLLW, and all oysters (≥20 mm) within transects were counted. The Downtown Coos Bay study site (Fig. 2) was initially explored as a potential index site, but this area proved unsuitable because of the extremely high and patchy densities of oysters, primarily caused by the highly variable availability of rock as a suitable substrata.

Changes in Oyster Distribution, Abundance, and Size

Distribution in Coos Bay

The spatial distribution of *O. lurida* within Coos Bay in 2006 was generally similar to the distribution described earlier by Baker (1987) and by Baker et al. (2000), with a few notable changes. In 1986 and 1997, the lower bay distribution of *O. lurida* ended near the North Bend airport (near the Pony Point study site; Fig. 2) and the upper bay range limit was found in Isthmus slough near Millington (Fig. 2). In 2006, the lower bay range extended to rip rap at the end of the airport runway and the upper bay range had increased slightly to include Shinglehouse Slough and a short distance further up Isthmus Slough (Fig. 2).

Notable Areas of Population Change

Haynes Inlet and North Slough

Two subestuaries are located in the northern portion of Coos Bay, roughly where the bay is separated into the western and eastern arms. The re established population of *O. lurida* was first discovered in Haynes Inlet (Baker et al. 2000). The oysters are evenly distributed and occur at densities that are similar to those found in the quantitative surveys. High densities of *O. lurida* are limited to locations where substrate is suitable. Hard substrate (i.e., sandstone, shell, bark, basalt, and gravel) is readily available throughout this area and lends to the even distribution. Adult *O. lurida* were absent in North Slough during the surveys conducted in 1997, but they were present in the qualitative surveys conducted in 2006 when their range extended 2.8 km upstream.

Marshfield Channel

In the area east of the entrance of Isthmus Slough oysters are currently found commonly attached to decaying bark, the primary available substrate of the area. Fossil shells of *O. lurida* are dense in the fill material and banks of this area, but live oysters were absent here in 1997. Optimal settlement substrate is lacking throughout this area.

Shinglehouse Slough

In 2006, a dense intertidal population of Olympia oysters was found within Shinglehouse Slough in an area noted in 1997 as "marginal/incidental." This area is the site where a highway bridge was replaced in 1988 and substantial amounts of gravel were added below the bridge to help stabilize the sediments. The gravel provides a suitable substratum for *O. lurida* and the oysters were attached directly to the small rocks embedded in the soft mud.

South Slough

The South Slough tidal inlet forms the primary subestuary of lower Coos Bay. Several large adult *O. lurida* were observed attached to floating docks located throughout the Charleston

Boat Basin during the qualitative surveys conducted in 2006. In a result similar to the 1997 surveys, these adults were the only living *O. lurida* found in the lower bay area. Although other areas in South Slough are potentially suitable for *O. lurida* (i.e., Collver Point, Joe Ney Slough, Long Island Point), oysters were absent. South Slough National Estuarine Research Reserve is currently undertaking a project to evaluate the viability of habitats further upstream in areas that are potentially suitable for settlement and recovery of oyster populations on benthic substrata.

Changes in Oyster Abundance

Quantitative surveys of oyster abundance in Coos Bay conducted in 2006 revealed much higher densities of *O. lurida* than those found previously (Table 1). In general, large oysters (≥20 mm) had become much more abundant within the mid region of their range (Eastside, Coos Bay), and they also increased in abundance at the upper region (Millington and Haynes Inlet) extensions of the bay (Fig. 2).

The most notable areas of population change occurred in Millington and at the Eastside/Downtown Coos Bay study site (Fig. 2).

Millington

During the 1997 surveys this area was noted for the absence of living oysters. In 2006, we observed that a small but apparently viable population had become established on the woody debris embedded in the soft mud. Very little substratum that is suitable for settlement of *O. lurida* occurs at this site, and further recovery of the oyster populations appears to be limited by the availability of hard surfaces.

Eastside/Downtown Coos Bay

Dense populations of *O. lurida* were observed in 2006 throughout the intertidal areas of lower Isthmus Slough and the downtown shoreline of Coos Bay wherever suitable substrate was available. Oyster densities of 46.7 per m^2 and 61.3 per m^2 were observed at the Eastside and Downtown Coos Bay locations, respectively. These high densities of oysters are typical of the adjoining areas and are greater than the densities observed in 1997 (Table 1, Baker et al. 2000).

Changes in oyster sizes

Populations of adult oysters observed in our 2006 quantitative surveys included a broader range of smaller size classes in comparison with the sizes of oysters measured in 1997 (Fig. 4). In 2006, the average shell length for adult oysters (≥20 mm) was 32.8 (S.D. 7.4) mm compared with 38.1 (S.D. 4.5) mm in 1997. Despite the small number of adult shells measured in 1997 ($n = 17$) compared with the larger number measured in 2006 ($n = 177$), a single factor ANOVA of the size frequencies of oyster shell lengths (20 mm bins) revealed that the difference between the populations was highly significant ($F = 8.3755$; $P = 0.0042$). Pearson's coefficient of skewness also differed substantially between the populations measured in 1997 (0.0775) when the modal shell length was 44.0 mm, and the population measured in 2006 (0.0662) when the modal shell length was 33.0 mm. Negative skew in favor of smaller size classes in 2006 indicates that the populations of *O. lurida* probably experienced substantial and repeated episodes of recruitment during the preceding years.

Index Survey

The oyster index survey site established near Eastside (Fig. 2) yielded an average *O. lurida* density of 56.4 oysters per m^2. This high density of adult oysters is comparable to the high densities of *O. lurida* observed nearby at the Eastside study site and at the Coos Bay study site (Table 1). Our initial measurements of high and consistently occurring oyster densities at this site establish the baseline for future measurements of *O. lurida* populations within the mesohaline region of the estuary.

DISCUSSION

Beds of *O. lurida* were historically abundant in the Coos estuary and South Slough (Oregon) where they were used extensively as a food source by the indigenous people. Several shell middens that contain native oysters occur along the shoreline of the South Slough (Moss & Erlandson 1995) and they have radiocarbon ages of about 400 ± 60 y before present. Olympia oyster shells are commonly included in the dredged materials removed from the estuarine channels. Beds of *O. lurida* probably became locally extinct in Coos Bay and South Slough prior to written history caused by basin wide changes in

TABLE 1.

Comparison of the densities of *O. lurida* at various study sites in Coos Bay between intertidal surveys conducted in 1996–97 and 2006.

	1996 1997	2006
	Large oysters (≥20 mm)	Large oysters (≥20 mm)
Study Site	Density (#/m^2)	Density (#/m^2)
Millington	0	2.7
Eastside	0.7	46.7
Downtown Coos Bay	6.7	61.3
Haynes Inlet	0.7	4.7
Pony Point	5.3	3.3

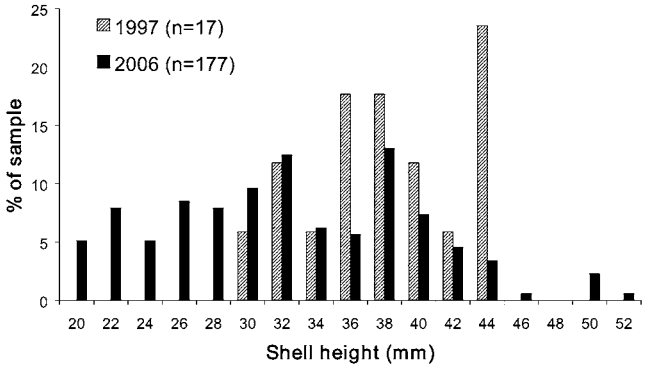

Figure 4. Comparison of the size distribution of adult *O. lurida* from surveys conducted in 1997 and 2006. Oyster sizes for the 1997 surveys are adapted from Baker et al. (2000). Note: Shell height is synonymous with shell length.

the inputs and distribution of fine sediments associated with fire and/or a tsunami (Nelson et al. 1996, Rumrill 2006). Over the first century after colonization of the shoreline of the Coos estuary by euro western settlers (*ca*. 1850 1950), aquatic and estuarine habitats within portions of Coos Bay were chronically degraded by growing urbanization and the cumulative effects of sedimentation, log storage, bark decay, dredging, deposition of dredge spoils, diking, filling, domestic and industrial pollution, commercial mariculture, and by the colonization of estuarine habitats by nonindigenous aquatic species. Despite these alter ations and degradation of the shoreline, and reduction of the entire wet surface area of the Coos estuary by 26% (Borde et al. 2003), water column and benthic habitat conditions have improved considerably over the past 30 years within particular regions of the tidal basin; conditions are now conducive to the recovery of Olympia oysters. In 1988, after several years of inadvertent inoculations *via* commercial shellfish culture activ ities, discontinuous populations of Olympia oysters became re established at low intertidal and subtidal elevations within the polyhaline (salinity 22 28 ppt) region of the Coos estuary (Baker et al. 2000). Baker hypothesized that changes in *O. lurida* range were dependent on changes to salinity intrusion, primarily attributed to deepening of the navigational channel. Additional channel deepening occurred roughly simultaneous with the previous surveys and may be responsible for the increased spatial distribution of *O. lurida* observed in 2006. It is anticipated that further changes to the navigational channel will result in alterations in salinity intrusion and thus may dictate future changes in the distribution and range of *O. lurida* populations.

Although isolated populations of Olympia oysters have become marginally established a within the Coos estuary, widespread recovery of *O. lurida* has not occurred because of several potentially limiting factors. These factors include: (a) suboptimal biotic and physical conditions that may hamper feeding, survivorship, growth, and reproduction; (b) inadequate production and larval retention; (c) decreased availability of adequate shell substratum for settlement; (d) poor survival of postsettled juveniles; and (e) predation, competition, and ecological interactions with other established Olympia and nonnative species. It is anticipated that once these hurdles are understood and perhaps overcome, it may be possible to initiate recovery of Olympia oyster beds in Coos Bay and South Slough in a manner that will allow the oyster populations to become self sustaining. Re establishment of self sustaining populations of *O. lurida* is desirable because, in addition to the recovery of the oysters, the growing physical structure of the oyster beds will serve to restore some of the lost ecological functions to the estuarine tidal basin, and the living oyster beds may reach a point in the future where they can provide substantial benefits for diverse communities of invertebrates, fish, shorebirds, and humans.

CONCLUSION

Populations of *O. lurida* currently exhibit spatial expansion and increased abundance in parts of Coos Bay, and also provide evidence of recruitment by juveniles into the established pop ulations of adults. Olympia oysters seem to have become a viable species and it is possible that they may continue to expand their distribution and fulfill their former role in the estuarine ecosys tem at some time in the future. However, our field observations indicate that the availability of suitable substratum is likely a key limiting factor that hinders further recovery in Coos Bay. The potential of oyster populations to recover in Netarts and Yaquina Bay is currently being explored *via* enhancement projects. These projects include ecological assessment work that will provide guidance for the future of Olympia oysters in Oregon's historically productive bays and estuaries.

ACKNOWLEDGMENTS

The authors thank Nick Wilsman, Bruce Miller, Jean McCrae, Sylvia Yamada, and Kate Groth for assistance in moving this project forward, and for their encouraging words. Dean Headlee and Jill Smith provided excellent help in the field. The authors also thank the federal and state agencies for their continued steps to encourage and support research related to the restoration and recovery of Olympia oysters whose eco nomic value is less apparent than its value to the ecosystems of the Pacific Northwest.

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A Guide to Olympia Oyster Restoration and Conservation

ENVIRONMENTAL CONDITIONS AND SITES THAT SUPPORT SUSTAINABLE POPULATIONS

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Smithsonian Institution

NOAA

Coastal Conservancy

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

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CALIFORNIA

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National Estuarine Research Reserve System

Elkhorn Slough Foundation Since 1982

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Contents

Synopsis

This guide identifies key environmental conditions that affect Olympia oysters. A qualitative evaluation of 28 embayments along much of the range of the species identifies the areas at risk due to low population sizes or unreliable recruitment, and characterizes patterns of exposure to stressors. The most frequently encountered stressors were sedimentation and predation. Competition, cold water temperatures, warm air temperatures, and freshwater inputs were also common concerns at many bays. Quantitative site evaluations incorporating oyster attributes and environmental conditions were conducted at six estuaries in California and Oregon to prioritize sites for conservation value and restoration potential. Development of an online site evaluation tool allows end-users to conduct similar evaluations in new regions, thereby guiding future restoration and management efforts.

Executive Summary

High densities of Olympia oysters at China Camp State Park, San Francisco Bay, California.

The Olympia oyster *(Ostrea lurida)* has declined at many estuaries in its native range along the Pacific coast from Baja California to British Columbia. In the past decade, efforts have begun to conserve, enhance or restore Olympia oyster populations. The purpose of this guide is to inform these initiatives, with emphasis on environmental conditions that will foster success.

Sustainable oyster populations exhibit a suite of attributes, including large adult population size, high density on hard substrates, high and reliable rate of juvenile recruitment, diversity of size classes, and high survival rate.

Numerous environmental factors affect these attributes of sustainable oyster populations. Based on results from field monitoring and laboratory experiments, combined with a thorough literature review and our own expert opinions, we determined how sensitive Olympia oysters are to a variety of potential stressors. We found that Olympia oysters are highly sensitive to sedimentation and freshwater inputs, and moderately sensitive to excessively cold water temperature, high air temperature, food limitation, predation, and hypoxia. In contrast, sensitivity to a variety of other environmental factors currently appears to be relatively low; these factors include high water temperature, contaminants, competition, acidification, sea level rise, pathogens and diseases.

In addition to examining sensitivities of Olympia oysters to a variety of environmental factors, we characterized their exposure to these stressors. This is an important distinction, because oysters may be quite sensitive to an environmental factor and yet this is not relevant for management if they are rarely

Researcher examining oysters in Nootka Sound, Vancouver Island, British Columbia.

exposed to this factor in a given location. We solicited assessments by local experts of exposure to stressors in 28 embayments across much of the range of the species.

Sedimentation was by far the most commonly encountered stressor, affecting populations in 71% of the embayments examined. Predation by drills and by other species was the next most common, identified as significant at 43% of embayments. Competition, cold water temperatures, warm air temperatures, and freshwater inputs also frequently pose threats to oysters (at 25–39% of embayments). Other stressors appear to be less common across this broad range; hypoxia, food limitation, contaminants, disease, warm water temperatures and acidification were identified as important at fewer than 20% of embayments, although at these places they may play a significant role.

This evaluation of 28 embayments provides an unprecedented synthesis of stressors faced by Olympia oysters across much of the range of the species. This comparison also yields insights into the status of oyster populations. The regional comparison identified that 21% of embayments experience many years with zero or near-zero recruitment of juveniles, which poses a threat to their long-term sustainability. Adult population sizes were also estimated. At 39% of embayments, there are estimated to be more than 1 million oysters present. While this is perhaps still a fraction of historical population sizes, these larger populations are likely to be fairly stable. At 43% of the embayments, populations were estimated at between 10,000 and 1 million individuals, which may raise some concern for their sustainability without management intervention. At 18% of embayments, estimates indicated that fewer than 10,000 oysters were present. These areas are excellent candidates for additional conservation and restoration efforts.

Into the cold bay
Place oysters where they can best
Survive stressful times

In addition to the broad comparisons among embayments, we also conducted much more detailed evaluations of sites within some of them. We incorporated quantitative field data on oyster attributes and environmental conditions into tables that served to prioritize sites for oyster conservation or restoration. We conducted such site evaluations at six estuaries in Oregon and California. We also developed an online site evaluation tool (available at www.climate-and-oysters.org) that can be applied by any user to assess other sites with new data.

This approach to quantifying the relative conservation value and restoration potential of multiple sites can be used to inform management actions. Agencies, nongovernmental organizations, community groups, or others considering the launch of a new restoration project can determine whether a particular site is likely to yield success. Funding agencies can use scores to help evaluate multiple restoration proposals and regulatory agencies can use the scores to direct policy protecting valuable existing populations.

In summary, this guide supports Olympia oyster conservation and restoration by enhancing the understanding of the attributes of sustainable oyster populations, the environmental conditions that most strongly affect them, and the embayments and specific sites that best support them.

Background

Purpose and development of this guide

Top: dense oyster recruitment on the San Francisco Bay Living Shorelines Project. Above: spreading shell for restoration in Netarts Bay, Oregon.

The purpose of this guide is to inform restoration and conservation of Olympia oysters *(Ostrea lurida)*. It was prepared by an interdisciplinary team funded by NOAA's National Estuarine Research Reserve Science Collaborative from 2011 to 2015. We first completed a guide for Central California in close collaboration with stakeholders and with substantial new data from field monitoring and laboratory experiments (Wasson et al. 2014). The current guide is an update of the earlier one, including evaluation of embayments along much of the range of the species, and incorporating input from oyster researchers and literature from other regions to increase generality. The intended audience includes oyster restoration practitioners, restoration scientists, and organizations involved in planning, funding, or permitting restoration and conservation.

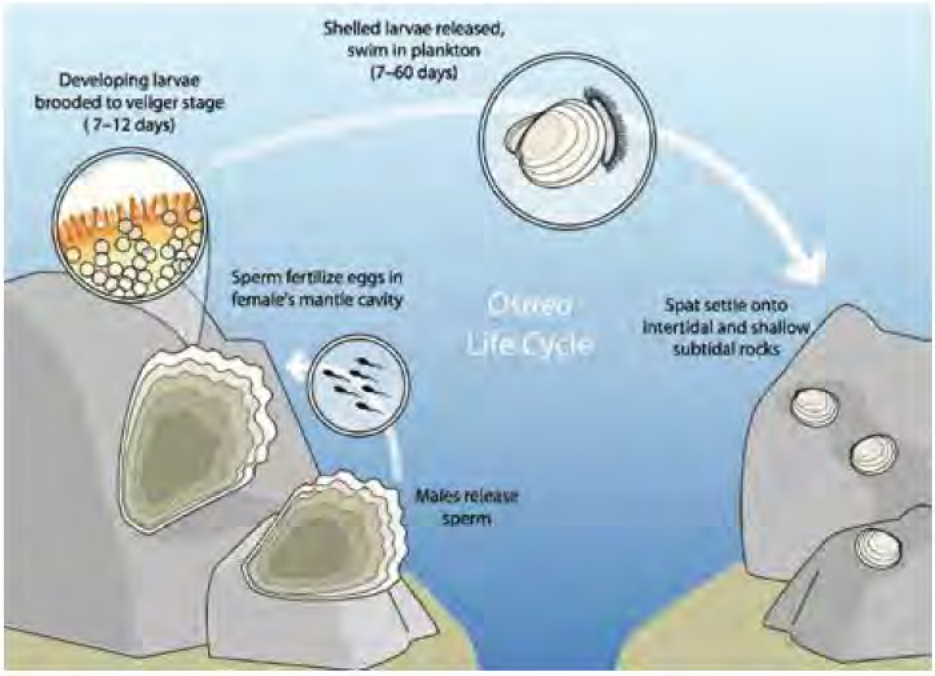
We characterized oyster populations and environmental factors that affected them at two spatial scales. Most broadly, we compared oysters and environmental stressors across much of the range of the species, to identify key opportunities and threats. At a much narrower spatial scale, but with greater depth, we also conducted site evaluations intended to aid end-users in prioritizing sites within particular embayments. We conducted site evaluations in Central California (Wasson et al. 2014), Southern California (Appendix 1) and southern Oregon (Appendix 2).

This is not a "how to" manual for field restoration methods, nor does it address the human processes that are essential for restoration and conservation (permitting, community support, public outreach, etc.). Guides that address these issues are sorely needed and would complement the current effort.

Olympia oysters: challenges and opportunities

LIFE-CYCLE AND ECOLOGY

Olympia oysters are primarily estuarine and generally not found on the open coast (Baker 1995). In Central California, they are most abundant around the 0-meter tide mark, Mean Lower Low Water (MLLW), and in Southern California at −0.3 m (authors' unpublished data), but have been reported from as high as 1 m above MLLW to depths of 10 m (Baker 1995). They require hard substrate on which to settle. They are sequential hermaphrodites—typically, but not always, starting out as males—and may switch sexes twice within the course of a year (Moore et al. in prep.). Females brood larvae in their mantles for 7–12 days (Coe 1931, Hopkins



Schematic of Olympia oyster life cycle. Adult males release sperm that is taken up by nearby females. Eggs are fertilized within the mantle cavity and developing larvae are brooded to the veliger stage, released into the plankton, and transported with tides and currents. Larvae settle irreversibly onto hard substrate as juvenile oysters and grow to sexual maturity within months to a year. (Julia C. Blum)

1936, Strathmann 1987), after which they are released to swim in the plankton for 5 days (authors' personal observations) to 4 weeks (Breese 1953).

Large adult oysters sharing space with bay mussels at the Berkeley Marina, San Francisco Bay.

TRENDS IN DISTRIBUTION AND ABUNDANCE

Olympia oysters range from Central Baja California, Mexico, to British Columbia, Canada (Polson and Zacherl 2009). Abundance varies enormously from scant, but persistent, populations consisting of a handful of individuals, to locations with nearly 100 percent cover of oysters on hard substrates at MLLW (authors' personal observations). In most locations, the size of the pre-European-contact population is unknown. However, there were sufficient populations in many locations, including San Francisco Bay prior to the Gold Rush, to support a commercial fishery (Conte and Dupuy 1982; reviewed in Zu Ermgassen et al. 2012). Based on a review of the former extent of commercial oyster grounds from the earliest available records (mid-1800s to early 1900s), Zu Ermgassen et al. (2012) estimated oyster grounds in Puget Sound, Humboldt Bay, San Francisco Bay, Elkhorn Slough and Mission Bay to be at 1% of historic levels.

CONSERVATION AND RESTORATION

The earliest efforts to restore Olympia oysters began in Puget Sound in 1999 (Peter-Contesse and Peabody 2005) and included seeding oyster shell and large-scale deployment of Pacific oyster shell for natural set. Current smaller-scale projects in Oregon and in Central and Southern California range from deploying small structures to assess recruitment patterns and best methods, to larger-scale mixed-species restoration projects with both physical and biological objectives in a "living shorelines" model.

Rocky substrate with oysters in San Francisco Bay.

Winter storm, downpour
Bay oysters shut their valves tight
Long wait to exhale

It is worth noting that the term "restoration" is used rather broadly, to describe efforts to increase regional numbers of Olympia oysters, back towards levels that were presumed to be considerably higher historically and prehistorically along the entire coast (Zu Ermgassen et al. 2012). At the level of specific sites, there is usually no information about historic oyster densities. Moreover, human activities have changed conditions such as sedimentation and freshwater inputs so that the best locations for oysters today may differ from the best historic sites. Thus, at the level of an individual site, a project may more accurately be described as oyster "enhancement" rather than "restoration".

Sedimentation rates have also increased at many estuaries, such that oysters can no longer survive on tiny bits of natural hard substrate on the bottom or the low-relief oyster reefs that Olympias may have once made. Thus, some restoration efforts provide large artificial hard substrates raised above the sediments, which result in quite different oyster habitat than was historically present.

Climate change is a challenge that must be understood and addressed as a part of restoration. Current model projections suggest rising air and water temperatures, acidification of surface waters and more frequent and severe flood events. These are likely to affect both existing oyster populations and restoration efforts. Climate change stressors may interact with and perhaps act synergistically with each other and with other anthropogenic stressors such as invasive species (for example, predatory oyster drills and potential space competitors such as the Pacific oyster *Crassostrea gigas*), high nutrient levels, and pathogens and disease. Climate change effects are not likely to be the same in all locations, nor are other anthropogenic stressors equally important everywhere. Conservation and restoration efforts require a better understanding of the importance of local environmental factors, both now and in the future.

Intertidal community with oysters.

Information sources for this guide

Stressor experiments on oysters at Bodega Marine Lab, California.

IDENTIFICATION OF KEY OYSTER ATTRIBUTES AND ENVIRONMENTAL STRESSORS

We relied heavily on our earlier guide (Wasson et al. 2014) for assessments of oyster attributes and environmental stressors. That in turn was based on extensive new field data collection and analysis at sites in central California, and laboratory experiments on stressors, both of which are described in detail in the original guide and associated appendices (Wasson et al. 2014), as well as a recent publication (Cheng et al. 2015). Both the original and current guide also involved syntheses of the existing published literature, unpublished data and observations of the authors, and personal communications from colleagues. Earlier reviews (Couch and Hassler 1989, Baker 1995, White et al. 2009) provided an excellent base for identification of key environmental factors. Many of the oyster attributes and environmental factors we included are the same as the "universal metrics" recommended for oyster restoration monitoring (Baggett et al. 2014), though we emphasize those most relevant to Olympia oysters.

EXPERT ASSESSMENTS OF WEST COAST EMBAYMENTS

We invited oyster researchers working along the entire range of the species to evaluate embayments with regard to oyster populations and environmental conditions. The assessments were not quantitative, but rather involved determining whether oyster attributes or stressors fell into "high," "medium" or "low" categories. Broad definitions of these categories (see Table 1) helped provide consistency among assessments by different experts. These expert assessments provide a basis for examining geographic patterns in status of Olympia oyster populations and in expression of stressors.

SITE EVALUATIONS

The data and approach used for site evaluations of Southern California and southern Oregon are detailed in Appendices 1 and 2, respectively. Our earlier site evaluations of Central California are detailed in Wasson et al. 2014.

Azevedo Pond in Elkhorn Slough, California.

Location of embayments where experts conducted assessments of oyster attributes and environmental stressors. Note that multiple regions within San Francisco Bay, Puget Sound, and the Strait of Georgia were assessed.

Field monitoring at the Berkeley Marina, San Francisco Bay.

Attributes of Sustainable Oyster Populations

OVERVIEW

Successful Olympia oyster populations exhibit a suite of biological attributes that we characterized and describe below. These are attributes that can be assessed at the level of individual sites, as a part of site evaluations. Two of these attributes (population size and reliability of recruitment) are also included in our comparison of entire embayments.

The attributes we have focused on include two "universal metrics" recommended for oyster restoration monitoring (Baggett et al. 204), oyster density and size frequency distribution. However, other metrics that apply to larger, reef-forming oysters such as reef height and area are not useful for Olympia oysters and were not included. Conversely, we included metrics not part of the universal recommendations, but very important to Olympia oysters such as recruitment—recruitment failure is common in this species, perhaps because of relatively low population sizes.

MODERATE-TO-HIGH ADULT DENSITIES (importance: *very high*)

The density of adult oysters at a site can serve as a cumulative indicator of its appropriateness for conservation or restoration; moderate to high adult densities result from one or more years of significant recruitment and survival. Current oyster density data are important for prioritizing conservation areas, yet some populations fluctuate from year to year and it is better to have multiple years of data for greater confidence. High oyster densities on existing substrate can be used to assess suitability for restoration at that site, provided there is existing hard substrate to begin with. In a survey of 24 locations across the species' entire range, Polson and Zacherl (2005) recorded a wide range of densities from one individual to 146.8 /m^2 , but we recorded much higher densities at several sites in San Francisco Bay in 2012–13, up to 961/ m^2 in San Francisco Bay. Densities in Newport Bay and San Diego Bay are generally much lower (up to 55/m^2 and 219/m^2, respectively). Similarly, Coos Bay sites we evaluated were generally lower (up to 76.4/m^2), although recent survey work at a mitigation site found densities as high as 1000/m^2 (S. Groth personal communication).

TOTAL ABUNDANCE AT SITE (importance: *very high)*

An order-of-magnitude estimate of the total number of oysters living at a site is a good indicator of its relative conservation value. In some cases, adult density per square meter of hard substrate may not represent density at larger scales (e.g., hectares), because there is very limited hard substrate. A site that has a million oysters within a hectare should have greater conservation value than a site that has a thousand oysters per hectare, and far greater than one that has ten oysters per hectare, even if all those sites have the same density per square meter. Therefore, it is important to establish where to draw the line around a site of interest and whether or not to include the full tidal range encompassing all colonized hard substrate. For assessments in Central California, we limited the total

Monitoring a remarkably dense population of Olympia oysters in Nootka Sound, Vancouver Island, British Columbia.

area for each site calculation to a 1-m wide band extending 300 m alongshore and centered around study transects at the tidal elevation of maximum oyster density. We were then able to use our density measurements (above) to generate order of magnitude estimates of total population. Site-level oyster population estimates in all California study bays ranged from fewer than 100 to 10,000s of individuals, with a high of estimate 100,000s of individuals at a single site in San Francisco Bay.

Broad assessments of abundance at the level of entire embayments are also useful for comparisons. Table 1 reveals that in 39% of embayments assessed, Olympia oyster populations are estimated to be above 1 million individuals. At 43%, populations are estimated at between 10,000 and 1 million oysters. However, at 18%, abundance of Olympia oysters is estimated at fewer than 10,000 individuals, which is of concern for long-term stability and persistence.

OYSTER SIZES: BROAD SIZE DISTRIBUTION (importance: *high)* AND LARGE SIZES (importance: *medium)*

The presence of oysters distributed among a broad range of size classes is a good indicator of a healthy population, indicating a combination of recent recruitment, growth, and long-term survival. Each is an important aspect of a sustainable population, but it is time-consuming and sometimes logistically challenging to measure each separately. Because recruitment can vary from year to year, the best estimates of size distribution will include several years of data. At the very least, estimates ought to be made after the recruitment season, to include newly settled juveniles. Consistent absence of particular size classes does suggest potential limitations for populations. For example, absence of small sizes might suggest recruitment limitation or absence of large size classes might indicate a lack of long-term survival. However, although a broad range of sizes is regularly seen at high quality sites in Central California, not all Olympia oyster populations show persistent evidence of previous recruitment, particularly if growth to adult size happens very quickly and subsequent growth of those same individuals is limited. We measured oysters in quadrats

Top: measuring oysters. Above: multiple age classes.

along our study transects, categorized these into 10 mm size classes, and generated a size-class diversity index using a formula typically used to compare species diversity, the Gini-Simpson index. Our sites ranged from an index of 0.25 at a location in Elkhorn Slough where all oysters were from a single recruitment event, so that size diversity was very low, to an index of 0.876, at a site in San Francisco Bay where there were many oysters in multiple size classes. Newport Bay and Southern Oregon sites were all between 0.50 and 0.77.

In addition, when we included data on the largest oysters, the table was more accurate in ranking sites that we know from previous research have had consistent recruitment and moderate to high densities of oysters over time periods longer than the current study. We used the mean of the upper quartile of oyster sizes measured in our quadrats. Across study sites, the average sizes of the largest oysters ranged from 12 mm—a site in San Francisco heavily impacted by oyster drill predation—to 66 mm at an Elkhorn Slough site. Across all bays, largest oysters were typically between 30 and 50 mm, although oysters at most Elkhorn Slough sites tended to be above 50 mm.

RECRUITMENT RATE: HIGH RECRUIT DENSITY (importance: *high)* AND RELIABLE RECRUITMENT (importance: *medium)*

Recruitment is absolutely necessary for a site to support a sustainable oyster population in the long run. Several factors influence whether or not there is high and reliable recruitment at a site, including processes affecting larval transport and retention, and the number and proximity of other colonized sites that could serve as larval sources. Estimating recruitment rate may be especially important for sites without adults where restoration actions are being considered. However, potential restoration sites that exhibit low recruitment may not need to be eliminated if seeding those sites with settled oysters is a viable option, and if this can be done at a large enough scale that a new, self-sustaining population can be formed, producing and retaining sufficient larvae. In central California, we counted recruits to standardized settlement tiles, deployed and retrieved quarterly, to arrive at a measure of recruits/unit area/day. We also calculated the coefficient of variation (CV) quarterly per site to generate a measure of reliability of recruitment; a low CV indicates a relatively consistent rate while a large one inconsistent recruitment. In Central California, quarterly average recruit density ranged from 0 at several Elkhorn Slough sites to 88 recruits/m^2/day at a San Francisco Bay site. In Southern California sites, where recruitment rate was calculated between June and October, rates ranged from 24–42 recruits/m^2/day in Newport Bay and from 136–1349 recruits/m^2/day in San Diego; measurements from southern Oregon calculated for a similar time period ranged from 3–39 recruits/m^2/day. Recruitment CV ranged from 0.5 at a Newport Bay site to ~3 at several Elkhorn sites and one in San Francisco Bay, all of which had recruitment in only one of two study years.

Table 1: Synopsis of Oyster Population Attributes and Stressors Across Range of Olympia Oyster

	OYSTER ATTRIBUTES		STRESSORS[3]													SOURCES
	POPULATION SIZE[1]	RECRUITMENT[2]	SEDIMENTATION	PREDATION BY DRILLS	PREDATION BY OTHER SPECIES	WATER TEMP. TOO LOW	COMPETITION BY PACIFIC OYSTERS	COMPETITION BY OTHER SPECIES	AIR TEMP. TOO HIGH	LOW SALINITY	FOOD LIMITATION	DISEASE/ PATHOGENS	ACIDIFICATION	WATER TEMP. TOO HIGH	CONTAMINANTS	HYPOXIA	
CALIFORNIA																	
San Diego Bay																	S. Briley & H. Henderson, personal communication
Newport Bay																	S. Briley & D. Zacherl, personal communication
Alamitos Bay																	S. Briley & D. Zacherl, personal communication
Elkhorn Slough																	Wasson 2010, Wasson et al. 2014, Wasson, personal communication
SAN FRANCISCO BAY																	
South Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
Central Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
North Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
Tomales Bay																	Kimbro et al. 2009, E. Grosholz, personal communication
Humboldt Bay																	D. Couch & K. Ramey, personal communication
OREGON																	
South Slough																	A. Helms & B. Yednock, personal communication
Coos Bay																	A. Helms & B. Yednock, personal communication
Yaquina Bay																	D. Vander Schaaf, personal communication
Netarts Bay																	D. Vander Schaaf, personal communication
WASHINGTON																	
Willapa Bay																	Trimble et al. 2009, J. Ruesink, personal communication
PUGET SOUND																	
Henderson Inlet																	B. Allen, personal communication
Totten Inlet																	B. Allen, personal communication
Noth Bay, Case Inlet																	White et al. 2009, J. Ruesink, personal communication
Belfair, Hood Canal																	J. Ruesink and S. Valdez, personal communication
Dabob/Quilcene, Hood Canal																	J. Ruesink and S. Valdez, personal communication
Port Gamble Bay																	B. Allen, personal communication
Discovery Bay																	B. Allen, personal communication
Dyes Inlet																	B. Allen, personal communication
Liberty Bay																	B. Allen, personal communication
Fidalgo Bay																	P. Dinnel, personal communication
BRITISH COLUMBIA																	
STRAIT OF GEORGIA																	
Victoria area																	J. Carolsfeld, personal communication
Nanaimo area																	S. Dudas, personal communication
Baynes Sound area																	S. Dudas, personal communication
Quadra/Cortes Island area																	S. Dudas, personal communication

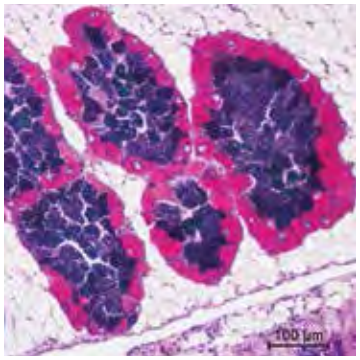
1. Population size estimate for estuary/region (intertidal and subtidal combined, even though latter is very uncertain)
   - <10,000
   - <1 million
   - >1 million

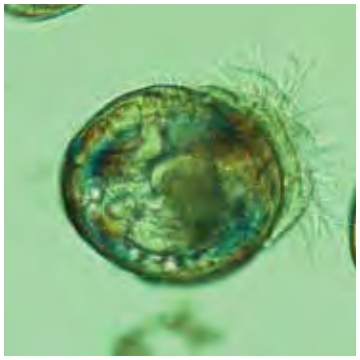
2. Recruitment assessment
   - many years with zero or near zero recruitment
   - occasional years with zero or near zero recruitment
   - no years with zero or near zero recruitment

   (for entire estuary/region)

3. Stressor assessment: negative effects include low recruitment, dieoffs of adults, or absence of oysters at otherwise favorable sites
   - stressor affects >10% of population every year or >25% every 5 years
   - significant problems, but not regularly or affecting much of the bay
   - no evidence of significant problem

Lighter colors indicate lower levels of certainty.





From top to bottom: life stages of the oyster: gonads, brooded larvae, free-swimming veligers, "spat"—settled young oysters.

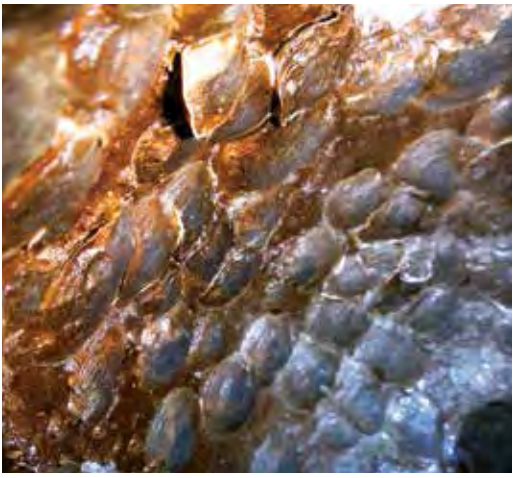
Across the range of the Olympia oyster, there is reliable recruitment at some embayments (Table 1). However, at 61% of them, there are at least some years with zero or near zero recruitment. At Elkhorn Slough, Tomales Bay, South Slough, Netarts Bay, Fidalgo Bay and in the northern Strait of Georgia, there are many years with zero recruitment. Such populations may be at risk of local extinction, particularly if changing climate conditions lead to increased numbers of consecutive years with zero recruitment. The sites with unreliable recruitment were ones that did not have large (over 1 million oysters) population sizes (Table 1).

HIGH JUVENILE SURVIVAL RATE (importance: *high)*

Juvenile stages are particularly susceptible to predation and other stressors that could lead to mortality. Survival to the adult stage is critical for reproduction and the overall sustainability of a population. In many cases, high rates of juvenile survival will be reflected in a broad range of oyster sizes present at a site (with the abovementioned exceptions). Thus, while survival rates are not critical to measure *in situ,* doing so allows for a more precise understanding of why certain size classes might be missing at a site. In central California, we allowed oysters to recruit to tiles in the field and then tracked the survival and growth of these oysters. For locations that did not have natural recruitment, we deployed tiles from nearby locations that had recruitment. Across embayments measurements of survival were made on oysters of different ages and over different time scales, making direction comparisons impossible. Early survival was high in San Diego (typically 99.9%/day for 90 days) and at most Central California sites (99.9% to 99.45%/day). Survival of juveniles on tiles in Coos Bay ranged from 45 to 79% at three sites across a study period of six months (January to July) (Rimler 2014). The methods used for the site evaluation table were too different to compare among embayments.

HIGH JUVENILE GROWTH RATE (importance: *low to high)*

As noted above, juvenile oysters are generally more susceptible to predators and environmental stressors than are adult oysters, suggesting the clear benefits of growing quickly after settlement. High juvenile growth rates indicate favorable conditions (such as available food and sufficiently high salinity and dissolved oxygen) and should lead to healthy adult populations. However, sites with high food resources and warm water, which can promote growth, may also suffer from low dissolved oxygen. Additionally, low juvenile growth rate does not necessarily indicate poor field conditions. Growth may be limited by high recruitment densities rather than by a lack of food or by other unfavorable conditions. Marking and remeasuring oysters is time-consuming. Size-class distribution calculations, as mentioned above, provide indirect measurements of growth and survival. Such calculations could be substituted for direct measurement in sites with existing oyster populations. For sites without oysters or with few oysters, deploying settled oysters on tiles, as we did, to observe growth and mortality, can indicate whether conditions at a site are appropriate for restoration with seeded oysters. Across embayments growth



Top: tracking survival and growth of oysters on monitoring tiles. Middle: Olympia oyster spat on Pacific oyster shell. Above: juvenile Olympia oysters on eelgrass.

measurements were made on oysters of different ages and over different time scales, making direction comparisons impossible. For Central California, growth ranged from 0.037 mm/day at one San Francisco Bay site to 0.11 mm/day at four Elkhorn Slough and one San Francisco sites across six quarters. At San Diego Bay sites, growth of ~30 day old oysters was 0.24 to 0.39 mm/day over a two month period. In Southern Oregon growth ranged from 0.03 to 0.14 mm/day from April to July.

HIGH LARVAL CONTRIBUTION TO REGION (importance: *medium to high)*

Sites that support significant adult populations also might export larvae and be of particular conservation value to the regional population. Ideally, this information would be included in evaluating sites for conservation. Measurements of fecundity and larval connectivity can help to identify what sites might most contribute to regional larval supply, but a thorough understanding of larval sources and sinks also requires an understanding of tidal currents and other transport processes around and between sites. At present this represents a major data gap in consideration of specific sites for restoration as well as for understanding the importance of oyster populations within regions.

Using shell chemistry analysis, we were able to evaluate the relative contributions of larvae produced in regions within San Francisco Bay to other regions in the Bay in 2012. Due to low adult densities and/or low fecundity at some sites, only six sites were evaluated in this portion of our research. For the locations we evaluated, our estimates ranged from 3 million larvae exported from a South Bay site to more than 26 million exported larvae from a North Bay site (Wasson et al. 2014). Carson (2010) used shell chemistry analysis to determine the origin of newly settled spat and thus the connectivity between sites in San Diego Bay, Mission Bay, and Agua Hedionda and Batiquitos in north San Diego County. Over the course of the whole recruitment season, sites in San Diego Bay and North County supplied more than half of their own recruits, while newly settled spat in Mission Bay were almost all from the other locations. However, Carson noted that the proportions of self-recruits and the relative contributions from each bay varied between the first and second half of the summer. Source and sink dynamics also likely vary between years, so the results of these two studies should not be considered definitive.

Larvae floating free
Attach to hard surfaces
Forever settled

Environmental Stressors

OVERVIEW

The distribution and abundance of Olympia oysters are affected by numerous environmental factors. We identified those environmental factors most important to Olympia oysters. Three of these—temperature, salinity, and dissolved oxygen—are ones considered "universal metrics" to monitor for any oyster restoration project (Baggett et al. 2014).

Through our data from field monitoring and laboratory experiments, combined with a thorough review of the literature and our team's expert opinion, we determined the *sensitivity* of Olympia oysters to a variety of potential stressors. Sensitivity is the degree of responsiveness to a realistic level of the environmental factor, for instance, high mortality rates or high recruitment failure in response to a potential stressor is considered high sensitivity, while limited sublethal effects would represent low sensitivity. Below, we explain how we determined sensitivity, highlighting the data or literature used to make the assessment. However, this categorization of sensitivities should not be considered final and comprehensive; as new studies are conducted our understanding will evolve. For instance, as a result of collaboration with colleagues from a broader geographic area, our evaluations of sensitivity have already been updated from our earlier efforts for Central California (Wasson et al. 2014).

In addition to assessing sensitivity of Olympia oysters, we also evaluated their *exposure* to environmental stressors. Exposure is the actual experience that oysters have with the stressor in the field. The distinction between sensitivity and exposure is important. For instance, Olympia oysters are quite sensitive to

Table 2: Overview of Olympia Oyster Sensitivity and Exposure to Different Stressors

STRESSORS	SENSITIVITY	EXPOSURE
Sedimentation		
Low salinity		
Predation		
Water temperature too low		
Air temperature too high		
Food limitation		
Hypoxia		
Competition		
Water temperature too high		
Acidification		
Sea level rise		
Contaminants		
Disease/Pathogens		

KEY

LOW MEDIUM HIGH

HIGH: For sensitivity, this indicates teh stressor can have strong negative effects on oysters; for exposure, indicates it was considered a concern at ≥50% of surveyed bays

MEDIUM: For sensitivity, this indicates the stressor can have moderate negative effects on oysters; for exposure, indicates it was considered a concern at ≥25% of surveyed bays

LOW: For sensitivity, this indicates the stressor has few negative effects on oysters; for exposure, indicates it was considered a concern at <25% of surveyed bays

Sensitivity assessments were based on literature review, field data, and laboratory experiments. *Exposure* assessments were based on the evaluation of 28 bays by local experts (Table 1).

Top: large cobble provides hard substrate in Elkhorn Slough, California. Above: oysters in muddy conditions in Alamitos Bay, Southern California.

prolonged periods of low salinity. However, this is only relevant to those places that receive significant freshwater input, such as northern San Francisco Bay. The interannual variation in the amount of freshwater flow leads Olympia oyster populations to expand upstream in dry years into areas that are then inundated with fresher water in wetter years, causing mass mortality. Patterns of exposure at 28 embayments are characterized in Table 1. A summary of both sensitivity and exposure is provided in Table 2. We considered overall exposure to be high if concerns were identified (yellow or red colors) at ≥50% of embayments that were assessed; medium if ≥25% of embayments identified concerns, and low if <25% of embayments identified concerns.

Below, we review a series of environmental factors relevant to oysters. For each we first discuss sensitivity, then methods for quantifying stressor levels, and then exposure.

SEDIMENTATION (sensitivity: *high;* exposure: *high)*

Sensitivity: Olympia oysters cannot survive extended durations of burial in soft sediments. Exact tolerances to burial are not known for this species, but sedimentation has been identified as a stressor (Blake and Bradbury 2013). Other oyster species have been shown to be able to survive short-term burial (Hinchey et al. 2006), but longer-term burial can reduce recruitment and increase mortality (Lenihan 1999). Grain size is an important aspect of sedimentation (Thrush et al. 2004); while significant accumulation of fine-grained sediment could limit water circulation and challenge feeding and respiration, even complete sediment burial in coarser-grained sands may not be detrimental. Sediment types and deposition and movement rates interact with availability of larger hard substrates at a site. If the only hard substrates available to oysters at a site are limited numbers of shells of other oysters, then they cannot survive much deposition of fine sediments. However, at sites with large hard substrates, such as natural boulders or artificial rip rap, oysters can be raised above the sediment sufficiently to avoid burial. For instance, the majority of Elkhorn Slough consists of mudflats with deep fine sediments. Oysters are entirely absent from these areas, except where artificial hard substrates are available for attachment, allowing them to avoid burial (Wasson 2010). In Willapa Bay, removal of extensive accumulated shell mounds during harvesting of Olympia oysters a century or more ago may continue to hamper recovery of Olympia oyster populations, because oysters that settle on smaller, less stable substrates are more prone to burial (Trimble et al. 2009). Oysters are thus highly sensitive to sedimentation, and generally absent from areas with deep fine sediments, but this sensitivity can be mitigated with sufficiently large hard substrates. Many restoration efforts provide hard substrate for oysters through addition of bare Pacific oyster half shell, reef balls, and other techniques. One example is the Coastal Conservancy's San Francisco Bay Living Shorelines Project, which constructed reefs in 2012 with mounds of clean Pacific oyster shell, and with artificial reef methods such as structures made from cement mixed with mined oyster shell and sand. Up to 3 million native oysters have settled onto these shell bags and cement structures.

Constructed reefs with Pacific shell bags provide hard substrate in San Francisco Bay.

Assessment method: To determine potential negative effects of sedimentation on oysters at a site, both sediment depth and availability of hard substrates at the appropriate tidal elevation must be assessed. Wasson (2010) plotted the relationship between sediment depth and substrate size needed to sustain live oysters for Elkhorn Slough, but this relationship probably differs somewhat among embayments. As a general guide, the diameter of hard substrates available should be comparable to the depth of fine sediments. For example, if there are 2 cm of fine sediments at a site, then small bits of shell 2 cm in size probably can support oysters. However, if the mud is 50 cm deep, rocks 50 cm in size are needed to prevent burial and support live oysters. Other dynamic factors, such as seasonal deposition or strong currents that can turn rocks, can complicate this rule of thumb.

In stormy winters
Many oysters do perish
Empty shells linger

Exposure: Table 1 reveals that exposure to sedimentation is high, with moderate or high stressor levels reported at 71% of embayments. Thus sedimentation limits the potential distribution and abundance of oysters at many embayments. However, at some estuaries, such as San Diego Bay, there is such extensive man-made hard substrate (armored shores, cobble, rip rap) that sedimentation is not considered an important threat at many sites. In the northern part of the range, oysters are often found in less muddy habitats where they can survive on small bits of natural hard substrate.

LOW SALINITY (sensitivity: *high;* exposure: *medium)*

Sensitivity: Salinity places basic physiological constraints on all marine and estuarine organisms (Hochachka and Somero 2002), and is a fundamental determinant of where species can live in an estuary (Remane and Schlieper 1971). Although Olympia oysters tolerate a range of salinity levels, low salinity exposure is stressful, can reduce reproduction (Oates 2013), and cause death in severe cases (Gibson 1974). In a laboratory experiment, we found that juvenile Olympia oysters suffered significant mortality when exposed to salinity levels below 10 for five or more days (Cheng et al. 2015). However, our field data from Central California showed a strong negative correlation between exposure to salinity below 25 and several oyster attributes, including average size, recruitment rate, and growth (Wasson et al. 2014). Thresholds may show local adaptation and vary across regions.

Die-off of oysters at China Camp, San Francisco Bay, after prolonged heavy winter rains in 2006.

Assessment method: Salinity can be best measured with *in situ* sondes continuously collecting data, but can also be assessed with less frequent spot samples (weekly or monthly). The salinity data must then be related to thresholds relevant to oysters, which could potentially vary between locations.

Exposure: Low salinity limits the distribution or abundance of oysters at about a quarter of embayments (Table 1). For instance, in San Francisco Bay, high freshwater flow in wet years following precipitation events and snowmelt can lead to low salinity conditions and subsequent massive die-offs in oyster populations that settled during dry years (Zabin et al. 2010). In Coos Bay, oyster reproduction was lower at a site with lower salinity (Oates 2013). However other estuaries, such as Elkhorn Slough and Humboldt Bay (D. Couch, personal communication) oysters are found in strongly marine-influenced areas, with rapid flushing of freshwater and thus little exposure of oysters to prolonged salinity stress. In other embayments, spatial salinity patterns may be fairly consistent across years, such that there are brackish or freshwater areas where no oysters occur, and consistently higher salinities in the areas where oysters do occur.

PREDATION (sensitivity: *medium;* exposure: *medium)*

Sensitivity: Olympia oysters may be quite sensitive to some types of predation. In particular, studies from West Coast estuaries have shown that introduced species such as Atlantic oyster drills *(Urosalpinx cinerea)* and Japanese oyster drills *(Ocenebra inornata)* can have substantial local impacts on oyster populations (Willapa Bay, Buhle and Ruesink 2009, Tomales Bay, Kimbro et al. 2009, Humboldt Bay, Koeppel 2011, Puget Sound, Blake and Bradbury 2013). However, the importance of drill predation within a bay appears to be highly variable, due at least in part to variability of drill abundance (Buhle and Ruesink 2009, Kimbro et al. 2009, Koeppel 2011). For example, *U. cinerea* is well established in some parts of San Francisco Bay, and appears to impact populations where it is especially abundant, but it is present in low abundance or absent from many other locations. Additionally, recent work at one site in San Francisco Bay found that drill predation varied with tidal elevation: drills killed ~60% of adult oysters at +7 cm MLLW within two months, while oysters at +37 cm were not preyed upon (Kiriakopolos et al. 2014).

Crabs, particularly larger cancrid crabs, may also prey on native oysters, and pose a significant source of mortality in some locations. Koeppel (2011) reported evidence of crab predation (chipped/crushed shells) from two study sites in Humboldt Bay; in follow-up feeding trials in the laboratory *Cancer productus* readily consumed oysters attached to tiles while *Romaleon antennarium* did not. In contrast, positive effects of crabs on oysters have been found elsewhere as crabs prey on oyster drills, reducing predation pressure on oysters (Buhle and Ruesink 2009, Kimbro et al. 2009). Seastars can also exert high predation pressure in fairly marine sites (Ruesink, personal communication) Other predators, such as rays, birds and small mammals may also prey on native oysters, but to our knowledge such predation has not been quantified. Human collection of Olympia oysters is likely not a major factor in most locations, but this might

Monitoring at Elkhorn Slough, California.

change if native oyster populations become more abundant in easily accessible locations and may occur occasionally (anecdotal information reported to Zabin at Elkhorn Slough 2012).

Assessment method: Oyster drill abundance can be quantified in field transects of oyster beds. Drill densities may not correlate exactly with per capita effects on oysters, because these are also affected by availability of other prey types and potential predators of drills, as noted above. Predation by crabs, rays, birds and small mammals is harder to quantify. Manipulative experiments—such as comparing mortality in caged vs. uncaged oysters—are needed to shed light on strength of predation effects at a site.

Exposure: Significant effects of drills on oysters have been noted in 43% of embayments assessed, but drills are entirely absent from others, such as many Southern California bays, Elkhorn Slough, South Slough and Coos Bay in Oregon, and at British Columbia sites (Table 1). Predation by other species is also considered significant at 43% of embayments, with a variety of predators involved, although in many cases these impacts have not been experimentally tested or quantified. Ray and duck predation have been frequently observed at Humboldt Bay (D. Couch, personal communication); predation by crabs has been observed in Netarts Bay (D. Vander Schaaf, personal communication) and extremely high predation pressure from seastars has been observed at one site in Puget Sound, Dabob/Quilcene in Hood Canal (J. Ruesink, personal communication). Elsewhere in Puget Sound, predation by the crabs *Cancer productus* and *Cancer gracilis* and the sea stars *Pisaster brevispinus* and *Evasterias troschellii* has been observed (B. Allen, personal communication). In Totten Inlet, Henderson Inlet, and Port Gamble Bay and other historic Pacific oyster culture sites in Puget Sound a predatory

Non-native oyster drills prey on native oysters.

Non-native green crab with Olympia oysters in Nootka Sound, British Columbia.

flatworm introduced with Pacific oysters *(Koinostylochus ostreophagus)* has been noted (Blake and Bradbury 2013, B. Allen, personal communication).

WATER TEMPERATURE TOO LOW (sensitivity: *medium;* exposure: *medium)*
WATER TEMPERATURE TOO HIGH (sensitivity: *low;* exposure: *low)*

Sensitivity: Temperature is a major driver of virtually all physiological processes, such as respiration, metabolism, filtration, and excretion (Hochachka and Somero 2002). Excessively cold water can hamper oyster reproduction and growth. Numerous studies have correlated onset of reproduction or larval settlement with particular temperatures; for instance recently Oates (2013) found gametogenesis to occur at temperatures greater than 14.5°C in Coos Bay, Oregon, while other recent studies documented reproduction at a range from 12–21°C, but higher temperatures led to much faster production of larvae following reproductive onset (Santos et al. 1993). However, temperature thresholds for reproduction not only vary across different embayments but also may not show clear patterns within a system (Seale and Zacherl 2009). Our laboratory experiments showed significantly increased growth of juvenile oysters at 24 vs. 20°C (Cheng et al. 2015). Our field data from central California

showed positive correlations between percentage of days with temperatures >12°C measured at a site and several oyster attributes, including growth rate, average size, recruitment rates, and adult density (Wasson et al. 2014). On the other hand, excessively warm water can have negative effects on oysters. However, such thresholds appear to occur at quite high temperatures; experiments in central California have shown that Olympia oysters have an LT50 (50% mortality) between 38 and 39°C (Brown et al. 2004, Cheng, unpublished data). Thresholds may vary across the range of the species.

Assessment method: Water temperature can best be assessed by continuous measurements taken by *in situ* instruments. To evaluate temperature conditions for oysters, these measurements can be related to thresholds. Such thresholds would probably differ across a latitudinal gradient.

For instance, for our evaluations of sites in Central California, we quantified the percentage of measurements taken that were above 12°C, because this threshold provided most significant statistical relationships with oyster attributes (Wasson et al. 2014). In Coos Bay, 15°C was used based on locally observed thresholds for reproduction (Pritchard 2014). In Newport Bay, temperature was recorded from three study sites only and critical thresholds were not known. We used the average warm-season temperature and ranked lower a site with an average of <17°C compared with others where the average was ~19°C.

Liberty Bay, Puget Sound, Washington, following enhancement project.

Exposure: Exposure to lower than optimal water temperatures is common across the range of the oyster, since fastest reproduction and growth occurs above 20°C, yet few sites have average temperatures this high. Low water temperatures were listed as a concern for 39% of embayments. One might suspect that these were mostly northern sites, but in fact there is no particular latitudinal pattern. In some more southern embayments such as Tomales Bay, sites near the mouth of the bay can have very cold summer temperatures due to strong oceanic influence and low residence time, while some more northern embayments such as in the Strait of Georgia have less direct marine influence and shallow depths that allow for substantial warming in the breeding season.

Historical data and near-term models suggest that increased sea surface temperatures have occurred and will continue to occur in estuaries worldwide (Cloern et al. 2011). Near-term warming of estuarine waters will probably be beneficial for oyster growth and reproduction, based on existing experimental work. Exposure to greater than optimal water temperatures appears to be rare in most embayments (Table 1).

AIR TEMPERATURE TOO HIGH (sensitivity: *medium;* exposure: *medium)*

Sensitivity: Air temperatures during low tide can reach and exceed oysters' thermal maximum, while water temperatures rarely reach these high levels. Our lab experiments showed that Olympia oysters can withstand high air temperatures during low tide exposure, with some mortality beginning to occur at 40°C (Wasson et al. 2014). When paired with another stressor, such as low salinity, high air temperature can have more pronounced lethal effects (Wasson et al. 2014). Oysters may also be sensitive to low air temperatures and the northern limit of the species may be set by freezing (Baker 1995), but we lack data on sensitivity and have not included this stressor here. In various bays in Oregon and Washington, significant negative effects of low air temperature have been observed, (B. Allen, personal communication).

Olympia oysters on hard substrate in Elkhorn Slough, California.

Blazing heat and air
Meet a patch of oysters bare
How will they now fare?

Assessment method: To precisely quantify low tide air temperatures, *in situ* temperature loggers deployed near the oysters are ideal. Percentage of days above a threshold, such as 40°C, can be calculated. Thresholds may show local adaptation and vary across regions.

Exposure: In our site evaluations in Central California and Oregon, we found air temperatures rarely to exceed 30°C during low tide exposure. In these areas, the lowest tides (with longest air exposure) mostly occur near dawn or dusk, resulting in low measured air temperatures at low tide. However in Washington estuaries, summer low tides often occur close to midday. In Willapa Bay, exposure to high air temperatures results in significant mortality of juvenile oysters at higher tidal elevations (Trimble et al. 2009). High air temperatures were also identified as a concern at the most southern embayments. Thus in the regional comparison (Table 1), exposure to high air temperature does not follow a clear latitudinal gradient, but rather shows some expression in both southern and northern sites, but not at intermediate ones. Such exposure is projected to increase with climate change.

Oysters in a high flow habitat in Newport Bay, California, which may enhance feeding and oxygenation.

FOOD LIMITATION (sensitivity: *medium;* exposure: *medium)*

Sensitivity: Phytoplankton (single-celled planktonic algae) serves as food for filter-feeding oysters. Both food concentration and feeding time can be limiting, for example in intertidal areas with periods of aerial exposure compared with constantly submerged subtidal areas (Kimbro et al. 2009, Deck 2011). Limited food supply can result in reduced growth, shifts in size frequency, and reduced or delayed reproductive ability in other oyster species (e.g. Hofmann et al. 1994, Powell et al. 1995). Food limitation also may lead to reduced growth and weight, and delayed time to settlement in Olympia oyster larvae (Hettinger et al. 2013). Chlorophyll concentrations also correlate with reproduction in the field in Oregon (Oates 2013). Our field data from Central California indicate that levels of chlorophyll *a* are positively correlated with oyster performance (Wasson et al. 2014).

Assessment method: To estimate phytoplankton abundance at sites, one can measure the abundance of chlorophyll *a*, a plant pigment that is commonly used as a proxy for phytoplankton biomass. Exact thresholds are not known, but concentrations below 5 µg/L during summer-fall are probably too low, and concentrations >10 µg/L are desirable.

Exposure: Little is known about whether food is limiting for Olympia oysters at many sites across their range. In Central California, some sites had levels (<5 µg/L) that may be too low to sustain successful oyster populations (Wasson et al. 2014). Food limitation was identified as a potential stressor at seven embayments in California and Oregon. Exposure to food limitation was not listed as a concern at the other 75% of embayments that were evaluated (Table 1), presumably because productivity is high in these places.

LOW OXYGEN (sensitivity: *medium;* exposure: *low)*

Sensitivity: Hypoxia is the depletion of oxygen from water, typically defined as a dissolved oxygen threshold below 2–5 mg/L (by different standards). Estuaries and near-shore systems often exhibit hypoxia as a result of eutrophication. Eutrophication stimulates the primary production of plants, which then die and are decomposed via microbial consumption, which depletes the water column of oxygen. Overproduction of plants (e.g., algae) can also reduce dissolved oxygen at night when plants respire. Worldwide, hypoxia appears to be expanding in frequency and areal extent (Diaz and Rosenberg 2008). Our experimental results suggest that diel-cycling hypoxia (modeled after the conditions at Elkhorn Slough) is not lethal, but has substantial sublethal effects on growth (Cheng et al. 2015). Periodic die-offs have been observed at Elkhorn Slough at sites with restricted tidal exchange following unusually long anoxic periods (Wasson, unpublished data).

Assessment method: Ideally, dissolved oxygen concentrations should be measured with *in situ* sondes collecting data continuously. One can then quantify hypoxia through measures such as the percentage of measurements where

Oysters raised in the lab, subjected to low dissolved oxygen (top) and normal levels (bottom).

dissolved oxygen was lower than 5 mg/L. However, many monitoring programs only collect grab samples during the daytime. We have found that variance from 100% saturated oxygen conditions (both increases or decreases) in daytime measurements correlate quite well with duration of nighttime hypoxia. So measures of average variance from fully saturated oxygen conditions (such as 9 mg/L) can be used as a proxy for hypoxia.

Exposure: Across embayments, hypoxia was only identified as a high threat for oysters at Elkhorn Slough (Table 1), an estuary very heavily affected by agricultural nutrient loading. Oxygen levels are expected to decrease as climate warms (Levin and Breitburg 2015), so this stressor may increase in frequency and may occur in new locations.

COMPETITION (sensitivity: *low;* exposure: *medium)*

Sensitivity: Other species co-occurring with Olympia oysters on hard substrates may compete with them for space on which to settle or grow, or for food. Our field data from Central California showed no negative correlation between space covered by other sessile species and oyster density, recruitment, or growth at/near MLLW (Wasson et al. 2014). The main groups of species present at MLLW were the green algae *Ulva* spp., red filamentous algae, and barnacles. Many sites were high in bare hard substrate availability. Previous work indicates that the effects of competition are variable, and more likely to have an impact on early life stages of Olympia oysters. The presence of competitors reduced total recruitment in San Francisco Bay and reduced recruit size in Tomales Bay, though effects varied by site (Deck 2011). Competitive effects increased at some sites at lower tidal heights, but this was not consistent across sites or bays. Only minimal effects were observed on other aspects of oyster life stages. Wasson (2010) found no correlation between recruit size or survival and distance to the nearest competitor near MLLW in Elkhorn Slough. However, greater low intertidal and subtidal coverage by fouling species was observed, which could indicate potential effects at lower height. In the Pacific Northwest, Trimble et al. (2009) found that high cover of sessile invertebrate species, mainly barnacles and ascidians, reduced juvenile survival and growth, and tidal height did not affect this. In Puget Sound, barnacles, jingle shells and bryozoans compete for space, potentially limiting oyster recruitment (B. Allen, personal communication).

Competition with the introduced Pacific oyster *Crassostrea gigas* has been demonstrated in Willapa Bay to negatively impact Olympia oyster growth and increase mortality (Buhle and Ruesink 2009, Trimble et al. 2009). Although the potential impacts of *C. gigas* on *O. lurida* are not known for San Diego Bay, concerns about potential competition as well as a desire to not enhance *C. gigas* populations have been a factor in the design of restoration projects there. Indeed, many restoration practitioners are worried about inadvertently increasing populations of nonnative species through the provision of new hard substrates intended for native oysters.

Tube worms co-occur with oysters in Elkhorn Slough, California.

Assessment method: Percent coverage of potential competing species can be assessed in field transects along with oysters. Another simple proxy for effect of competition is percent coverage by bare space on hard substrates—if this is high, competition is presumably not a major factor. To truly determine the effects of potential competitors on oysters, manipulative experiments are required.

Exposure: Multiple factors, including the identity and abundance of potential competing species, environmental stressors, predation, and the timing of recruitment and growth of potential competitors, will determine the degree to which competition is a factor in any given location. Competition with *C. gigas* was identified as being of moderate importance in a number of bays in California, Oregon and Washington, but unimportant elsewhere (See Table 1). Competition with other species was indicated as being potentially of high importance at Netarts and Yaquina, and of moderate importance at various bays in Oregon, Washington, and British Columbia.

ACIDIFICATION: LOW pH/ALKALINITY (sensitivity: *low;* exposure: *low)*

Sensitivity: One of the better-studied consequences of global change is the increasing acidity of ocean water due to the greater concentration of carbon dioxide (CO_2) in the atmosphere. Aragonite is the form of calcium carbonate used by most larval bivalves to build their shells; one aspect of more acidic water is that aragonite is less available to larvae, resulting in small, thinner or malformed shells and/or death (Ekstrom et al. 2015). Experimental studies of Olympia oysters have demonstrated some negative effects of acidification (Hettinger et al. 2012, 2013), though these were mostly sublethal and not as strong as effects demonstrated on other oyster species. Many estuaries, such as San Francisco Bay and Tomales Bay, have relatively large seasonal and diurnal fluctuations in pH and carbonate saturation as the result of inputs from both watershed (river inflow) and nearshore oceans (via upwelling), and the influence of plant metabolism (daily cycles of photosynthesis and respiration)

Monitoring Olympia oysters among Pacific oysters and mussels in Newport Bay, Southern California.

(Smith and Hollibaugh 1997). Consequently, organisms in these locations, including oysters, often already experience a very wide range of pH and carbonate saturation conditions, and we are not aware of any evidence to suggest that oysters currently are negatively impacted by these fluctuating conditions in much of the range. At some estuaries, such as Netarts Bay, acidification is a new stressor for *Crassostrea gigas,* leading to lower larval production and growth (Barton et al. 2012), and may also affect *Ostrea lurida* (D. Vander Schaaf, personal communication), although the brooding habits of this species may offer greater protection to larvae.

Assessment method: Measurements of pH by water quality instruments provide a reasonable estimate of acidification, but the precision of typical sensors is too low to detect subtle trend changes. Calculations can be made of frequency or duration of low pH events. More precise pH sensors, and at least occasional assessment of alkalinity and dissolved inorganic carbon is ideal, although the required instruments are expensive.

Exposure: Across embayments, acidification was currently ranked as a low threat to oysters, with the exception of Netarts Bay where it was ranked high, and Tomales, Yaquina and Victoria, where it was ranked of moderate importance (Table 1). Acidification has been shown to negatively impact growth and potentially increase mortality in larval Pacific oysters in hatcheries in Oregon (see Barton et al. 2012). Although we are unaware of documented impacts to Olympia oysters under current conditions, acidification may impact native oysters more strongly in the future. Potentially, exposure to acidification will increase as increasing atmospheric CO_2 results in increasing water-column pCO_2, along with future changes in river inflows and upwelling inputs (Cayan et al. 2008, Checkley and Barth 2009), although the complexity of carbonate chemistry in the coastal zone makes predicting impacts difficult (Waldbusser and Salisbury 2014).

Monitoring restoration at Netarts Bay, Oregon, a site where Pacific oysters have been threatened by acidification.

Live oyster surrounded by oil at Angel Island, San Francisco Bay, following 2009 Cosco Busan oil spill.

CONTAMINANTS (sensitivity: *low;* exposure: *low)*

Sensitivity: Polluted water, notably the discharge of high amounts of sulfite wastes from paper mills in the Pacific Northwest, once had major impacts on native oysters (Blake and Bradbury 2013), and the dumping of untreated sewage may have harmed oysters in San Francisco Bay as well as shut down oyster farming operations due to public health concerns (multiple reports, reviewed by Baker 1995).

Despite the persistent presence of contaminants at many sites, oysters do not appear to be very sensitive to them, generally. In California, Olympia oyster populations exist in habitats formerly considered "polluted," such as near a wastewater treatment outfall in Humboldt Bay, CA, in marina basins in San Francisco Bay, and in an area formerly contaminated with heavy metals and polychlorinated biphenyls near Stege Marsh, Richmond, CA (Couch and Hassler 1989, Hwang et al. 2013). In many locations, heavy metals and other long-lasting pollutants that are the legacy of now-closed industry may be taken up by oysters. For example, a sample of 20 apparently healthy oysters taken in 2006 from an oyster restoration site in San Rafael (San Francisco Bay) indicated very high levels of copper, suggesting the presence of a substantial source of this pollutant nearby (Gerhart, personal communication). However, oysters continue to thrive at this site and at other restoration sites nearby.

Assessment method: Contaminant sampling methods for sediments and oyster tissue differ by the contaminant in question. Many estuaries are contaminated by a range of PAHs, heavy metals and legacy pesticides as well as emerging contaminants. Quantifying the bioavailability and toxicity of these compounds, let alone their interactive effects, is very expensive and technically challenging.

Exposure: Current environmental laws have reduced the use and release of contaminants, such as organic biocides (Axiak et al. 1995), polycyclic aromatic hydrocarbons, and heavy metals (Connor 1972), which were previously found to affect oyster populations. Contaminants were considered a low threat across embayments, with the exception of Yaquina Bay and Discovery Bay, where this stressor was ranked a moderate threat (See Table 1).

PATHOGENS AND DISEASES (sensitivity: *variable;* exposure: *low)*

Sensitivity: Overall, oyster diseases and pathogens currently do not appear to be a major factor influencing native oyster populations in Central California. While individual oysters may suffer from infections, rates are low overall and no observed population diebacks have been linked to disease.

However, it would be unwise to entirely dismiss disease as a potential stressor for Olympia oysters. Eastern oysters in the Chesapeake and Delaware bays were apparently disease-free for decades until the introduction of oysters from the Gulf of Mexico led to emergence of two new diseases in the 1950s. Oyster disease agents are certainly present, having been reported from both commercially

grown Pacific oysters and native oysters in multiple bays along the coast, including Elkhorn Slough, and Tomales and Humboldt bays in California, and Netarts, Yaquina, and Alsea bays in Oregon (Mix and Sprague 1974, Friedman et al. 2005, Burge et al. 2007, Moore et al. 2011). Olympia oysters may become more susceptible to disease as restoration moves forward and population density increases. Additionally, disease prevalence and impact may increase as a result of other stressors associated with climate change, such as increasing water temperatures, which have been linked to herpes outbreaks in commercial oyster species in Tomales Bay (Burge et al. 2007).

Assessment method: An overview of assessment methods for oyster diseases and pathogens is provided by Baggett et al. (2014). Microscopic examination of stained histological sections and/or genetic analyses are appropriate for detecting various pathogens or diseases. If oyster density is considered too low to sacrifice animals for pre-restoration health surveys at the restoration location, information from the nearest population(s) that can be sampled is useful. Additionally, seed oysters from nearby populations with known health history may be deployed at the proposed site. To understand population-level effects, one must quantify percentage of individuals infected, intensity of individual infections and outcomes for those individuals.

Exposure: Overall, exposure to disease appears to be low according to the expert assessments (Table 1). We review highlights of potential disease concerns from south to north.

Monitoring at Nootka Sound, Vancouver Island, British Columbia.

Reef balls deployed in Elkhorn Slough (top) and San Francisco Bay (bottom).

From Southern California to Tomales Bay, disease was not considered a significant factor affecting Olympia oysters in any embayment (Table 1). The most recent published surveys of disease in Olympia oysters in the San Francisco Bay Area (Friedman et al. 2005; Moore et al. 2011) reported that potentially pathogenic bacteria, viruses, and protists are present only in a minority of oysters, and typically at levels lower than those associated with disease. These studies showed little evidence for presence of disease except for disseminated neoplasia in Drakes Estero, and Candlestick Point, Oyster Point, and Coyote Point in San Francisco Bay (Friedman et al. 2005, et al. 2008, Moore et al. 2011). The levels measured at these four sites are unlikely to seriously affect oyster populations or negatively affect restoration efforts (Grosholz et al. 2008).

In Humboldt Bay, there is evidence of the occurrence of Denman Island disease, and oyster experts coded this as a moderate concern because of potential mortality in older oysters following cold temperatures (D. Couch and K. Ramey, personal communication). However, there is no evidence from any site that Denman Island disease causes significant population level effects on Olympia oysters (J. Moore, personal communication).

In Coos Bay, disease was considered a moderate stressor because 17% of Olympia oysters tested for diseases showed tissue irregularities, focal hemocytosis, and nuclear degeneration (Rumrill 2010). In Netarts and Yaquina bays concerns about *Vibrio tubyashi* led to scores of moderate and high stressor levels for diseases (D. Vander Schaaf, personal communication).

Disease was not considered an important stressor at any embayment in Washington or British Columbia. While several disease agents were recently identified in surveys of Olympia oysters in British Columbia, these were generally detected at low prevalence and intensity and were not believed to have significant health impacts (Meyer et al. 2010).

San Francisco Bay Living Shorelines Project constructed reefs at the San Rafael Shoreline.

Sunset low tide monitoring at Point Orient, San Francisco Bay.

SEA LEVEL RISE (sensitivity: *low;* exposure: *low)*

Sensitivity: Olympia oysters are not very sensitive to projected sea level rise. One potential impact of sea level rise could be increased local resuspension of sediment due to greater wave action and tidal currents associated with deeper waters. This could result in stressors associated with increased sediment burial in shallower areas. However, more hard substrate may be available for oysters as sea levels rise, both because existing hard substrates protecting human infrastructure may become submerged, and due to further shoreline hardening to protect human land uses from sea level rise. Given the drawbacks of traditional shoreline hardening, measures such as living shorelines—creating habitat for multiple species—are increasingly being incorporated into thoughtfully planned nature-based solutions.

Assessment method: One can assess hard substrate availability at different elevations to determine potential effects of projected sea level rise on habitat availability for oysters.

Exposure: Rates of sea level rise on the northeast Pacific coast have been relatively slow compared to other regions, but are anticipated to accelerate soon (Bromirski et al. 2011). Exposure to sea level rise also depends on change in land surface elevation, which can be affected at a regional scale by factors such as geologic uplift, or at a local scale by factors such as groundwater overdraft leading to subsidence.

INTERACTIONS BETWEEN STRESSORS

Environmental stressors often occur in combination. It is therefore important to understand not only the impacts of individual stressors but also the effects of combinations of multiple stressors on Olympia oysters. Multiple stressors can produce additive effects (i.e., equal to the sum of the stressor impacts), or interactive ones (i.e., either more detrimental or less detrimental than would be expected by simply adding the effects of the stressors).

We used field studies in Central California, combined with previous work, to measure baseline patterns of potential environmental stressors in relation to oyster demographics. We used several multivariate analyses of a broad suite of environmental variables (including air and water temperature, salinity, and dissolved oxygen) and oyster demographic parameters (density, growth rate, size, recruitment rate) to identify which stressor or combinations of stressors explained the most variation in oyster demography.

We used laboratory experiments to more closely investigate causal relationships between multiple stressors and Olympia oyster survival and performance. In the first experiment, we examined interactions between warm water temperatures and low oxygen levels applied as simultaneous stressors. Following a recovery period, we applied low salinity stress, so that interactions between all three stressors could be examined. Here, we found no evidence for interactive effects, but rather, these stressors were additive (Cheng et al. 2015). In the second experiment, we assessed the effects of low salinity and high air

Tank experiments examining multiple stressors at the Bodega Marine Lab in California.

temperature simultaneously, and with different amounts of time between applying the two stressors. When applied simultaneously, we saw synergistic effects (detrimental effects beyond what would be predicted by simply adding the effects of low salinity and air temperature). When oysters were given recovery time between stressors, this synergistic response disappeared (Wasson et al. 2014). Previous studies have found interactive effects to be generally more common than additive effects (Crain et al. 2008, Darling and Cote 2008), but we found that results are dependent on the specific stressors and their timing. Although some stressors like low salinity and high air temperature may co-occur (for example, during springtime in some parts of San Francisco Bay) and produce synergistic effects, realistic recovery time between stressors may lead to effects that are more additive in nature.

Many of the environmental factors discussed above also interact with tidal elevation. For instance, feeding time is longer at lower elevations, so phytoplankton concentrations need not be as high to support subtidal populations as high intertidal ones. Exposure to warm air increases with increasing tidal elevation, while coverage of most sessile invertebrates decreases with increasing tidal elevation. For rigorous comparisons among sites, it is thus important to examine biological and environmental conditions across similar tidal elevations; in our assessments of Central California sites, we focused on Mean Lower Low Water because this is where oyster densities are typically highest. For practitioners elsewhere using our site evaluation tool to rank sites for their restoration potential, it is important to consider the role of tidal elevation. For instance, a site that receives a low score because of frequent high air temperatures may be a fine place to do a subtidal restoration project. Considerations of interactions between environmental factors and tidal elevations is thus essential.

Rocky intertidal habitat at Strawberry (Brickyard Cove), San Francisco Bay.

Site Evaluations

Background and Goals

Resource managers and restoration practitioners indicated a need for tools to help rank sites in terms of their suitability for native oyster restoration and conservation (Wasson et al. 2013). Site evaluations have been conducted by other researchers in some regions, including Puget Sound (Blake and Bradbury 2013) and British Columbia (Stanton et al. 2011). However, there was no quantitative methodology for comparing sites in terms of their restoration potential or conservation value. We thus developed quantitative metrics and report-card style summary tables to evaluate sites. With extensive grant funding, we were able to conduct thorough field monitoring data and evaluate 21 sites in Central California (Wasson et al. 2014). Subsequently, we were able to conduct scaled-back evaluations of sites in Southern California (Appendix 1) and southern Oregon (Appendix 2) using existing data for those regions. Furthermore, we developed an online version of the site evaluation tables as a tool for scientists and practitioners working in other estuaries (available at www.climate-and-oysters.org).

Our Approach to Site Evaluation

The site evaluation tables score sites based on oyster performance and on measurements of key environmental parameters. To create the tables, we used the same oyster attributes described above, and all the environmental stressors with high and medium oyster sensitivities discussed above (with the exception of sedimentation, not relevant to most of our sites, which had ample large hard substrates preventing sediment burial, or would have them as a result of restoration projects).

For each parameter for which data were available, we converted raw data to a score. This conversion was based on thresholds we set using expert judgment. For instance, one parameter was oyster drill density. If there were zero oyster drills per square meter, this was assigned a 100, the best score. If there were more than five oyster drills per square meter, this was assigned a 0, the worst score. Intermediate densities received intermediate scores (25 for 3–5 drills, 50 for 1–2 drills, and 75 for between 0–1 drills per square meter). Thresholds were different for Oregon, Central California, and Southern California, and depended on the range of the raw data and/or knowledge of key thresholds at each location, with the goal being to rank sites relative to one another within each region. We shaded cells in the tables, with light colors for low scores and dark colors for high scores, to make patterns easily distinguishable at a glance (Appendix 1, 2, and Wasson et al. 2014).

We assigned weightings to each parameter in the tables. In particular key oyster attributes such as density and recruitment were weighted highly relative to other parameters, since they are the most reliable indicators of oyster success. Relationships between environmental factors such as temperature and oysters are weaker (and were not quantified for Southern California, Coos Bay or South Slough) and thus were weighted lower. The weightings are clearly shown

in the tables so the process of obtaining a total score is transparent. In the online tool, users can adjust the weightings themselves.

We calculated overall scores using all the weighted parameters. The tables include three different overall scores at the bottom: 1) a score indicating suitability of the site for restoration through addition of hard substrates; 2) a score indicating suitability of the site for restoration through addition of hard substrates seeded with juvenile oysters, sufficient to establish a self-sustaining population supplying larvae to this area, and 3) a score indicating value of this area for conservation of existing oyster populations. Details on all the parameters included their weighting, and calculation of the overall scores are included in the notes associated with the tables (Appendix 1, 2 and Wasson et al. 2014 [including their appendices 2,4]).

Site Evaluation Case Studies

CENTRAL CALIFORNIA

We evaluated twelve sites in San Francisco Bay and nine sites in Elkhorn Slough (Wasson et al. 2014). On the whole, sites in San Francisco Bay scored higher than those at Elkhorn Slough, generally due to higher scores for oyster parameters. Top scoring sites were Berkeley Marina, Strawberry (Brickyard Cove), Point Pinole, and San Rafael Shoreline in San Francisco Bay and South Marsh and Kirby Park at Elkhorn Slough. Major stressors differed between the two bays, with more sites in San Francisco Bay experiencing periodic low salinity, higher air temperatures, and relatively low chlorophyll *a*; while low dissolved oxygen was the major stressor at Elkhorn Slough, with low chlorophyll *a* and low water temperatures mainly at a few marine-influenced sites near the mouth of the estuary. At both estuaries, mid-estuary sites generally scored higher than other sites, which is consistent with our working knowledge of the sites. Although North Bay sites in San Francisco Bay also scored high during this relatively short study period, these sites are more vulnerable to low salinity events. Over the nearly 10 years we have been working in San Francisco Bay, we have seen populations at these sites decline steeply during years of heavy rain. Sites in the South Bay, which have oyster drill populations and warmer air temperatures, such as Eden Landing and Coyote Point, scored lower. At Elkhorn Slough, several sites with little to no recruitment and/or adult oysters, such as Vierra and Moss

Urbanized conditions in San Francisco Bay (near right) compared to rural conditions at Elkhorn Slough, California (far right).

Landing, also received low overall scores, as did some upper estuary and tidally muted sites with low recruitment and poor water quality.

SOUTHERN CALIFORNIA

Fourteen sites, seven each in Newport Bay and San Diego Bay, were evaluated using data collected between 2010 and 2014 as part of several research projects. Not all data were collected at all sites, but measurements of some critical oyster parameters were similar enough to allow comparisons.

Overall, greater variability between sites existed within San Diego Bay, whereas the sites in Newport Bay were more similar in all oyster attributes studied. San Diego sites as a rule had much higher recruitment rates (one to two orders of magnitude) than Newport Bay sites, and thus had higher restoration scores overall. San Diego sites also had high juvenile growth rates compared with Central California, although these were somewhat skewed by the short time period (70 days) over which these new settlers were tracked; there was also high survivorship of juveniles over this same time period. These parameters were not available for Newport Bay. Adult densities were low at four sites in San Diego; two sites had no adults and two sites had fewer than 10 individuals/m^2. This was due to a paucity of hard substrate at these locations. All sites in San Diego received high to medium high scores for restoration success due to high recruitment rates, rapid juvenile growth and good juvenile survival, although data on potential critical environmental parameters were missing. Three sites—Chula Vista Wildlife Refuge, J Street Marina, and Coronado Cays—received the highest restoration scores, with Chula Vista scoring the highest of the three due to high densities of adult oysters (291/m^2). Chula Vista also received the highest conservation score due its large oyster population (estimated in 10,000s).

Monitoring site in Newport Bay, Southern California.

Olympia oyster restoration in South Slough, Oregon.

None of the Newport Bay sites received a high score for restoration success, but neither did any site rank poorly—rather, all sites scored medium high. All sites had moderate to moderately high scores for adult densities, sizes and size-class distributions, and the three sites for which recruitment was tracked also had moderate scores. Two sites received high scores for conservation, 15th Street, and Newport Aquatic Center, but the latter was evaluated on the basis of its population estimate only (15,000 individuals) as other data were unavailable. Water temperature was the only environmental parameter measured for Newport Bay and only for three sites, so potential environmental stressors for this bay could not be quantified.

SOUTHERN OREGON

We evaluated three locations in the northeastern portion of the Coos estuary (referred to as Coos Bay), and two sites in South Slough, which comprises the major southern arm of the Coos estuary (Appendix 2). In Coos Bay, large deposits of recent fossil Olympia oyster shells have been found in dredge spoils and American Indian shell middens, but oyster populations became locally extinct prior to European settlement. Only after accidental introductions in the 1980s through aquaculture activities did they become reestablished in the estuary (Baker et al. 2000). The sites in Coos Bay consist of fairly established oyster populations stemming from this re-introduction. In South Slough, Olympia oysters were absent until they were reintroduced through a project that began in 2008. As a result, in general, Coos Bay sites had higher adult densities than the South Slough sites.

The highest scoring site for restoration in Coos Bay was Downtown, although Haynes Inlet received only a slightly lower score. Downtown had the highest adult and recruit densities and larval abundance. For habitat attributes, Downtown also had the highest availability of hard substrate, which was a potential limiting factor for other sites. All Coos Bay sites had substantial freshwater inputs, with daily salinity averages below 25 for up to 76 percent of the year, but this seemed compatible with substantial oyster populations, perhaps due to local adaptation to lower salinity. Coalbank Slough had the highest risk of low pH events, but pH at this site was highly variable. Average chlorophyll *a* concentrations measured at Haynes Inlet and Coalbank Slough were moderate and may contribute to higher oyster performance at these sites whereas average chlorophyll *a* concentrations in South Slough were lower. At nearby weather stations, high air temperature events were rare. Sedimentation in South Slough appears to be high and may impact future restoration seeding operations.

Top: monitoring tiles at Kirby Park in Elkhorn Slough, California. Bottom: students with The Watershed Project.

Challenges and Limitations to Site Evaluations

It is important to keep in mind that the site evaluation tables are based strictly on biological/ecological measurements and do not take into account other important considerations in site selection, such as community support, access, funding, and permit procedures.

Even from a strictly scientific perspective, there is still much to learn about native oyster population biology and ecology in our region, and of course there are many unknowns as we project into the future, given a changing climate. In many cases, data are available only for short time spans that likely do not represent the full range of conditions at a site over longer periods, or, particularly for many of the physical parameters, detailed data are only available at larger spatial scales, yet conditions may vary with microclimates at the site level. Many of the physical parameters likely to be important to oysters are difficult and/or costly to measure. Also unknown is the degree to which oysters may display adaptation to local conditions, such that the relative importance of any given physical parameter might vary between embayments. Additionally, we don't yet know the degree to which populations are connected, which could mean that the critical factor of recruitment rate may be partially decoupled from site-level conditions. While oyster attributes, such as size or density, are easily measured, our understanding of the relative importance even of these parameters to the sustainability of oyster populations in a given region is also limited. Thus, in the creation of these tables, we relied on our expert opinion to weigh the relative importance of oyster performance data and the likelihood of extreme climate events at our study sites, particularly in converting raw data into weighted ranks. As such, the tables represent a combination of empirically derived data and judgment calls.

Thus, site scores should be considered advisory only and are intended to provide guidance for restoration by comparing sites within regions, rather than as an absolute ranking across all locations. For some sites, it is also possible that modifications to the restoration approach could help ameliorate stressors. For example, substrates could be deployed in the shallow subtidal rather than in the intertidal zone to reduce heat stress at a site with frequent very-high air temperatures.

Online Site Evaluation Tool

We have created an online site evaluation tool in Excel that allows users to populate a table with their own data (available at www.climate-and-oysters.org). There are separate sheets for assessing conservation value of sites for existing oyster populations vs. restoration potential (with and without seeding). Users can adjust the weight of different parameters as they see fit. The table allows for assessments to be conducted with considerably fewer parameters than we included in our original evaluations (Wasson et al. 2014), which in most locations is likely to be the case.

Installing monitoring tiles in San Francisco Bay.

At an absolute minimum, we recommend collecting data on adult oyster densities and diversity of size classes for restoration sites being considered (these are also two of the four "universal metrics" recommended for oyster restoration monitoring by Baggett et al. 2014). To determine a site's conservation value the extent of shoreline with hard substrate at the appropriate tidal height should be assessed. This, together with density, can provide an estimate of abundance of oysters at the site. Data on recruitment rates, derived by deploying clean substrate at the start of recruitment season, should be collected if at all possible; ideally these data should be collected over several years, as recruitment can be highly variable at some locations. Recruitment to deployed substrate and subsequent measurements of growth and survival should be evaluated for sites that do not have hard substrate but are being considered for restoration involving substrate addition. If possible, data on environmental variables should also be incorporated. Across embayments, the most critical factors to assess appear to be: 1) the longer-term risk of low salinity exposure; 2) exposure to high air temperatures, 3) risk of predation by oyster drills and other species, and 4) competition with *Crassostrea gigas* and other sessile organisms. Data from a nearby monitoring station can often be used to determine whether there is a risk of extended freshwater events during wet years, and to calculate maximum daily summer air temperatures (although exposure to air temperatures will be mitigated by tides and influenced by micro-climates at the site level.) Chlorophyll and water temperature data are also regularly available from water monitoring programs and yield important information. Assessing whether oyster drills and other potential predators and competitors are abundant at the site can also be done fairly easily.

Placing shell bags for restoration at Netarts Bay, Oregon.

Management Applications of Site Evaluation Tools

The site evaluation tools developed here can be applied to two main types of management questions:

Student volunteers with The Watershed Project monitor conditions at Point Pinole, California.

1. **Conservation: Which sites currently support healthy and abundant existing oyster populations that are most likely to be sustainable in the long-term?**

   Example of management decisions: strategic planners and resource agency staff involved in permitting determine which sites/populations need special protection from development or nearby disturbance; regulatory agency considers oyster needs when designating a new marine protected area.

2. **Restoration/Enhancement**

   a. **Which sites are best for success and long-term sustainability of oyster restoration or enhancement projects?**

      Examples of management decisions: funding agency decides between competing projects in different locations; strategic planner for estuarine restoration picks target areas; restoration group decides where to propose next project.

   b. **Is an oyster restoration or enhancement project done at site X likely to be successful?**

      (This question is very similar to 2a, but in this case applied to a single site as a "yes/no" question about doing restoration, rather than involving prioritization between multiple sites.)

      Example of management decision: restoration group decides whether to propose project at a particular site; funder decides whether to fund; conservation land trust or resource management organization decides whether to invest in oyster restoration at a particular property they own.

Elegant oysters,
unique history and lore.
Habitats prevail!

Conclusions

This guide has synthesized data from recent laboratory experiments and field monitoring, and the published literature. We have used this information to characterize the attributes of sustainable Olympia oyster populations, and to identify the stressful environmental factors that affect them most strongly across the range of the species.

Overall, the most frequently encountered stressors across 28 embayments were sedimentation and predation. Competition, cold water temperatures, warm air temperatures, and freshwater inputs were also common concerns at many bays. These types of stressors are natural components of marine ecosystems. However, they have been exacerbated by human activities; for instance, a major predator in some embayments is a non-native snail introduced with aquaculture, and some land uses in estuarine watersheds (hydraulic mining, agriculture) have increased sedimentation rates in some estuaries. Global climate change may also increase exposure to these stressors, for instance increasing storm intensity and freshwater inputs or increasing frequency of exposure to high air temperatures or acidified waters.

We examined interactions between different stressors under laboratory conditions and found that the types of responses observed depended on the stressor and the timing of application. We documented some linear, additive relationships between stressors, and some that were non-linear and synergistic. It is clear that decreasing stressor levels through ecosystem management (such as reducing hypoxia resulting from nutrient loading) will support oysters, but it is hard to predict whether such stressor reduction will increase resilience to other stressors, such as those related to climate change.

Top: Isthmus Slough, Oregon. Bottom: Olympia oysters in Nootka Sound, Vancouver Island, British Columbia.

We have developed a site evaluation tool and used it to assess restoration and conservation potential of Olympia oysters in two Oregon and four California estuaries. As more investigations are conducted and restoration projects are implemented, understanding of oyster sustainability will evolve, and these guidelines will need updating. We hope that in the coming years, the recommendations provided here will support improved oyster conservation and restoration.

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From waters unknown
New lives spring into being
Next generation

Image Credits

Abbreviations: T *(top),* M *(middle),* B *(bottom),* L *(left),* C *(center),* R *(right)*

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Haikus: These originated as a joking response to a request to reduce our research into short, succinct paragraphs. It turned out they were fun to do.

Appendices

Appendix 1
Southern California Site Evaluations: Newport and San Diego Bays

Appendix 2
Southern Oregon Site Evaluations: Coos Bay and South Slough

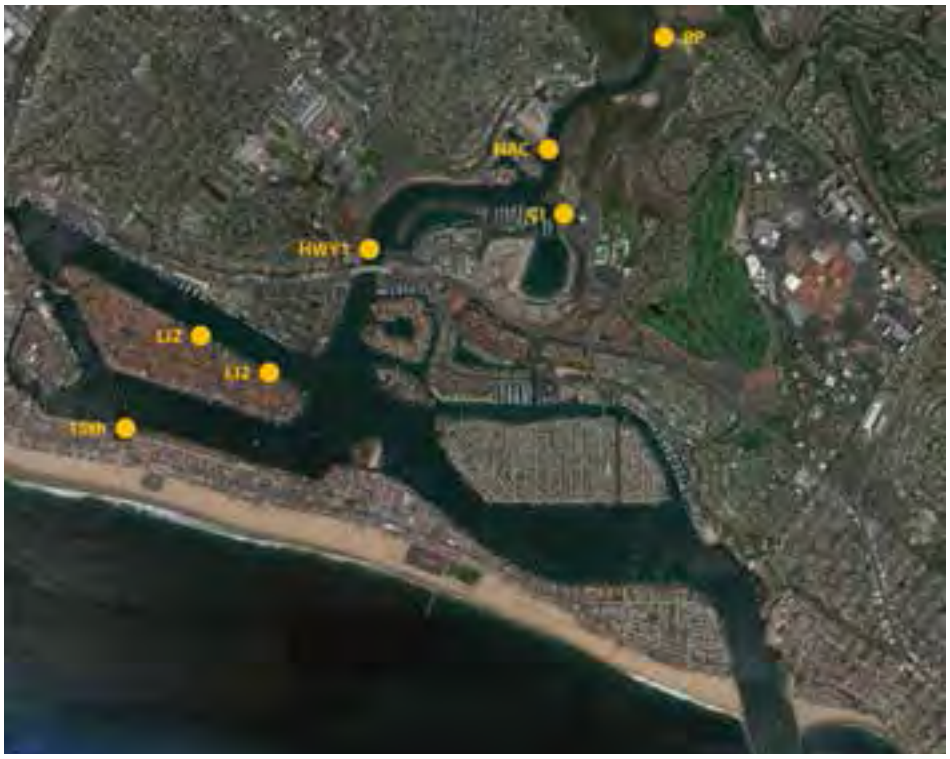
Appendix 1. Southern California Site Evaluations: Newport and San Diego Bays

Overview

Seven sites in Newport Bay and in San Diego Bay were evaluated using the Site Evaluation Tables. The method of Wasson et al. 2014 was modified for these sites, because few environmental data were available and differences in data collection and the range of key oyster parameters required some revisions to scoring. The site locations and data collection and processing methods are described below, followed by a summary of the site evaluation results.

Table 1. List of field sites, site codes, and location by bay.

Bay	*Site Name*	*Site Code*	*GPS Coordinates*
Newport	Highway 1	HWY1	33.6178 -117.9049
Newport	Coney Island	CI	33.6196 -117.8922
Newport	15th Street	15th	33.6083, -117.9204
Newport	Rocky Point	RP	33.6295 -117.8859
Newport	Lido Island Site 1	LI 1	33.6131 -117.9157
Newport	Lido Island Site 2	LI 2	33.6113 -117.9119
Newport	Newport Aquatic Center	NAC	33.6232 -117.8933
San Diego	Chula Vista Wildlife Reserve	CVWR	32.6143 -117.1138
San Diego	D Street Marsh	DSM	32.6471 -117.1162
San Diego	Signature Park	SP	32.6333 -117.1076
San Diego	J Street Marina	JSM	32.6203 -117.1042
San Diego	Coronado Cays	CC	32.6264 -117.1294
San Diego	Pond 11 North	P11N	32.6027 -117.1180
San Diego	Pond 11 South	P11S	32.6025 -117.1179



Map 1. Newport Bay field sites.

Map 2. San Diego Bay field sites.

Field Parameters

Table 2. List of parameters measured as part of this guide. Please refer to Table 1 for site codes. Timescales: Q = Quarterly, M = Monthly, B = Biweekly, C = Continuous, P = Periodically

Oyster Attributes	*Sites and Timescale*
Adult density	Newport sites (P, Oct - Apr); San Diego sites (P, May - Dec)
Size	Only Newport sites, except NAC (P, Oct - Feb)
Growth rate	Only San Diego Bay sites (~M, May-Sept), except PIIS
Survival rate	Only San Diego Bay sites (~M, May-Sept), except PIIS
Recruitment rate	All sites (B) except HWY1, LI 1, LI 2, NAC

Table 3. List of environmental factors, sites where data were collected, and the timescale for data collection.

Environmental Factors	
Available substrate	All sites (P)
Water Temperature	15th, CI, RP (C)

Field Methods

Oyster Attributes

Adult oyster density

We monitored oyster density at Newport Bay sites between October and April from 2010 to 2013 and at San Diego Bay sites between May and December of 2013. At each site, we laid out a 50 X 2 m transect centered near 0 to +0.5 m mean lower low water (MLLW) and then counted the total number of oysters within 30 randomly placed 0.25 m^2 quadrats along the transect. Density data were also used in calculations for population estimates on hard substrate over a 2 x 150 m area at each site.

Adult oyster size

At all Newport Bay sites except Newport Aquatic Center, adult oyster sizes were surveyed October - November 2010 and January-February 2011. At haphazard points along the transect (see Adult Oyster Density, above), the longest dimension of all native oysters encountered was measured (n = 17 to 57 individuals). These data were used to generate the mean upper quartile. Size distribution data were sorted into 10 mm bins and used to calculate a size-class diversity index:

Gini-Simpson Index = 1 – Simson's index (D_s)

$D_s = \sum p_i^2$

P_i = proportion of individuals in each group

Recruitment

We monitored recruitment by deploying four 15 x 15 cm red unglazed ceramic tiles near 0 m MLLW in all San Diego sites from June to October 2013 and at 15th Street, Coney Island and Rocky Point (Newport Bay) year-round from 2006 to 2014. From June to October tiles were collected in each bay approximately every two weeks, and we used these data to calculate recruitment rate. The total number of oysters was counted on each tile using a dissecting microscope to calculate a recruitment rate for each two-week period. The average recruitment rate was determined by averaging the rate from each collection period. The reliability of recruitment over the years was calculated for Newport Bay sites as the coefficient of variation of recruitment rate.

Juvenile growth and survival

At San Diego sites two additional recruitment tiles were deployed (see Recruitment, above), on May 30, 2013 and were collected and returned to the field ~monthly through September 2013 to measure growth and survival rates. Ten oysters per tile were identified after tile collection in June 2013 and their starting lengths were measured. In July and early September 2013, tiles were collected and oysters remaining from the original 10 were measured for growth and survival. Growth and survival rates were averaged between the two collection periods for each site.

Environmental Factors

Available substrate

In each bay, we used a 50 cm x 50 cm gridded quadrat along a transect (see Adult Oyster Density, above), to determine habitat percent cover. For each quadrat, we recorded habitat cover at 49 data points (e.g., mud, sand, dead shell, *Mytilus* spp*., O. lurida,* etc.*)* and from this calculated habitat percent cover. We combined habitat types into hard and soft substrate, and used average percent cover of hard substrate multiplied by oyster density to generate population size estimates.

Water temperature

In Newport Bay, Onset TidbiT temperature loggers were attached to recruitment tees near MLLW at 15th Street, Coney Island and Rocky Point. Loggers collected continuous data every 15 minutes from December 2009 through May 2012. As a rough estimate of water temperature, values above 29°C were excluded to eliminate air temperatures. The average daily warm period temperature was

determined as the average of daily temperature means during April – September over each year.

Modifications to the Site Evaluation Table

We made several modifications to the online version of Site Evaluation Table (Wasson et al. 2014). Because recruitment was recorded only for June-October for San Diego, we used average recruitment rate for that period only for both Newport Bay and San Diego. This resulted in significantly higher recruitment rates than the year-round rate reported for Central California. To reflect this we recalibrated the scoring bins, generally using order of magnitude differences in the raw data. Growth rates were calculated only for new settlers and only over a very short time period (~70 days), during which growth would be expected to be quite high. In contrast, the Central California data included older, larger oysters tracked over longer time periods. We adjusted scores for this parameter, reflecting the spread of the data. We also dropped scores for two sites, Coronado Cays and Signature Park, where fewer than 10 of the individuals being measured survived. We also decided to report water temperatures as the warm period daily average (April – September). We had data on water temperature for only three sites. Based on the assumption that warmer sites are generally better than cooler sites (Wasson et al. 2014), we scored the two warmer sites 100 and the cooler site at 75. It should be noted, however, that there is no indication from the data collected that the cooler site is impacting oyster performance.

Site Evaluations

Fourteen sites were evaluated in the two Southern California bays. Overall, greater variability between sites existed within San Diego Bay, whereas the seven sites in Newport Bay were more consistent in all oyster attributes studied. Chula Vista Wildlife Reserve scored among the highest in conservation value, largely due to the highest adult density of all the southern California sites surveyed. Other top scoring conservation sites included Pond 11 South and J Street Marina in San Diego Bay and Newport Aquatic Center and 15th Street in Newport Bay, although all Newport Bay sites displayed relatively high conservation scores. However, it should be noted that the high score generated for Newport Aquatic Center is based on two parameters (population estimate and drill predation) and Pond 11 South on three parameters (population estimate, recruitment rate, and drill predation). San Diego sites demonstrate exceptionally high larval recruitment, much higher than Newport Bay sites. High recruitment, along with high juvenile survival and growth rates, resulted in all San Diego sites receiving high or medium high scores as potential restoration sites. All of these can be considered a high

priority for restoration through the addition of hard substrate. The top restoration sites in Newport Bay were Newport Aquatic Center, 15th Street, Rocky Point, Highway 1 and Coney Island, with the two Lido sites showing slightly lower restoration scores; generally Newport sites scored lower than San Diego sites for restoration. Newport Aquatic Center already has a large oyster population; on this basis, the other high ranking sites might be preferentially selected for restoration. All sites received a boost in overall scores in the Seeding Score tab, but given the relatively high rates of recruitment in both bays, seeding is clearly not indicated as a restoration method.

However, there are several additional factors present at these sites not incorporated into the site evaluation metrics. First is the amount of available area for potential restoration. Most of the Newport Bay shoreline in particular is heavily armored by man-made substrates including rip rap, sea walls and pilings. Though oysters may perform well at certain sites, there may be little space available for hard substrate addition, particularly Newport Aquatic Center. Another factor of growing concern is the prevalence of the non-native oyster, *Crassostrea gigas*. Densities of *C. gigas* are higher in San Diego Bay than in Newport Bay and in San Diego Bay in particular, densities of *C. gigas* at some sites (Coronado Cays and J Street Marsh) are quite high. It is unclear if high *C. gigas* densities are having a negative impact on native oysters, however, in an effort to reduce potential competition between the two oyster species, restoration practitioners have deployed oyster restoration efforts at tidal elevations lower than the height where *C. gigas* are found in greater abundance (+ 0.75 to 1 m MLLW). Therefore, it is still unclear if high *C. gigas* populations would negatively impact native oyster restoration success or whether restoration plans may be altered to limit any potential negative impacts.

Newport Bay Site Evaluation Table (detailed version available from www.oysters-and-climate.org)

	Rocky Point	Newport Aquatic Center	Coney Island	HWY 1	Lido Island Site 1	Lido Island Site 2	15th Street
ADULT OYSTER DENSITY	50	50	50	50	50	50	50
OYSTER POPULATION SIZE	75	100	75	75	75	75	100
ADULT OYSTER SIZE	50		50	50	50	50	50
DIVERSITY OF SIZE CLASSES	50		75	75	50	50	75
RECRUIT DENSITY	50		50				50
RELIABLE RECRUITMENT	100		50				100
WATER TEMPERATURE	100		100				75
DRILL PREDATION	100	100	100	100	100	100	100
OVERALL SCORES							
Restoration (natural recruitment)	69	71	68	68	62	62	70
Restoration (with seeding)	71	80	70	71	64	64	72
Conservation	71	100	74	75	73	73	89

San Diego Bay Site Evaluation Table (detailed version available from www.oysters-and-climate.org)

	D Street Marsh	Signature Park	Coronado Cays	J Street Marina	CVWR	Pond 11 North	Pond 11 South
ADULT OYSTER DENSITY	0	0	25	50	75	25	50
OYSTER POPULATION SIZE	0	0	50	75	100	25	75
RECRUIT DENSITY	75	75	100	75	75	100	100
SURVIVAL RATE	100	100	100	100	100	100	
GROWTH RATE	75			75	50	100	
DRILL PREDATION	100	100	100	100	100	100	100
OVERALL SCORES							
Restoration (natural recruitment)	66	64	79	78	81	81	82
Restoration (with seeding)	77	77	87	83	80	90	87
Conservation	0	0	72	79	91	61	85

Appendix 2. Southern Oregon Site Evaluations: Coos Bay and South Slough

Overview

We (A. Helms, B. Yednock) evaluated three sites in the northeastern portion of the Coos estuary (referred to as Coos Bay), and one site in South Slough, which comprises the major southern arm of the Coos estuary. The majority of the data used to evaluate the three sites in Coos Bay came from previously published manuscripts (Groth and Rumrill 2009) and student theses (Pritchard 2014, Rimler 2014, Oates 2013). A small amount of unpublished data that were collected in 2014 by staff and interns of South Slough National Estuarine Research Reserve at one of the Coos Bay sites (Coalbank Slough) and at two Olympia oyster reintroduction sites in South Slough were also included in the site evaluation tables. With the exception of South Slough, where oysters were absent until they were reintroduced through a project that began in 2008, the sites in Coos Bay consist of fairly established oyster populations stemming from the reappearance of Olympia oysters to the Coos estuary in the late 1980s. As a result, in general, Coos Bay sites have higher adult densities than the South Slough sites. The site locations and data collection and processing methods are described below, followed by a summary of the site evaluation results.

Site selection and use of field data in site evaluations

We selected three sites (Downtown Coos Bay, Haynes Inlet, and Coalbank Slough) for restoration evaluations because these sites had data available for both adult oysters and recruits, including growth and survival rates, in addition to larval abundance. Each of these three sites also paired with water quality sonde stations in Coos Bay that were between 1.2 to 3 km away. There were three additional sites from the Groth and Rumrill 2009 study in Coos Bay (Millington, Eastside, Pony Point) where adult density measures were available but no recruitment, growth, or survival measurements were made. From Pritchard (2013) and Rimler (2013), there were three additional Coos Bay sites (Empire, Catching Slough, and Airport) with recruitment and larval abundance data, but adult oyster measurements were not made as part of their work. Therefore, these latter 6 sites were not included in this evaluation.

We selected two reintroduction sites (South Slough-Valino Island and South Slough-Long Island) in the South Slough estuary for evaluating their appropriateness for restoration, based on seeding. The Seeding Score is calculated with a formula that makes recruitment rate less important, to determine if it is appropriate for restoration with seeding by aquaculture spat. Environmental conditions for both sites were characterized by data from the same nearby continuous water quality monitoring station. These two sites do not have naturally established adult oyster populations like the Coos Bay sites that were evaluated for restoration. The adults at these two sites were generated from a reintroduction project that began in 2008 with Olympia oyster cultch from a hatchery along with settled juveniles from the hatchery (2009); both were transplanted to Younker Point in Coos Bay for growth and survival studies. Burial by sediments was responsible for the relocation of the oysters from the reintroduction project site at Younker Point to the two seeding sites, Valino Island and Long Island, located further up the estuary and across from each other separated by the main channel. Oysters were transplanted to the current two locations in 2012 and monitoring began in 2014.

We selected one site, Downtown, to evaluate for its current conservation value based on it having the highest density of adults and recruits and the highest larval abundance of the three sites evaluated for restoration. It also has comparatively more available hard substrate than the other sites, which is an important factor. This evaluation required a new parameter *adult oyster population size*, which had not been quantified for any Coos Bay sites. Based on adult oyster densities from Groth and Rumrill (2009) at this site along with a quick field assessment we conducted in May of 2015, we roughly estimated that there are likely more than 1000 oysters along 300 m of intertidal shoreline. Despite oysters being very patchy along the shoreline, there are areas of higher density including the field site where Rimler 2014 conducted her research.

Field Sites

Table 1. List of oyster field sites, site codes, and locations by sub-basin

Embayment	*Site Name*	*Site Code*	*GPS Coordinates*
Coos Bay	Downtown Coos Bay	DN	43.37853 N, 124.21559 W
Coos Bay	Haynes Inlet	HI	43.44070 N, 124.22086 W
Coos Bay	Coalbank Slough Coalbank-Railroad Bridge Coalbank-Edgewater Hotel	CB CB-RB CB-EH	43.35590 N, 124.2091 W 43.36021 N, 124.20616 W 43.36006 N, 124.20689 W
South Slough	South Slough-Valino Island South Slough-Long Island	SS-VA SS-LI	43.30775 N, 124.31962 W 43.30716 N, 124.3186 W

Table 2. List of continuous water quality and meteorological stations, station institution, and location by bay.

Embayment	*Station Name*	*Station Code*	*Station Institution*	*GPS Coordinates*	*Distance from oyster field site*
Coos Bay	Kokwel Wharf	KW	Coquille Indian Tribe	43.4034055 N, 124.219477 W	2.9 km (DN)
Coos Bay	North Point	NP	NERR, Partnership for Coastal Watersheds	43.42575 N, 124.222703 W	1.6 km (HI)
Coos Bay	Isthmus Slough	IS	NERR, Partnership for Coastal Watersheds	43.327808 N, 124.200409 W	3 km (CB)
South Slough	Valino Island	VA	NERR SWMP	43.3172374 N, 124.3216473 W	1.2 km (SS)
Coos Bay	North	KOTH	Southwest Oregon	43.4171° N,	3.3 km (HI)

	Bend Airport		Regional Airport	124.2460° W	5.1 km (DN) 7.6 km (CB)
South Slough	Charleston Met	CM	NERR SWMP	43.3450 N, 124.3287 W	4.4 km (SS)

Field Parameters

Table 3. List of oyster attributes, sites where data were collected, and the timescale for data collection.

Oyster Attributes	*Sites*	*Timescale*
Adult density	DN, HI CB-RB, CB-EH, SS-VA, SS-LI	2006 2014
Size	DN CB-RB, CB-EH, SS-VA, SS-LI	2006 2014
Size Frequency	DN CB-RB, CB-EH, SS-VA, SS-LI	2006 2014
Growth rate	DN, HI, CB SS-VA, SS-LI	Jan - July 2013 Jan – May 2009
Survival rate	DN, HI, CB	Jan - July 2013
Recruitment rate	DN, HI, CB	July-Nov 2012, May-Aug2013
Larval abundance	DN, HI, CB	July-Nov 2012, May-Aug 2013

Environmental Parameters

Table 4. List of environmental factors, sites where data were collected, and the timescale for data collection.

Environmental Factors	*Sites*	*Timescale*
Water temperature	KW NP, IS VA	Sept 2013-March 2015 Oct 2013-March 2015 Jan 2010-Dec 2014
Dissolved oxygen	KW NP, IS VA	Sept 2013-March 2015 Oct 2013-March 2015 Jan 2010-Dec 2014
Salinity	KW NP, IS VA	Sept 2013-March 2015 Oct 2013-March 2015 Jan 2010-Dec 2014
pH	KW NP, IS VA	Sept 2013-March 2015 Oct 2013-March 2015 Jan 2010-Dec 2014
Air temperature	KOTH, CM	Jan 2013-Dec 2014
Substrate availability	DN, HI, CB	2012-2013
Chlorophyll a	VA HI, CB	2010-2013 2013

Field Methods

Oyster Attributes

Adult oyster density and size

Means for adult density per m^2 for Downtown and Haynes Inlet were used from Groth and Rumrill (2009). Mean adult size for Downtown was also used from Groth and Rumrill (2009) and only included measurements for oysters >20 mm; size data were unavailable for Haynes Inlet. Data for mean adult density per m^2 and adult size measurements were collected at Coalbank Slough and South Slough in 2014 as part of an oyster restoration monitoring project. For these surveys, data were collected at 2 m intervals along three 10 m transects at each of the two sites in South Slough and two sites in Coalbank Slough. A maximum of 10 oysters within a ½ m^2 quadrat were measured. Five density observations were also made for each transect at 2 m intervals. Data from the two sites in Coalbank Slough (CB-RB and CB-EH) were combined to represent the size and density of adult oysters in Coalbank Slough. The site (CB) where recruitment data were collected by Rimler (2014) is approximately 500 meters from CB-RB and CB-EH.

Diversity of size classes

Data from Groth and Rumrill (2009) were used to evaluate size-class diversity for Downtown. Because only oysters >20 mm in length were measured in the study, this sample represents the largest oysters, so this measurement needs to be interpreted carefully. Size data from the 2014 monitoring surveys at the Coalbank Slough and South Slough sites were used to assess size class diversity for those locations (no size limit was used for those oyster measurements). Oyster sizes were placed into 10 mm bins and used to generate a size-class diversity index (Gini-Simpson).

Gini-Simpson Index = 1 – Simpson index (D_s)
$D_s = \sum p_i^2$
P_i = proportion of individuals in each group

Growth and survival

Data for these attributes came from Rimler (2014). For this study 7 to 8 oysters (17.5 – 27.5 mm in height) were epoxied to each of four 10 cm x 10 cm unglazed ceramic tiles that were deployed at each site from 1/10/2013 until 7/10/2013. Tiles were retrieved and oysters were measured and assessed for survival four times during the deployment period. Mean growth rate per day from January to July is reported in the site evaluation tables. A survival rate (% survival from January-July) was calculated from the same data and reported in the site evaluation tables. The growth rate for the South Slough sites shown in the seeding score site evaluation table was calculated from data presented in Rumrill (2010) and based on measurements of oysters growing on shell bags that were sampled four times from January to May in 2009.

Recruitment

Recruitment data also came from Rimler (2014) in which eight replicate 10 cm x 10 cm unglazed tile plates were deployed at each site from 8/3/2012 to 11/14/2012 and 6/10/2013 to 11/18/2013. Plates were retrieved and replaced approximately every two weeks during the deployment period. The number of recruits was counted in a randomly selected subsection of each plate and used to calculate the mean number of recruits per

100 cm^2. For the site evaluation tables, we converted the means reported in Rimler (2014) to mean number per m^2 per day.

Larval abundance

Mean larval abundance data came from Pritchard (2014). For this study, larval traps were deployed at the same time and adjacent to the settlement plates used by Rimler (2014). Traps consisted of a funnel (7 cm x 5 cm), a PVC tube (61 cm x 5 cm), and a PVC stake fully inserted into the sediment. D-stage, umbo-stage, and settler abundances were counted from each of five replicate traps approximately every two weeks. Peak mean abundance of umbo-stage larvae (reported in the site evaluation tables) was calculated from collections in 2012 and 2013 and averaged across years.

Environmental Factors

Water temperature, salinity, dissolved oxygen, pH

YSI EXO2 or 6600V2 water quality sondes were deployed at permanent monitoring locations in Coos Bay and South Slough. Water quality sondes collect water temperature, specific conductivity, salinity, dissolved oxygen, pH, turbidity, and water depth data continuously every 15 minutes. Data collection and management follow standardized National Estuarine Research Reserve System-wide Monitoring Program (NERR SWMP) protocols (http://cdmo.baruch.sc.edu).

Chlorophyll *a*

For Haynes Inlet and Coalbank Slough, Oates (2013) collected chlorophyll *a* data by monthly grab samples with three replicates averaged for monthly values, however only the highest and lowest monthly values were reported in the thesis. Therefore, we present in the site evaluation table the highest monthly average for chlorophyll *a* at those sites. For the South Slough sites, chlorophyll *a* values were used from the NERR SWMP monthly nutrient program (2010-2014) which collects monthly triplicate grab samples. For comparability with the restoration sites, we also only present the highest monthly average and we only used summer months.

Air temperature

Air temperature data for the Restoration Site Evaluation Table were recorded by the North Bend, OR airport meteorological station (KOTH) and reported as daily maximum mean values. Air temperature data for the seeding sites in South Slough were recorded by the NERR SWMP meteorological station (CM) and were calculated as daily maximum mean values from 15 min averages; the data logger records measurements every 5 seconds and these are averaged over a 15 min interval.

Available substrate

The type and amount of available substrate was qualitatively described in Rimler (2014) for the three sites included in the Restoration Site Evaluation Table: Downtown, Haynes Inlet, Coalbank Slough. Because sites were described relative to each other, qualitative information was used to create categories and related scores for each category.

Modifications to the Site Evaluation Table

In general, we followed the methods of Wasson et al. (2014) for site evaluations, in terms of parameters included and thresholds used to assign scores. However, we omitted *Reliable Recruitment* and *Larvae Exported* as parameters because data for these parameters were not available for any of our sites. We included *Adult Oyster Size*, *Diversity of Size Classes*, and *Chlorophyll* a as parameters for sites when sufficient data were available. We added parameters for *Larval Abundance*, *Risk of Low pH Events*, and *Hard Substrate Availability* because these are important factors for assessing oyster success and data were available for these parameters for all of our sites. Generally, bins were selected based on the distribution and variability in available datasets to maximize our ability to rank sites relative to one another. For *Survival Rate* and *Low Dissolved Oxygen*, we changed the scoring bin thresholds, because our units of measurement for these parameters differed from those of Wasson et al. (2014). For *Growth Rate*, we reduced all bin thresholds by 50% because data were only available for two quarters (i.e. six months) for our sites, whereas Wasson et al. (2014) averaged growth across all quarters of a year. For the *Low Dissolved Oxygen* parameter, we also used a different assessment metric since we had continuous sonde measurements; percent of data observations where DO fell below 5 mg/L were calculated. Bins for dissolved oxygen were selected to capture large site differences between the number of observations below 5 mg/L. For example, sites had a range including 0, 6, 1,035, and 3,333 instances where DO fell below 5 mg/L; these raw observations were adjusted by total number of observations in the dataset, which varied by site. For *Salinity Range,* we changed the threshold to percent days per year where average salinity was less than 15 ppt (from 25 ppt used in Wasson et al. (2014)). Evidence supports this lower threshold for Coos Bay and South Slough. Gibson (1974) found that salinities of 15 ppt and lower demonstrated deleterious effects on oyster populations in Oregon and Oates (2013) found low salinity effects on various reproductive condition indices at salinities lower than 15 ppt. However, our sites experience a wide range of salinity from 2.7 to 33.3 ppt, primarily from seasonal freshwater inputs, and oyster presence in these low salinity areas indicates oysters may be adapted to local conditions. We also changed the threshold for *Water Temperature* from 12°C to 15°C based on site-specific data on oyster temperature requirements; 15°C is thought to be a critical reproductive temperature; below this temperature spawning may not occur (Pritchard 2013). For the *Chlorophyll a* parameter, we used the highest monthly average concentration from each site because this was a common measure available for all sites.

Results of site evaluations

Restoration potential

Three sites (Downtown, Haynes Inlet, Coalbank Slough) were evaluated for restoration potential. The highest scoring site for restoration in Coos Bay was Downtown, although Haynes Inlet resulted in only a slightly lower score. Downtown had as much as 16 times higher densities of adults and 3 times the larval abundance as Haynes Inlet and Coalbank Slough. In addition, Downtown had the highest availability of hard substrate (e.g. rip-rap, rock, rubble, pilings), which is a potential limiting factor for other sites. It appears salinity may not be a major stressor for oysters at Coos Bay sites where daily averages were below 15 ppt for up to 39 percent of the year. All of the Coos Bay sites that we evaluated are located in the mid to upper estuary where they can experience long periods of high freshwater riverine input during the rainy season (November– April). In particular, Coalbank

Slough had the highest percentage of years with consecutive low salinity events (6 events lasting up to 11 days) followed by Downtown with 1 event (lasting 4 days) over the 1.5 year period; Haynes Inlet had no prolonged low salinity events. Olympia oysters are generally absent from the lower reaches of the estuary where salinities are highest, with the exception of the Charleston Marina and (after reintroduction) South Slough.

Coalbank Slough and Haynes Inlet experienced lower dissolved oxygen (DO) concentrations than Downtown but overall low DO events were uncommon at all sites with < 2.5 % of values falling below 5 mg/L. Water temperatures were higher at Downtown and Coalbank Slough than at Haynes Inlet, most likely due to the location of Haynes Inlet which is lower in the estuary, although all sites had similar scoring for water temperature. Low pH events may be a stressor for oysters in upper estuary/riverine sites, although this stressor needs to be evaluated for local effects in estuaries. Coalbank Slough had the highest risk of low pH events and is located the furthest up the estuary, but pH at this site is highly variable. Average chlorophyll concentrations measured at Haynes Inlet and Coalbank were moderate and may contribute to higher oyster performance at these sites. At all sites, high air temperature events (> 30°C) were rare (<1% days/yr), therefore this stressor doesn't currently seem to be a concern.

Additional data from three sites in Coos Bay (Airport, Empire, and Catching Slough) are available from the Pritchard and Rimler theses but the data are not presented here as these have more data gaps than the sites we included in our restoration potential evaluation tables. Density data for another location in Coos Bay (Isthmus Slough mitigation site) are also available from the work of Scott Groth (Oregon Department of Fish and Wildlife) where densities of up to 1000/m^2 were observed. Including additional sites and filling in data gaps will be an important step for future revisions of the Coos Bay appendix of the Guide.

Restoration potential with seeding

We evaluated two reintroduction sites in South Slough to determine the restoration potential of these sites with seeding. Both sites scored similarly overall (56 & 58%). Although Valino Island (SS-VI) had slightly higher adult oyster density and size than Long Island (SS-LI), it had a lower diversity index which resulted in a slightly lower overall score. Since the sites were located very close together and relocated oysters were placed at both new sites randomly, we also considered the averaged metrics from the two sites for a combined score. The environmental factors that may contribute to potential stress for oysters were low chlorophyll levels, some low DO events (2% of observations fell below 5 mg/L), as well as prolonged low salinity events (20% of the year). However, as with the Coos Bay sites, salinity may not be a stressor for native oysters in South Slough since salinity is seasonally variable and can range from 11.3-33.3 ppt. The salinity range metric at Valino Island scored high with only 1 % of days per year averaging less than 15 ppt. Also, there are commercial oyster (*Crassostrea gigas*) operations near Long Island as well as at locations further up the estuary. On the other hand, sedimentation may be a stressor for oysters in South Slough, although it hasn't formally been assessed. The fact that high sedimentation rates required the relocation of outplanted oysters to a new site in South Slough suggests sedimentation may impact future seeding operations.

Conservation value

Downtown Coos Bay was evaluated for its value as a conservation site because it has the highest recruitment rates and larval abundances of all the sites that were evaluated. It also has suitable substrate, which would favor recruitment and reduce pressure from sedimentation. The overall oyster conservation score for Downtown (71%) is reasonably high, suggesting it may be an important site to focus conservation efforts. However, it should be noted that the adult oyster population size was a rough estimate from a brief survey to count oyster densities and that more data should be collected at this site. Overall, this site scored fairly high for the environmental parameters, with the exception of prolonged low salinity events. However, as mentioned earlier, the presence of oysters in Coos Bay at locations with low and/or variable salinities suggests native oysters may be locally adapted to these conditions. Similarly, recruits and larval abundances are all high at the Downtown site so they do not appear to be affected by low salinity.

	COOS BAY			SOUTH SLOUGH		
	Downtown Coos Bay	Haynes Inlet	Coalbank Slough	South Slough combined	Valino Island	Long Island
ADULT OYSTER DENSITY	50	25	50	50	50	50
OYSTER POPULATION SIZE	75					
ADULT OYSTER SIZE	50		25	50	50	50
DIVERSITY OF SIZE CLASSES	50		75	75	50	75
RECRUIT DENSITY	75	75	50			
LARVAL ABUNDANCE	75	25	50			
SURVIVAL RATE	75	50	75			
GROWTH RATE	25	75	25	25	25	25
WATER TEMPERATURE	75	50	75	50	50	50
AIR TEMPERATURE	100	100	100	100	100	100
CHLOROPHYLL		25	25	25	25	25
LOW DISSOLVED OXYGEN	100	75	50	50	50	50
SALINITY RANGE	75	75	25	75	75	75
RISK OF LOW SALINITY EVENTS	0	100	0	50	50	50
RISK OF LOW PH EVENTS	75	100	25	75	75	75
HARD SUBSTRATE AVAILABILITY	75	50	50			
DRILL PREDATION	100	100	100	100	100	100
OVERALL SCORES						
Restoration (natural recruitment)	67	66	50			
Restoration (with seeding)				58	56	58
Conservation	71					

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March 20, 2019

To: Coos Bay Planning Commission/Coos Bay City Council

Re: Application file No. 187-18-000153-PLNG-01 filed by the Jordan Cove Energy Project L.P. for Coos Bay Estuary Navigation Reliability Alteration.

Dear members of the Coos Bay Planning Commission and City Council:

These written observations are to supplement and support testimony I may voice at the March 21 hearing(s) on the topic of "Navigational Reliability Improvements" (NRIs) in the shipping channel in lower Coos Bay.

According to page 1 of LCOG's staff report (*highlighting added here and elsewhere*):

> The applicant's intent is to increase the operational window to safely transit any vessel through the Channel. The NRIs ... are designed to increase the environmental operating windows for all ships entering Coos Bay by softening critical turns, relocating aids to navigation and reducing the required Channel directional changes. Minimizing delay is a clearly identified need. Various marine terminal businesses within Coos Bay require assurances that terminals can efficiently accommodate larger dimension bulk carriers in the future.

This passage overflows with the muddled double-talk we have grown used to hearing from Jordan Cove and its supporters. They've been spouting it for 15 wearisome years:

- The ***first*** and ***second*** sentences talk about increasing the "operational window" and the "environmental operating windows for all ships entering Coos Bay."

But anybody who is not napping can see that these windows are being washed for the benefit of the Jordan Cove LNG terminal, and possibly (as a sort of afterthought) for its immediate future neighbor, the Roseburg Timber chip export facility. Roseburg's letter of support, reproduced on PDF page 92 of the LCOG-produced staff report, suggests that its management considers it an advantage to have Jordan Cove for a neighbor, but if they do, they demonstrate great ignorance along with carelessness about their employees' lives. As I will document in this letter, the LNG industry itself warns against having other industries anywhere near LNG terminals. They do this for several reasons having to do with safety, the main one of which is the following, which should concern

Roseburg's management – if they care. If there is a spill of LNG at the LNG terminal, which is most likely while loading a carrier, although other possibilities exist, and the natural gas coming off the LNG ignites (possibly thanks a spark produced at the adjacent Roseburg terminal), the outlandishly severe burn characteristics of the gas can kill and cremate anyone then present at Roseburg. (For scientific support, see Chapter 1 in this letter.) In an apparent attempt to forestall such concerns, Jordan Cove has proposed building tall concrete walls called "vapor barriers" on the property line shared with Roseburg, but as I also document in this letter's Chapter 5, confining LNG spills and gas releases by such means could bring on a massive explosion, and a chain effect destroying the moored tanker and the entire Jordan Cove terminal. Obviously, such an event could also destroy the Roseburg facility and its personnel. Although at this point it is not clear to me whether these "vapor barriers" are still part of Jordan Cove's highly muddled, often outdated plans, no matter what the real plans are, Roseburg is far too eager to throw in its lot with a hazardous industry that could make a lot of Roseburg widows.

On top of these contradictions and absurdities, the U.S. Coast Guard's Letter of Recommendation ***(LOR)*** of May 10, 2018, reproduced on the Staff Report's PDF pages 96 and 97, recommends that "the Coos Bay channel be considered suitable for the type and frequency of marine traffic associated with" Jordan Cove. It then goes on to recommend various procedural and technical measures to enhance that presumed suitability, but to the best of my knowledge (because many of those recommendations are secret), the Coast Guard has not required the channel enlargements that the Planning Commission and the City are now asked to approve. This seems contradictory, but evidently Jordan Cove is pleased to have it both ways.

- The ***third*** sentence in the quote from LCOG's staff report states that "Minimizing delay is a clearly identified need."

This is echoed in a supporting letter reproduced on PDF pages 93 and 94 of the Staff Report, signed by Captain Wales of the Coos Bay pilots, who complains of "significant delays" for present ship traffic. But his concern about delays strikes me as odd, because during a meeting of the Port Safety Committee on January 15 this year, Captain Wales himself told me that delays for vessels needing to wait a few hours to enter Coos Bay were no great concern. This was in the context of questions I asked about transiting LNG carriers delaying such entries, because they will monopolize the highest tides. But now, in his newfound concern for delays, Captain Wales states that minimizing them:

> ". . . is a pressing concern because companies that utilize the Port of Coos Bay have identified potential new customers in Asia that desire to export cargo using bulk carriers that are slightly larger than the ships typically calling today. Various marine terminal businesses, within Coos Bay, require enhanced assurances that terminals will be able to efficiently accommodate larger dimension bulk carriers in the near term.

This is not very clear language, but I ***assume*** he means that those potential Asian customers want to export bulk cargo ***from*** Coos Bay, not ***to*** Coos Bay, because except

during its very early history Coos Bay was not an importing port, regardless of the vain dreams of Port Promoters, and for good reasons: its inland transportation connections were and remain inadequate, and our geography precludes substantial improvements.

But I also have to question the notion of exporting bulk cargoes ***from*** Coos Bay, if such cargoes are to be anything except logs and wood chips. Not that we haven's seen sensational plans to do so, but they always failed. Around 1979/80, for instance, Coos Bay was seized by a mania for exporting coal to Asia, and so were a number of other small ports in the Northwest. All or most of this coal would need to come from open-pit mines a thousand or more miles away; by that time all our local coal mines had vanished because their product was inferior. Although coal fever seized the Port, the Chamber of Commerce and the politicians, the upshot proved that nobody ever knew what they were talking about. The coal export promoter himself never realized that hauling coal by train to Coos Bay would make it too expensive; but he did succeed in selling stock in his venture to some locals, and that may have been his real objective. After a few years of high temperatures the coal fever subsided, but – proving that bad ideas and promoters never die – it was reborn in 2011, only to die again, sadly for those whose vain hopes spring eternal. (***NOTE:*** E.D. stands for "Economic Development"):

Repeating history can save E.D. officials' jobs, by getting the public excited again and again — with old, worthless news.

The 1980 coal export promoter's plan was destroyed by a report from Oregon State, on the cost per million Btus of coal delivered at west coast ports. The term for that is f.o.b., "free on board", meaning coal loaded on board a bulk carrier sailing to Asia. The study concluded:

"Coos Bay does not appear to be competitive with other West Coast ports for shipping local, Wyoming, Montana, or Utah coal. The lower Columbia River [ports] can export Wyoming and Montana coal at a lower cost per million Btu than Coos Bay, and Oxnard [California] can export Utah coal for a lower cost per million Btu than Coos Bay can."

Coos Bay's disadvantage was caused by a factor that has not changed: distance. Coal is cheap, but transportation can make it costly. Rail is cheaper than trucking, but much more costly than going by ship. The Wyoming, Montana and Utah coal mines are about 1000 railroad miles from port. Bringing their coal another 200 miles to Coos Bay will make it even more expensive, even if the Coos Bay branch line could carry the very heavy trains.

Also, Canada and Australia have advantages over the US in exporting coal to Asia. Australia's New Castle coal mine, for instance, is only 66 miles from port. The coal export situation is not as unfavorable on America's east coast, but that doesn't help Coos Bay.

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CB could become coal port again

Port officials say 100 ships per year could take fuel deliveries

BY GAIL ELBER

many ships for the cargo terminal missioners, Bishop said the Port had received a public records request on that subject from the Sierra Club.

"We are in discussions with coal developers and have entered into nondisclosure agreements with

Bishop said port staff was researching the issue and would make a recommendation to the commissioners on any opportunity that might arise.

Marine reserve proposal

posal creating no new marine reserves or marine protected areas in the area. The port asked the group to prepare majority and minority reports, but those haven't been vetted or approved by the committee members.

- Finally, the ***fourth*** sentence states:

  Various marine terminal businesses within Coos Bay require assurances that terminals can efficiently accommodate larger dimension bulk carriers in the future.

Nonspecific details about these "various marine terminal businesses" are provided by Captain Wales, who claims that

> Four terminals are currently in operation in the lower bay. Ten terminal and dock facilities are located in the upper bay. Currently, three of the terminals in the upper bay and one of the terminals in the lower bay can handle deep draft vessels.

Obviously Captain Wales, as someone with a direct interest in more ship traffic, has a tendency to exaggerate the number and the needs of Coos Bay's shipping terminals. But aside from the deep-draft Roseburg chip terminal, I'm puzzled about the identities of the other three "terminals" in the lower bay. I know the T-Dock and the barge slip, two idle, costly boondoggles created by the Port of Coos Bay and finally given to D B Western and Southport Lumber, respectively. But they hardly see any traffic, and "deep-draft" shipping is not a feasible option, so they are irrelevant.

In the ***upper bay,*** the term "ten terminal and dock facilities" seems purposely vague: how many of those ***are*** terminals? Is any old waterfront building with a hitching post in the mudflat a terminal? Or is 'terminal' to be taken as an adjective, as in 'near-death'? But the three deep-draft terminals in the upper bay must be Ocean Terminals and the Knutson facility, both of which export logs to China, an activity created by international politics, which could also kill it; and the third must be the Oregon Chip terminal. That's where deep-draft shipping ends, because from there south to the Georgia-Pacific terminal, at the end of the channel, depth is reduced from the standard -37 feet to -24.

But it has long been known that the ancient railroad bridge, which the Port of Coos Bay has insisted on preserving, limits the size of ships visiting the upper bay, which is where all three terminals are located. That, plus the fact that none of the proposed channel alterations will occur in the upper bay, seems to invalidate these claims about benefiting any upper bay terminals, by enabling bigger ships to reach them. And this, incidentally, also applies to the elephant in the room, the Port of Coos Bay's semi-secret plan to deepen the channel from -37 to -45 feet, supposedly for "facilitating future economic development in Oregon and [to] accommodate the growing global fleet", as stated on the Port's website. This, the main topic of Chapter 2, is clearly for the sole benefit of Jordan Cove too (why else would they be paying for it?), but the company want to get its salami one slice at a time, to minimize opposition. Even so, that project ought to be part of these considerations, because it could do enormous damage to the lower bay and the commercial activities it supports.

It is possible, however, to take my oral testimony along with this letter's more extensive comments, and condense all of it into one crucial question. That question, addressed to every public official eager to facilitate the siting of Jordan Cove LNG in Coos Bay, is:

> ***Do you really want to help site an irresponsibly planned hazardous industry that could kill and burn thousands of us, and even could – depending on circumstances – completely destroy our Bay Area ?***

In other words: are we this desperate?

I'm no fanatical anti-fossil-fuel-activist, and I have no objections to LNG and natural gas. For the foreseeable future we need both, since they help fuel modern society. It follows that the world needs gas pipelines and LNG tankers and LNG terminals; and there are many of the latter of which I approve. One shining example of a responsibly sited LNG terminal is Cheniere's, shown on page 13 of this letter, but there are many more.

But I have studied Jordan Cove's plans and its history for many years. I have also studied official and scientific documents pertaining to LNG fire hazards and LNG shipping, along with the LNG industry's own safety recommendations.

As a result, I have learned many things that are truly alarming. They show that an extremely hazardous industry is being courted and coddled even though its plans show utter disregard for its own industry's safety recommendations, and for public safety as a result.

"When an accident is waiting to happen, it eventually does."

Carmen Reinhart and Kenneth Rogoff

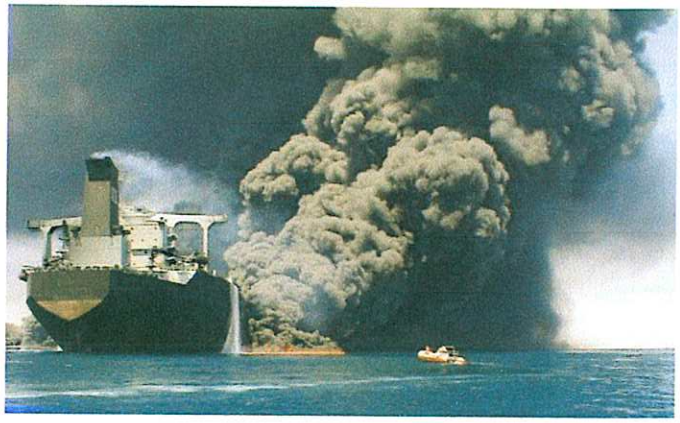
Even more shocking is that some government agencies are condoning this disregard of public safety simply because they lack ***applicable regulations.*** The worst example may be the U.S. Coast Guard, which has declared Coos Bay "suitable" for LNG tanker traffic even though Jordan Cove already wants to change it, another contradiction. More importantly, you should ponder that the Coast Guard has no standards or rules of any kind for controlling a loaded LNG tanker during the tsunami that's virtually certain to strike Coos Bay; and Jordan Cove is on the same page. The company's 'plan' for handling a tanker during that tsunami is based on no real-world experiences whatsoever.

"I'm very skeptical that anything can be done in a near-shore tsunami to protect the tanker," said Randy Clark, a security specialist with the U.S. Coast Guard. "There simply isn't enough time. . . . There are no real regulations. There is no requirement to mitigate this risk."

"Jordan Cove LNG terminal at Coos Bay designed for Cascadia quake, tsunami though hazards remain", *The Oregonian/Oregon Live*, June 26, 2014.

And yet the findings of Oregon State's marine geologists show an extremely high probability that a loaded LNG tanker will be struck by the tsunami, either while moored at the terminal or transiting Coos Bay, and unable to reach the safety of the ocean. Photographs taken after tsunamis elsewhere in the world show that the ship may easily be tossed onto land, with a high probability of being damaged and breached, and spilling LNG. When that occurs, by Jordan Cove's own admission, nearly 17,000 local residents will be at risk. Almost 5,000 of those live inside Coos Bay's city limits, and the number may be higher. [1])

[1]) A total number of 16,922 individuals at risk inside the 3 Hazard Zones extending 2.2 miles out from a potential LNG-based fire (in the bay or at the terminal) is mentioned in Jordan Cove's FEIS of 2015, on page 4-1031 (= p.1381 in the 7891-page PDF). Larry Mangan double-checked that number by counting residences in Google Earth high-quality aerial photos, and multiplying that number by 2.47 people per household, following Census data. In this way he counted 5,985 households within the 3 Hazard Zones. 5,985 households x 2.47 = 14,783 individuals, or about 2,000 less than Jordan Cove's count. For the city of Coos Bay his number came to 4,979. Both of Mangan's numbers are on the low side, however,



While the 181-page 'Staff Report' includes lengthy explorations of the legal aspects of Jordan Cove's proposal, it does not address the tsunami risk at all, nor the risk of LNG fires from other possible causes, including sabotage, equipment failures and human error, along with the risk posed to LNG facilities by terrorism, a possibility that the U.S. Congress has recognized since 9/11. Since that event successful terrorist attacks have been launched against ships including the oil tanker Limburg in 2002, shown above, and on the US Navy's USS Cole in 2000, shown below. It should be noted that even though the Limburg fire was spectacular, if it had been an LNG tanker instead of an oil tanker, nobody could have approached the fire (as the people in the small boat in the photo do) without dying, as I explain in Chapter 1.

With refreshing frankness, the LNG industry's safety agency recognizes that perfect safety is unachievable. This is why that same agency, **SIGTTO**, urges that ***LNG terminals and their ships be located far enough from inhabited areas so local populations cannot be endangered*** when spills occur. If that professional advice were taken seriously, Jordan Cove could not be sited here at all; and there seems to be the rub.

It may be argued that these issues were not part of LCOG's assignment. But they are highly relevant to Jordan Cove's present proposal, because if the City approves it, the company's propaganda will undoubtedly describe that as an endorsement. And maybe it will be – an endorsement given by people who were willfully blind and deaf.

Making this situation worse, Jordan Cove has shown time after time that it is not shy about spreading lies to steamroll its plans.

For example, its spokesmen have claimed that all 30-odd Japanese LNG import terminals survived the 2011 tsunami without damage. As I document in Chapter 3, on pages 29/31, only one Japanese LNG terminal was seriously exposed to the 2011 disaster, and it was badly damaged.

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because he left out multiple dwellings, including apartment buildings, retirement homes, motel guests, Coast Guard personnel in Charleston, tourists and the homeless.

A company spokesman has also claimed that their LNG tankers are perfectly capable of surviving a tsunami, as proved by experience when a tsunami hit a tanker at the Arun LNG export terminal in Indonesia. But as Chapter 3 also documents, that plant was outside the danger zone of the Indonesian tsunamis, the one in 2004 as well as in 2007.

As if this situation needed to become even more ominous, Jordan Cove's documents contain different versions of its tsunami plan that contradict each other. (See pages 19-24 and page 64 of this letter.)

Most likely conclusion to all this: nobody knows what to do about the looming earthquake-tsunami, but nobody will say so. I fear that may be true of Coos Bay's leaders as well.

> "The greatest evil…is conceived and ordered (moved, seconded, carried, and minuted) in clean, carpeted, warmed, and well-lighted offices, by quiet men with white collars and cut fingernails and smooth-shaven cheeks who do not need to raise their voice."
>
> *C.S. Lewis*

My letter brings out many more aspects of Jordan Cove's plans that take liberties with the truth and with public safety. They include, but are not limited to, the ones described in the chapter summaries below:

CHAPTER 1: Wrong industrial safety standards have been used. With the blessing or ignorance of the U.S. Coast Guard, Jordan Cove has improperly used safety standards for the petroleum industry. Standards for the LNG industry are published by **SIGTTO, the Society of International Gas Tanker and Terminal Operators**. Whether Jordan Cove is purposely ignoring SIGTTO's standards is not clear. What ***is*** clear is the company's inability to meet them in Coos Bay with regard to: (1) safe distances from populated areas, (2) timely escape routes for LNG carriers in emergencies including earthquakes, (3) avoiding moorage on the outside of a channel curve, and (4) avoiding long inshore channels.

*For more information see **CHAPTER 1**, starting on page 9.*

CHAPTER 2: The Coos Bay ship channel is unsuitable for LNG carrier traffic. Besides Jordan Cove's failure to apply the LNG industry's siting standards described in Chapter 1, Coast Guard officials have ignored industry standards for channel and turning basin dimensions. They have also ignored public input. The Jordan Cove project appears inseparable from the Port of Coos Bay's plan for enlarging the channel, which proposes drastic changes to the estuary. Both projects should be considered together, and not sequentially.

*For more information see **CHAPTER 2**, starting on page 14.*

CHAPTER 3: Misleading, obsolete and conflicting geologic information has been used. Often of puzzling origin and contradictory, the data misrepresent the geologic risks, enabling Jordan Cove to understate the dangers posed by the

looming offshore earthquake-tsunami, especially to LNG carriers in port. Plans for handling that cataclysm are contradictory, reckless and unrealistic, since despite claims to the contrary they are based on no real-world experiences whatsoever. For the same reason the Coast Guard's lack of regulations for dealing with tsunamis should not absolve it of responsibility for public safety.

*For more information see **CHAPTER 3**, starting on page 19.*

CHAPTER 4: **The Hazard Zones' dangers to schools and residential areas are being misrepresented.** Jordan Cove obfuscates and denigrates the dangers posed by LNG spills, especially from breached LNG carriers. This is done by misstating the science about LNG's fire hazards, and the risks to Coos Bay residents and schools. Contrary to Jordan Cove's claims, many different terrorism scenarios look feasible, but the company's poor documentation inhibits transparency. Public safety may require a large number of permanently staffed protective bunkers, but those needing shelter may lack time to reach them.

*For more information see **CHAPTER 4**, starting on page 32.*

CHAPTER 5: The Jordan Cove LNG terminal's siting and design increase chances of a major disaster in which the entire facility could be destroyed, along with any LNG carrier present. Prominent LNG fire scientists warn that the devices proposed to control vapor clouds at the Jordan Cove LNG terminal greatly increase chances of catastrophic fires and explosions.

*For more information see **CHAPTER 5**, starting on page 43.*

For your convenience I am supplying several copies of this letter. If you wish to distribute it by email, I will be glad to send you a PDF version; to receive one, please contact me at my email address found on the letterhead.

CHAPTER 1: Wrong industrial safety standards have been used. With the blessing or ignorance of the U.S. Coast Guard, Jordan Cove has improperly used safety standards for the petroleum industry. Standards for the LNG industry are published by **SIGTTO, the Society of International Gas Tanker and Terminal Operators**. Whether Jordan Cove is purposely ignoring SIGTTO's standards is not clear. What ***is*** clear is the company's inability to meet them in Coos Bay with regard to: (1) safe distances from populated areas, (2) timely escape routes for LNG carriers in emergencies including earthquakes, (3) avoiding moorage on the outside of a channel curve, and (4) avoiding long inshore channels.

Jordan Cove's 802-page Resource Report 13 *(hereafter called **'RR-13'**, and available on the Internet),* carries a publication date of September 2017, and claims:

> The [Jordan Cove] facilities have been designed to provide the safe transfer of LNG cargo from the ships to the on-shore storage facilities. Design is in accordance with applicable codes and standards, including but not limited to Oil Companies International Marine Forum (OCIMF), Society of International Gas Tanker and Terminal Operators (SIGTTO), American Petroleum Institute (API) and American Society of Civil Engineers (ASCE). *(RR-13, p. 59 and pp. 152/153)*

As is true of much of Jordan Cove's paperwork, this is obsolete and wrong. The plant will not be for "transfer of LNG cargo from the ships to the on-shore storage facilities. That describes the long-dead ***import*** terminal. But it's also misleading, because it was designed without regard for the SIGTTO rules, as the U.S. Coast Guard confirms:

> "Jordan Cove used the American National Standards Institute (ANSI)/American Petroleum Institute (API) Standard 780 Security Risk Assessment (SRA) Methodology, as the basic approach for assessing risk. The standard was published in June of 2013 as a U. S. standard for security risk assessments on petroleum and petrochemical facilities. The standard is a tool used to evaluate all security risks associated with petroleum and petrochemical infrastructure and operations ..." (*Coast Guard Analysis, page 5, § 5, on page 104 of LCOG's PDF.)*

The rest of that clearly indicates that the SRA addressed terrorist attacks on Jordan Cove's terminal, but more likely on its LNG carriers. The professional literature agrees that such attacks are likely to cause the biggest breaches in LNG ships, hence the biggest spills, the hottest gas fires, and the largest number of lives lost.

> "The attack on the World Trade Towers on 9-11-2001 heightened concerns about LNG safety, partly because of the presence of the import terminal in Boston Harbor (Everett, MA). The Government's responses to the multiple terrorist attacks on 911 included preventing a scheduled LNG ship from entering the Everett, MA, terminal, holding it offshore for several days before directing it to proceed to Elba Island, GA to unload. This was due to concerns that LNG facilities in highly populated areas might be considered attractive targets for terrorist attack; this concern is still with us."
>
> Jerry Havens and James Venart, *professors of chemical and mechanical engineering, and well-known experts on LNG fires: "UNITED STATES LNG TERMINAL SAFE-SITING POLICY IS FAULTY", January 14, 2015, to the Federal Energy Regulatory Commission, regarding the Jordan Cove Export Terminal Draft Environmental Impact Statement, Docket No. CP13-483.*

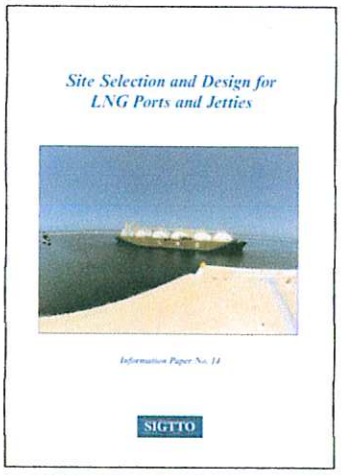
Even though the Coast Guard's analysis seemed to accept using the Petroleum Institute's methods, it observed (on PDF page 101, § 4), that "LNG is not considered oil". This is quite true, and it makes a huge

difference. While gas coming off spilled LNG may be less susceptible to explosions than petroleum, it has burn characteristics that are many times more dangerous. This makes me doubt that Boston citizens who anxiously watch an LNG carrier moving through their harbor to the Everett receiving terminal, built in 1971 before the era of terrorism, would still be anxious if it were an oil tanker. While natural gas is popular for burning cleanly and for not being poisonous, it can kill by explosion or suffocation in a confined space, and in its liquid form of LNG it can also kill by freezing. But most importantly, gas clouds ignited outdoors can kill by extreme heat radiation, even at considerable distances from the fire. That hazard is magnified if the gas came from spilled LNG, because in LNG both its volume and its incendiary power are concentrated 600 times. Moreover:

> "LNG fires burn hotter because the flame burns very cleanly and with little smoke. In oil fires, the smoke emitted by the fire absorbs some of the heat from the fire and reduces the amount of heat emitted. Scientists measure the amount of heat given off by a fire … in kilowatts per square meter (kW/m^2). Generally the heat given off by an LNG fire is reported to be more than 200 kW/m^2. By comparison, the [heat] of a very smoky oil fire can be as little as 20 kW/m^2." [2])

Simply put, at 200 kW/m^2, LNG fires can burn ten times hotter than oil fires. They can even burn fifteen times hotter, reaching more than 300 kW/m^2 [3])

This may explain why since 1979, quite early in its history, the LNG industry's SIGTTO has published safety recommendations for siting LNG terminals and docks. They admit that with a good but imperfect safety record, LNG spills will happen, and when ignited the gas coming off them can generate very intense heat, injuring and killing people. So the consequences of spills can be very bad for the public and the industry alike; and they may be worse if the spill was caused by terrorism, which is most likely to cause the 'pool fires' from LNG spilled on water that will produce the highest temperatures. Although the descriptions of the 3 Hazard Zones around potential LNG spills, in the Coast Guard's NVICs from 2005 and 2011, dwell mainly on destroyed 'infrastructure' and 'assets', other authorities, particularly the Hightower-Sandia report, make clear that from the fire out to 2.2 miles (the outer limit of Hazard Zone 3) dangers to people will vary from instant live cremation to skin burns. One would think that Jordan Cove and its consultants know this too; but if so they seem to take care not to dwell on it.



Although written by alleged LNG experts, no part of Jordan Cove's RR-13 displays any familiarity with SIGTTO's safety recommendations, and they are mentioned nowhere except for the above-cited claims that the authors DID use them.

[2]) "Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification," GAO for Department of Energy, February 2007; GAO 07-316 Maritime Security, p. 9.

[3]) Jerry Havens and James Venart: *Regarding the Jordan Cove Export Terminal Draft Environmental Impact Statement, Docket No. CP13-483: UNITED STATES LNG TERMINAL SAFE-SITING POLICY IS FAULTY,* January 14, 2015, p. 27: "... radiant heat fluxes from large LNG fires on water, which burn without much smoke, can exceed 300 kW/m^2."

(RR-13, p. 59 & 152/153). Even so, its Executive Summary asserts:

> It is our professional opinion that proper evaluation of issues has been undertaken and there are no safety of security issues with regards to the suitability of the waterway for proposed LNG importation/transportation.
> *(RR-13 p. 20, § 1)*

"The advantage of doing one's praising for oneself is that one can lay it on so thick and exactly in the right places."

Samuel Butler (1835-1902)

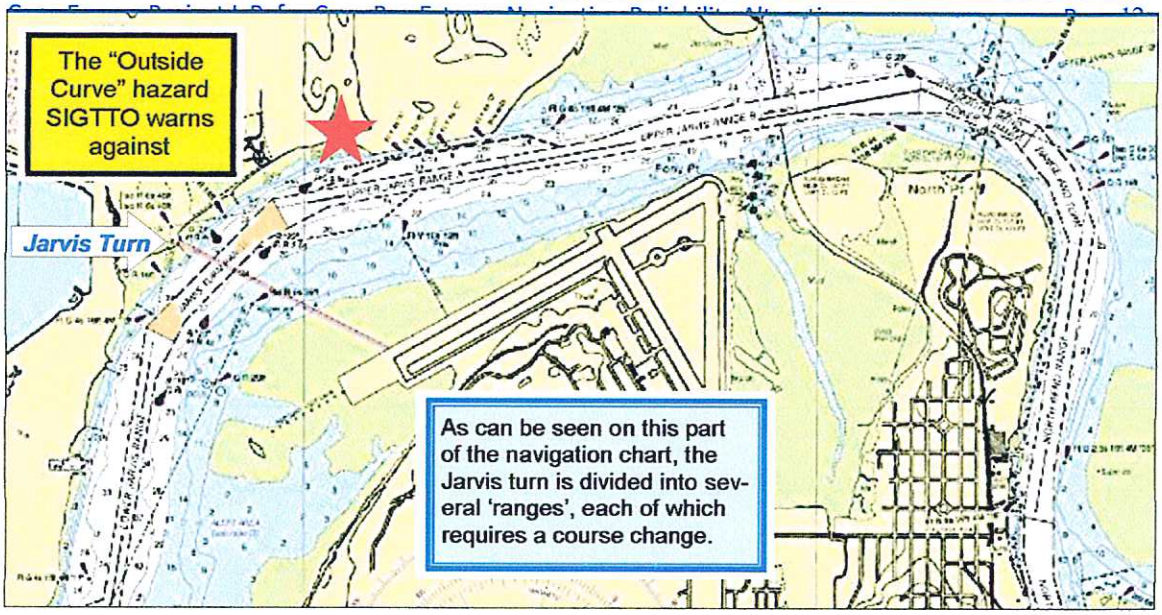
It does seem odd that although Jordan Cove has been planning to build an LNG terminal in Coos Bay for some fifteen years, it only joined SIGTTO, the Society of International Gas Tanker and Terminal Operators, headquartered in London, a couple of years ago. SIGTTO, which claims that its members represent more than 95% of the world's LNG tanker and terminal operators, publishes the industry's safety recommendations in booklets like *"Site Selection and Design for LNG Ports and Jetties"*, also called Information Paper No. 14, shown on the previous page. (What the British call '*jetties*' are what we call docks or wharves, whereas they might call the *jetties* at our harbor entrance 'breakwaters'.) Information Paper No. 14 contains a great deal of advice that, if taken seriously, casts a very strange light on any approvals for an LNG terminal in Coos Bay. Below are several such recommendations:

Society of International Gas Tanker and Terminal Operators (SIGTTO)

Site Selection and Design for LNG Ports and Jetties

- " ... although LNG has an enviable [safety] record, it is not risk free ... an accident, albeit rare, is possible as a result of human error or catastrophic event such as an earthquake." *(page 2)*
- "Port designers [should] construct jetties (= docks) handling hazardous cargoes [like LNG] in remote areas where ... any gas escape cannot affect local populations." *(p. 6)*
- "Pilots and tugs should be immediately available in case the LNG carrier has to leave the jetty in an emergency." *(p. 24)*
- "Provide escape routes in cases where a ship is unable to berth." [as in a tsunami] *(p. 15)*
- "River bends [are not] appropriate positions for LNG carrier jetties (= docks)." *(p. 24)*
- "Short approach channels are preferable to long inshore routes which carry more numerous hazards." *(p. 23)*

A practical application of SIGTTO's '*remote*' advice (in § 2) would use the Coast Guard-cited 3 Hazard Zones' outer limit of 2.2 miles as a minimum safety distance between the LNG terminal and its carriers, on one hand, and our local population on the other. If not, almost 17,000 people will be inside the Hazard Zones of a burning LNG carrier including five schools, two of which are within ⅔ miles of the shipping channel (See pages 35-37). Also, § 3 and § 4's sage advice to provide for 'escape routes' cannot be met in Coos Bay because 94% of the time the channel will be too shallow for passage, and transits at high-tide take 2 hours, while the expected tsunami's E.T.A. is 10 minutes. (See pages 21-22 & 27.)



§ 5 flags yet another problem, since Jordan Cove's moorage slip ***will*** be in a river bend, where moored LNG carriers will be vulnerable to incoming ships losing control while sailing through the Jarvis turn. The red star above marks the LNG carriers' moorage.

The local airport, also on the map, could make a handy excuse for a small plane full of terrorists and explosives to hit a departing LNG carrier, although other scenarios appear feasible. (See pages 40-42). Speaking of the airport, in May 2018 the Federal Aviation Administration sent 13 notices to Jordan Cove, announcing that several parts of the terminal, and of passing LNG carriers, are "presumed to be a hazard to air navigation," because they exceed "obstruction standards and/or would have an adverse physical or electromagnetic interference effect upon navigable airspace or air navigation facilities."

Finally, § 6 of the cited SIGTTO excerpts, which urges short approach channels, would merely put another nail in the LNG terminal's coffin, since Coos Bay definitely does not offer a short approach channel unless a brand new one were dug to the ocean, which doesn't seem likely. But this and the other SIGTTO recommendations will prove useless unless Jordan Cove and our authorities take them seriously. To many of us in Coos Bay, siting this terminal anywhere in our harbor seems completely reckless.

The two photos on the next page, of the Cheniere terminal at Sabine Pass in Louisiana, show a shining example of an LNG terminal sited in accordance with SIGTTO's recommendations, and especially with SIGTTO's key piece of advice (stated at the top and bottom of page 6 of Information Paper No. 14, and found on other pages as well) to site 'jetties' handling hazardous cargoes like LNG "in remote areas where other ships do not pose a (collision) risk and where any gas escape cannot affect local populations." In sharp contrast, Jordan Cove's 200-acre site abuts another industry and is less than a mile from an airport and homes; its LNG tankers will sail within less than a mile from even more homes, and two schools too. But Cheniere sits on 1000 acres of filled swamp land, surrounded by more swamp as far as the eye can see, even from a plane, and very sparsely inhabited, if at all. (Cameron Parish, though roughly the same size as Coos

County, has only 10% of its population, and no incorporated cities at all.) Unlike Jordan Cove, which abuts the Roseburg chip facility, Cheniere has no other industries as immediate neighbors, either. It could be argued that Cheniere has committed one deviation from SIGTTO's recommendations in the length of its access waterway, a straight, 3 mile channel from the Gulf of Mexico (shown below), but there are no residential areas alongside it, and unlike here, earthquakes and tsunamis are not a concern.

CHAPTER 2: The Coos Bay ship channel is unsuitable for LNG carrier traffic. In addition to Jordan Cove's failure to apply the LNG industry's siting standards described in Chapter 1, Coast Guard officials have ignored LNG industry standards for channel and turning basin dimensions. They have also ignored public input. The Jordan Cove project appears inseparable from the Port of Coos Bay's plan for enlarging the channel, which proposes drastic changes to the estuary. Both projects should be considered together, and not sequentially.

In his LOR (Letter of Recommendation) of May 10, 2018, to the FERC (staff report PDF pp. 96-97), Captain W. R. Timmons, U.S. Coast Guard, recommended that the Coos Bay channel *"be considered suitable"* for LNG carriers, even though two previous Coast Guard LORs, the most recent one of which was Captain F. G. Myer's of April 24, 2009, stated that it was *"not currently suitable, but could be made suitable"*. Since the Coos Bay channel has not been altered since, its newfound suitability seems peculiar, but an explanation may be found in Captain Timmons' statement that he had prepared his LOR "in consultation with a variety of state and local port stakeholders", including "*the Area Maritime Security Committees, Harbor Safety Committees, State Representatives, Pilot Organizations, and local emergency responders.*" This confirmed, by omission, that his 'stakeholders' did not include "*members of the public*", contrary to the Coast Guard's recommendation in NVIC 01-2011, page 5, § (5). And that is deplorable because the people of Coos Bay – as well as residents of several other, neighboring Counties – have been roiled by this project for 15 years already, and could have contributed much information that would have been less self-interested and less ideological than that provided by the Port's 'stakeholders', most of whom are insiders who stand to benefit personally. It follows that despite the LOR's warning that it was not an "enforceable order, permit, or authorization", LNG boosters greeted it with jubilation.[4])

However, all three Captains of the Port including Captain Timmons last May conditioned 'suitability' on numerous procedural and technical requirements, including LNG carriers that hold no more than 148,000 m³ of LNG, carrier transits that may occur only during daylight at slack high tide, and measures like the acquisition of ship traffic surveillance systems and the creation of exclusion zones around the ships. Except for the presently proposed channel modification, and the excavation and dredging for the tankers' moorage slip, the applicant appears not to propose drastic widening or deepening of the Coos Bay channel – not officially, anyway. But it is obvious that a semi-secret plan exists that will call for the deepening and widening of the channel in lower Coos Bay; and this plan is likely to be revealed as soon as approvals for the terminal and the pipeline are in the bag. At that point, apparently, it is hoped that the application of political pressure will lead to approval of the 'channel modification' as well. Clearly this is a political strategy, and equally clearly, our officials should weigh the entire package, the 'channel modification' together with the present application.

Even though according to the Coast Guard's LORs, LNG carriers with capacities larger than 148,000 m³ must not be used, Jordan Cove seems to be planning to use them anyway. Resource report 1 (on page 22) states:

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[4]) "U.S. Coast Guard says bay safe for LNG vessel traffic", *The World* (Coos Bay), May 15, 2018.

> The LNG carrier loading berth will be capable of accommodating LNG carriers with a cargo capacity range of 89,000 cubic meters to 217,000 cubic meters. The USCG Letter of Recommendation ("LOR") and Waterway Suitability Report ("WSR") currently allows LNG carriers up to 148,000 cubic meters to dock at the LNG Terminal berth.

Unless Jordan Cove is counting on loading ships capable of handling 217,000 m³ of LNG, it makes no sense to build a moorage slip and berth capable of handling vessels that size, because both the moorage slip and the berth would be larger than necessary, and more costly. And as things stand, handling the 148,000 m³ carriers will push the Coos Bay channel's capacities to their limits – or beyond, depending on one's tolerance for risk. Already, 148,000 m³ LNG carriers are far larger than the few chip ships and log carriers that still visit Coos Bay, and unless the harbor is drastically deepened and widened, most of the time vessels loaded with immense amounts of LNG, a highly hazardous substance, will be unable to leave Jordan Cove's moorage slip, even during emergencies. Given the present depth of the channel they will be able to move out to sea only during about 550 hours of slack high tides, or 6.3% out of an entire 8,750-hour year.

At present, most of the navigation channel is dredged to -37 feet. The draft of an LNG vessel that can carry 148,000 m³ of LNG is 12 meters, or 39.4 feet (The .4 stands for 4-tenths of a foot, not 4 inches). The Coast Guard requires a safety margin of 10% for underkeel clearance, which adds 3.9 feet (Again, the 9 is 9-tenths of a foot.) Altogether, 39.4 feet + 3.9 feet equals 43.3 feet. To achieve the needed total clearance of 43.3, the navigation channel will need 6.3 feet of tide water on top of the 37 foot deep navigation channel, which is measured from the mean low-low mark. 37 feet + 6.3 = 43.3 feet.

On a tide table for 2019, I checked the total number of high tides, which is 705 for the year. I also checked the number of high tides less than 6.3 feet, which is 168 for the year. Deducting the latter from the former leaves 537 usable tides during all of 2019, but due to the Coast Guard's requirement that they be daylight tides, perhaps half will be suitable, or 268; in other words, considerably less than one a day. (It is striking that the number of insufficiently high tides is largest during the summer months of May/June/July/August, which are also the longest days of the year.) Each carrier transit is estimated to take 1.5 to 2 hours, which is close to the duration of a slack high tide.

While the Coast Guard's conditions may enable LNG carriers to occasionally traverse the Coos Bay channel, calling it 'suitable' is a vast overstatement since they pose serious risks to at least half the local population, risk which, as acknowledged by Jordan Cove, will affect 16,922 people residing within the defined 'Hazard zones'.[5])

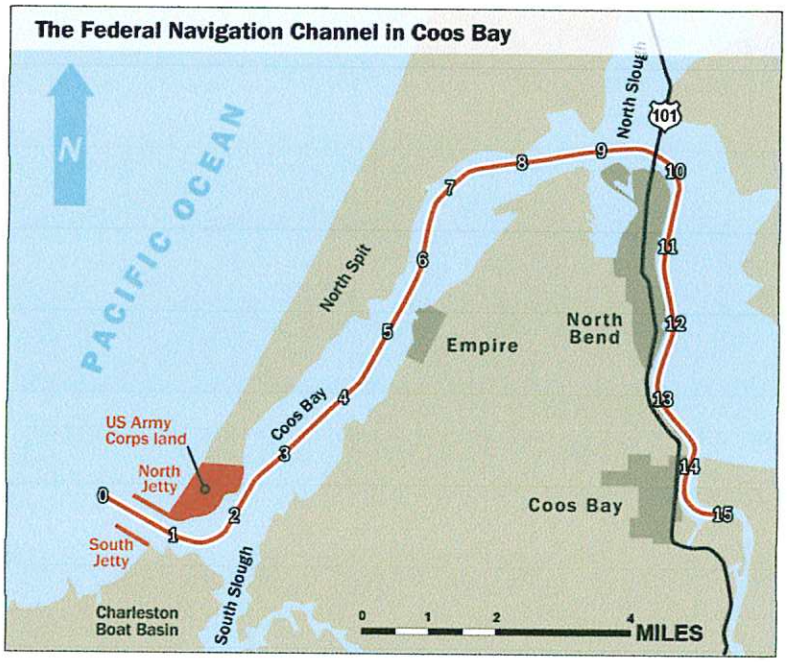
Accidents with LNG may be low-probability, but they will be high-consequence. What we are facing here are two very different philosophies about public safety. One says that human-made rules and devices will keep us safe. The other says that human-made rules and devices are fallible, so public safety can be truly assured only by back-up, fail-safe

[5]) This number is mentioned in Jordan Cove's FEIS of 2015, page 4-1031 (= p.1381 in the 7891-page PDF).

physical conditions such as short, roomy channels, short, quick escape routes, and proper distances between all LNG on one hand, whether at the terminal or in the ships, and local residents on the other. And 'proper' means far enough so nobody can get hurt when things go wrong, except the professionals involved. That ensures that the locals will be out of harm's way. But Coos Bay lacks achievable, physical, fail-safe conditions, and they cannot be created unless its population were forcibly removed, several miles away.

As stated already, the dredged depth of the Coos Bay channel is -37 feet. Its present width is 300 feet, and there is no turning basin in front of the Jordan Cove site. But for several years the Port of Coos Bay has been plotting a channel deepening and widening project, all of which is being paid for by Jordan Cove, even though the Port's website contains not a hint that this will be for Jordan Cove's benefit. Instead it states:

> The channel modification project is instrumental in facilitating future economic development in Oregon and will accommodate the growing global fleet.



For decades the slogan 'economic development' has sold boondoggles, most of which were funded or promoted by the Port, which has always lusted after them. And it's hard to say what *'accommodate the growing global fleet'* means, or what that will achieve. The most likely explanation is that this huge deepening project, requiring much blasting and the removal of 15 to 18 million cubic yards, is for Jordan Cove, and possibly for the adjacent Roseburg chip terminal, as a bonus. But it won't benefit any of the other local ship terminals, and it will hurt the fishing industry, commercial and recreational. It's also clear that Jordan Cove wants to avoid including the 'channel modification project' in its application, preferring to get its permits in stages – a typical political move. If or when its terminal and pipeline are approved, the channel modification will be next, with the main argument being the unfairness of approving a terminal without making it possible for Jordan Cove to operate it economically – with much bigger LNG tankers.

The channel modification project will only go as far as channel mile 8.2, or about the middle of the adjacent Roseburg property, and will deepen the channel from -37 to -45 feet while widening it from 300 to 450 feet. Most of the deepening, it seems, will need to remove bedrock, about 15 million tons of it.

According to the Coast Guard WSA of July 1, 2008, under 'Navigational Measures':

> LNG Tanker Size Limitations: Based on the Ship Simulation Study conducted by Moffatt & Nichol on March 17-20, 2008, the maximum size LNG tanker permitted to transit through the Port of Coos Bay is a spherical containment LNG carrier with the physical dimensions of a 148,000 m^3 class vessel. The ship dimensions used in the study reflect a length overall of 950 feet, beam of 150 feet and a loaded draft of 40 feet.

To accommodate vessels of that size, SIGTTO Information Paper No. 14 recommends:

> **2 PRINCIPAL RECOMMENDATIONS**
>
> **2.1 PORT DESIGN**
>
> **Approach channels.** Harbour channels should be of uniform cross-sectional depth, and have a minimum width, equal to five times the beam of the largest ship. *[Minimum 5 x 150 feet beam = **750** feet]*
>
> **Turning circles.** Turning circles should have a minimum diameter of twice the overall length of the largest ship, where current effect is minimal. Where turning circles are located in areas of current, diameters should be increased by the anticipated drift. *[Minimum 2 x 950 feet length = **1,900** feet]*
>
> *(SIGTTO Information Paper No. 14, page 3)*
>
> **General Requirements for LNG Carriers**
> (where figures are given they refer to LNG carriers of 135,000 m^3 capacity)
>
> **1.2 Approach channels and turning basins**
>
> Navigable depths (for most LNG carriers) should generally not be less than 13 metres below level of chart datum. *[13 meters = **-43** feet]*
>
> Channel width should be about five times the beam of the ship (approximately 250 metres). *[250 meters = **820** feet]*
>
> Turning areas should have a minimum diameter of two to three times the ship's length (approximately 600 to 900 metres). *[Min. = approx. **1,900** to **2,850** feet]*
>
> *(SIGTTO Information Paper No. 14, page 23)*

To summarize the channel dimension numbers:

Existing channel		**Modified channel**		**SIGTTO Channel Standards**	
width	depth	width	depth	Minimum width	Minimum depth
300 ft.	- 37 ft.	450 ft	- 45 ft.	**750 – 820 ft.**	**- 43 ft.**

SIGTTO's recommendations pertain to carriers of 135,000 m^3 capacity, while the Coast Guard assumes carriers of 148,000 m^3 capacity for Coos Bay; a 10% increase, but for simplicity we will ignore it. More importantly, while the deepening project's planned -45 feet would meet SIGTTO's depth recommendation, SIGTTO's recommended channel width of "about five times the beam of the ship (approximately 250 metres)" should be – given the ship's 150 foot beam – **750** feet, but 250 meters would be **820** feet. Whichever number is preferred, the Port's new channel width of 450 feet won't come close to it.

And with regard to the turning basins, it should be noted that the Port's project would create a new vessel turning basin with a designed length of 1,400 feet, a width of 1,100 feet, and depth of -37 feet, located between River Miles 7.3 to 7.8, meaning in front of the Jordan Cove moorage slip. The first mystery is why, if the channel is to be deepened to -45 feet, the turning basin should only be -37 feet deep. That doesn't make sense, but it is typical of Jordan Cove's jumbled planning method. In addition, both its length and width are seriously substandard. To summarize the turning basin numbers:

Proposed New Turning Basin			**SIGTTO-Recommended Turning Basin**	
length	width	depth	**Min. & Max. diameter**	Minimum depth
1,400 ft.	1,100 ft.	- 37 ft	**1,900 ft. – 2,850 ft.**	- 43 ft.

Two more aspects of the SIGTTO recommendations should be noted.

The SIGTTO numbers highlighted on this and the previous page make clear that SIGTTO expects a round turning basin (they also describe it as a 'turning circle'), while the Port's proposal envisions a rectangular one. This may be a tacit recognition of space limitations in the bay, but clearly round turning basins are more predictable, hence simpler to maneuver, and safer. This part of the plan may create yet another hazard.

Another problem is that SIGTTO's minimum basin diameter is twice the length of the ship, or 1,900 feet, and they suggest increasing it to up to three times the ship's length, or 2,850 feet, if current can be expected in that location. Coos Bay experiences strong tidal currents, which will get stronger yet if the channel is deepened and widened. Even if the loaded LNG carriers continue to move through the bay only at slack high tide, with a carrier transit time between 1.5 and 2 hours it seems doubtful that currents can be avoided completely; and then there are the seasonal currents from heavy rain flows into the estuary, which cannot be avoided at all. Therefore even the 1,900 feet minimum diameter may be inadequate for the turning basin, and something closer to 2,850 may be advisable. But that is 2 to 3 times what ~~the Port~~ Jordan Cove proposes.

> "Faced with the choice between changing one's mind and proving that there is no need to do so, almost everyone gets busy on the proof."
>
> *John Kenneth Galbraith*

Chapter 1 already dwelt on Jordan Cove's failure to meet SIGTTO's recommendations with regard to: (1) safe distances from populated areas, (2) timely escape routes in case of emergencies including earthquakes, (3) avoiding moorage on the outside of a curve in the channel, and (4) avoiding long, inshore channels. The present Chapter 2 has shown failures to meet industry standards for channels and turning basins.

We live in an imperfect world, and compromises need to be made. But Jordan Cove's proposals do not qualify as compromises. Instead they take so many liberties with the public's safety that they seem insupportable, *period.*

CHAPTER 3: Misleading, obsolete and conflicting geologic information has been used. Often of puzzling origin and contradictory, the data misrepresent the geologic risks, enabling Jordan Cove to understate the dangers posed by the looming offshore earthquake-tsunami, especially to LNG carriers in port. Plans for handling that cataclysm are contradictory, reckless and unrealistic, since despite claims to the contrary they are based on no real-world experiences whatsoever. For the same reason the Coast Guard's lack of regulations for dealing with tsunamis should not absolve it of responsibility for public safety.

It is to be expected that industrial promoters eager to sell their schemes will exaggerate their benefits and ignore the drawbacks. But when they promote a highly hazardous industry, developers' lies may end up destroying thousands of lives. At the risk of sounding impolite, critics of such promoters are entitled to be skeptical of their 'facts'. But some facts I do trust. Those include the 2012 report of the results of a 13-year study of offshore earthquakes, by a team of Oregon State University led by Chris Goldfinger:

> ... published online by the U.S. Geological Survey, the study concludes that there is a 40 percent chance of a major earthquake in the Coos Bay, Ore, region during the next 50 years. And that earthquake could approach the intensity of the Tohoku quake that devastated Japan in March of 2011.
>
> "The southern margin of Cascadia has a much higher occurrence level for major earthquakes than the northern end and, frankly, it is overdue for a rupture," said Chris Goldfinger, a professor in OSU's College of Earth, Ocean, and Atmospheric Sciences and lead author of the study. " ... major earthquakes tend to strike more frequently along the southern end – every 240 years or so – and it has been longer than that since it last happened," Goldfinger added. "The probability for an earthquake on the southern part of the fault is more than double that of the northern end." [6])

This high probability estimate, and professor Goldfinger's statement that the next quake is 'overdue', rested on his team's finding that during the last 10,000 years, 41 major earthquakes had struck the south coast, which worked out to an average interval of 'every 240 years or so' (244 to be exact.) Because the most recent one had struck in January 1700, if the average interval had worked like clockwork the next one should have hit Oregon's south coast during World War II. Even though it didn't, that doesn't mean we can rest easy; on the contrary.

> "The Cascadia subduction zone remained hidden from us for so long because we could not see deep enough into the past. It poses a danger to us today because we have not thought deeply enough about the future."
>
> Kathryn Schulz: *"The Really Big One - An earthquake will destroy a sizable portion of the coastal Northwest. The question is when."*

OSU's conclusion of a 40% chance of a major earthquake/tsunami striking Coos Bay in the next 50 years was announced in 2012, so it would terminate by 2062. If Jordan Cove were to get its approvals by the end of 2019 (and in the past, those decisions have always taken longer than

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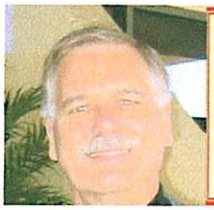
[6]) *OSU News and Research Communications*, 8/1/2012, "13-year Cascadia study complete – and earthquake risk looms large."

expected), the terminal might start operating by 2024. The useful life of a typical LNG terminal – unless market changes make it obsolete – is at least 50 years, which brings us to 2074; and since its useful life may be much longer, it could still be operating by the year 2100. So the likelihood of a major offshore earthquake-tsunami striking the Jordan Cove terminal during its working life is well above the 40% quoted by the OSU scientists. Describing it as a near-certainly may not be an exaggeration.



Says Bob Braddock, Jordan Cove project manager:

"We've tried to take everything into account and build everything up beyond what the state considers the worst case scenario."

Says Chris Goldfinger, seismologist and lead scientist of the 2012 Oregon State U study:

"It should be an assumption that this will happen during the lifetime of the facility. You can engineer anything to survive anything if you *put enough money into it, but I've seen a lot* of very well-engineered stuff destroyed as if it were Legos. ... From my perspective, and the probabilities, I would certainly have reservations about building one of these terminals down there."

Says Charles Miller, retired professor of oceanography, Oregon State University:

"Siting LNG terminals in locations near shore is unwise and might well be characterized as madness.... LNG storage in megaquake territory is profoundly unwise. ... Any thought of exporting LNG from massive compression and storage facilities in Oregon's tsunami zones should be abandoned. The savings to the corporations promoting construction of these facilities will be substantial if that wisdom is realized sooner rather than eventually."

Says Anne Trehu, an OSU geologist who studies the Cascadia Subduction Zone:

"I would say every one of us would be reluctant to suggest a liquefied natural gas terminal on the coast here."

Quotes by Braddock, Goldfinger and Trehu from "Jordan Cove LNG terminal at Coos Bay designed for Cascadia quake, tsunami though hazards remain". *The Oregonian/Oregon Live*, June 27, 2014. Those by Dr Miller are from his comments to FERC.

It's clear that scientists familiar with the OSU study are skeptical of claims that Jordan Cove's terminal will survive the earthquake/tsunami undamaged. But there has been little discussion of how an LNG carrier might fare during that calamity, due, I suspect, to a complete lack of real-world experiences. Granted that the earthquake is unlikely to damage a carrier afloat in the moorage slip or in the bay, the tsunami may be another matter entirely. When that starts rolling in, the ship could be seriously damaged. But that prospect seems to have activated Jordan Cove's propensity to deny both facts and common sense – just to get their plant built. In its Final EIS of 2015 it stated:

> "Geologic studies indicate that mega-thrust earthquakes have occurred numerous times in pre-history. (Nelson et al. 1996). The recurrence interval between Cascadia events has been irregular and ranges from about 100 to 1000 years (Atwater and Hemphill-Haley 1997). Typical recurrence intervals are thought to be on the order of 400 to 600 years. *(Clague et al. 2000)."*[7])

That would make the average interval a convenient 500 years, so since the last big quake occurred in 1700 we can all rest easy: the next one is still a couple of centuries off. Not a word on that page about the Goldfinger/OSU study, which set the interval at half as long, and called the next catastrophe 'overdue'.

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[7]) Jordan Cove Final EIS of 2015, p. 4-263 (= p. 613 in the 7891-page PDF).

Jordan Cove's FEIS also assured us:

> "It is calculated that it would take 25 minutes for a large tsunami generated from the CSZ [= Cascadia Subduction Zone] to reach Coos Bay after the earthquake event occurs, which would provide time for LNG vessels to disconnect from the berth and to reconnect with the tug boats. The tethered LNG vessel and the three tug boats would hold their position under power to offset the advancing wave and currents. The tsunami wave is predicted to impact the bow of the ship head on. If the LNG vessel is traversing the channel during the tsunami, the tugs would also provide assistance as described above." [8])

The 25 minutes turn up in the FEIS again, but instead of 'calculated' they are estimated:

> The location where a predicted tsunami would originate is offshore and 25 minutes is the estimated time for the wave to reach the LNG facility site. ... It is not intended to move the LNG carrier to the center of the Coos Bay channel. Instead an LNG carrier would remain in the slip but positioned just away from the dock and 25 minutes is sufficient time to accomplish this response. [9])

Actually, 25 minutes is a strange outlier among estimates of the interval between the earthquake and the tsunami's arrival. This is due to two observed facts that enable us to figure out that interval's length, give or take a couple of minutes. Those two facts are the Cascadia Subduction Zone's distance from the coast, and the known speed of tsunamis, which race submerged across oceans at jetliner speed, about 500 miles an hour, or 8.3 miles a minute. They will slow down and rise when they meet a rising sea floor, as when approaching a coast, and then they will make a horrible mess on any low-lying land near coastal waters like ours, until they have spent all that energy and run back out to sea. But that process can take half a day or longer, with tsunami waves coming and going, and deep troughs in-between; and I shouldn't need to dwell on all the debris they will drive around the bay for hours and hours – wrecked parts of buildings, planes, cars, logs – all terribly dangerous for anyone near shore, and for anyone on a tugboat in the bay.

> "If I were a tugboat operator, and a subduction zone earthquake started, I'd be doing what everybody else will be doing, and that is running for high ground. The last thing you want to do is get on a boat in a tsunami zone, and your chances of that working out are not good."
>
> Chris Goldfinger, *marine earthquake scientist who led the Cascadia Subduction Zone research published by OSU in 2012.*

[8]) Jordan Cove FEIS of 2015, pp. 4-251/4-252. (= pp. 601/602 in the 7891-page PDF).
[9]) Jordan Cove FEIS of 2015, p. W-1726 (= page 7246 in the 7891-page PDF).

The CSZ runs from above Vancouver Island down to Cape Mendocino, south of Eureka, CA, a distance of about 700 miles. On its way to Cape Mendocino it starts getting closer to the southern Oregon Coast, as the partial map below shows. In the lower left corner of that map is a distance scale for 300 kilometers, since metric measurements seem to be preferred by scientists. Using that scale (which equals about 200 miles) while eyeballing the map, the CSZ looks to be 90 km west of Coos Bay, or about 56 miles. 56 miles divided by tsunami speed, or 8.3 miles a minute, gives us a tsunami ETA of 6.45 minutes after the quake. But that is an oversimplification; we need to add some time for the tsunami's slowing down as it starts hitting the rising ocean floor, causing it to raise itself, while turning much of its horizontal energy into vertical. But even adding a few minutes is unlikely to produce a total interval of more than 10 minutes.

(I should mention one uncertain assumption, which is that the interval begins at the end of the earthquake – more or les with the final shock. While that is possible, it cannot be guaranteed. Since the quake is expected to last between 4 and 5 minutes, it seems possible that the first movements on the ocean floor will start generating tsunamis.)

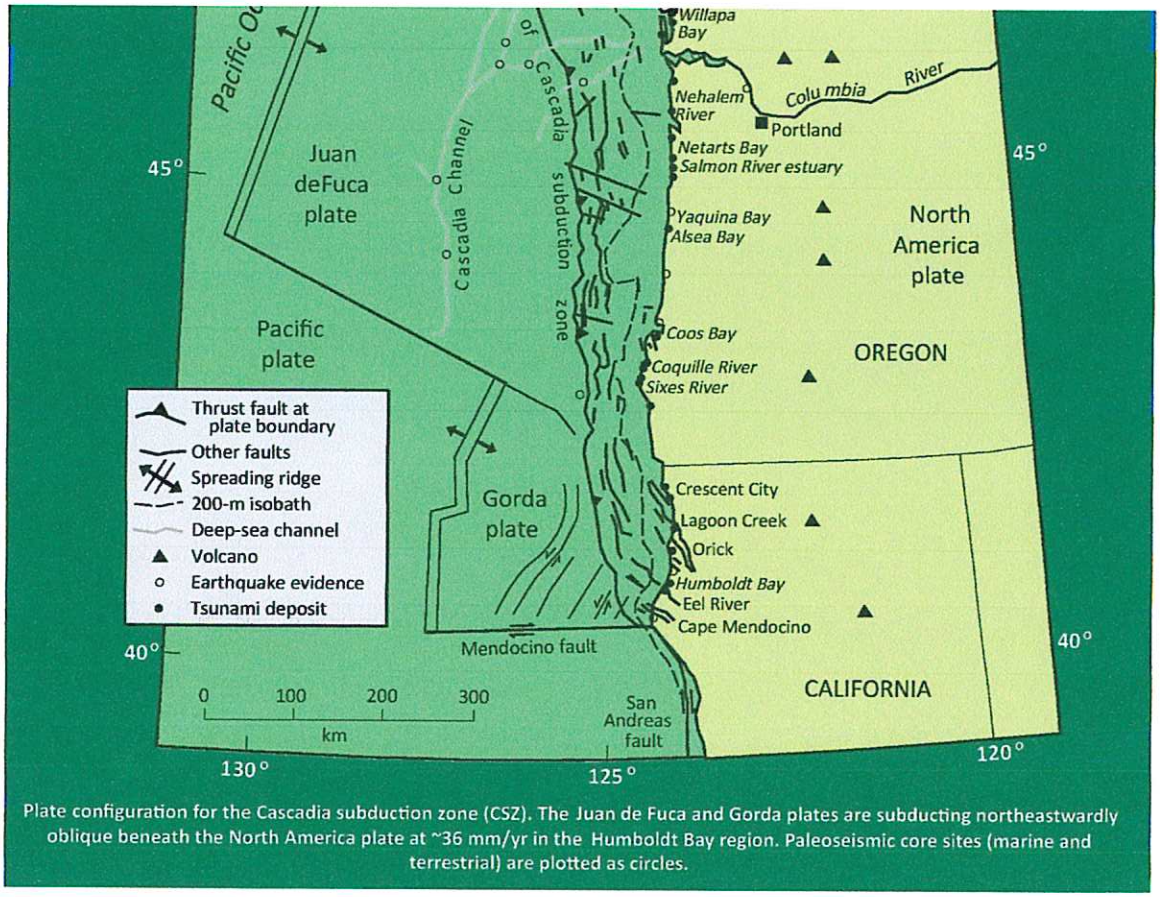

Plate configuration for the Cascadia subduction zone (CSZ). The Juan de Fuca and Gorda plates are subducting northeastwardly oblique beneath the North America plate at ~36 mm/yr in the Humboldt Bay region. Paleoseismic core sites (marine and terrestrial) are plotted as circles.

To determine the origin of Jordan Cove's 25-minute ETA for the tsunami, we could multiply 25 minutes by the tsunami speed per minute, which was 8.3 miles. But when we do that, the result places the CSZ 207.5 miles offshore, which equals 332 kilometers, although allowing for the coastal slowdown, 300 km may be more realistic. Either

number, 207.5 miles or 300 km, seems disconnected from geologic reality, unless the expectation was that the quake would come from the western edge of the Juan de Fuca plate, seen in upper left. None of the scientists whose work I have read assumes that. Contributing to the mysteriousness, Jordan Cove's states this, in their 2015 FEIS:

> The primary geologic hazard for the LNG terminal is the CSZ, which can generate strong horizontal and vertical ground motions and tsunami waves. At its nearest point, the CSZ is located 13 kilometers (km) (8.0 miles) from the site.[10])

A distance of only 13 km or 8 miles makes their 25 minute tsunami ETA even more improbable. Now Jordan Cove's RR-13 has a take on this which is close in distance, but far away on the tsunami's ETA. It tries to soothe us with this tsunami 'simulation' (as usual, the colors have been added):

> **1.** Tsunami event (requested by the State)
> **a.** An earthquake reported at 15 kilometers offshore
> **b.** Ship docked at terminal unloading *[sic]* cargo
> **c.** Earthquake magnitude 8.0
> **d.** Oregon Department of Geology has issued a warning that this will reach shore in 3 hours. *(RR-13, page 300)*

Let's look at this, starting with **assumption a**. Because we know that the Cascadia Subduction Zone, the source of all our major offshore earthquakes of the past 10,000 years, is located some 60 miles west of the southern Oregon coast, it makes no sense to assume a major earthquake '15 kilometers offshore,' which equals 9 miles offshore. At least on this Jordan Cove's FEIS and its RR-13 are in close agreement, since one says 8 miles and the other 9. But the agreement is a strange one, because an undersea earthquake from a CSZ only 8 or 9 miles from the coast could bring a tsunami to Coos Bay in less than 5 minutes, leaving no time at all to do anything with that LNG carrier in the moorage slip. Maybe the authors looked at the green map above and mistook the 200-meter isobath for the CSZ? But that looks as if it's 20 miles off Coos Bay.

The next one, **assumption b**, is wrong because it has the cargo loading process backwards, but we can ignore that for now. And **assumption c.** is merely dubious. It assumes an offshore earthquake of magnitude 8.0, even though most predictions consider a magnitude >9.0 possible, which is a huge difference on a logarithmic scale. We should *hope* for *only* 8.0 while preparing for worse, since nobody knows for sure.

> "When you put a hazardous facility in a tsunami zone, it won't really get its test flight until the tsunami rolls in. And that's the problem. In my mind, it's like Boeing building a new airplane and saying: *"Well, we've done all the computer models and now we're going to sell tickets on the test flight."* No matter how much engineering you throw at a facility on the coast, whether it's an LNG tank or whatever, things may just not go according to plan when the event really happens."
>
> Chris Goldfinger, *marine earthquake scientist who led the Cascadia Subduction Zone research published by OSU in 2012.*

[10]) Jordan Cove FEIS of 2015, page 4-246 (= page 596 in the 7891-page PDF). The second sentence, about the distance of the CSZ, is repeated on page 4-254 (= PDF page 604).

But the greatest danger lies in taking seriously **assumption d,** RR-13's 3-hour ETA for the tsunami, allegedly calculated by the "Oregon Department of Geology". I cannot believe that this came from DOGAMI, but maybe they produced it fifty years ago, when offshore geology was a virtual blank slate. Anyhow, it can be dismissed as irresponsibly wrong if it causes anyone inside a tsunami inundation zone to linger after the earthquake. But its most absurd aspect is that a 3-hour ETA of the tsunami, at standard tsunami speed of 8.3 mph, would place the CSZ about 1,500 miles west of here. Although that would be nice for us, it is regrettably untrue. With Jordan Cove's numbers being all over the place like this, there seem to be plenty of reasons to distrust the quality of the scientific work data used for its project. And there is more, on the topic of how to handle an LNG tanker during the event.

One of RR-13's authors is Frank Whipple, who is still doing work for the Port of Coos Bay under the corporate name Amergent Techs. RR-13 claims that all its authors including Frank Whipple have extensive experience and "... the appropriate skills necessary to meet the requirements of 33 CFR 103.410 ... Their resumes are provided in Chapter B." Unfortunately Chapter B is empty. Is secrecy about the qualifications of consultants on potentially hazardous projects really necessary, and why?

"Everything secret degenerates, even the administration of justice; nothing is safe that does not show how it can bear discussion and publicity."

Lord Acton

Be that as it may, one of Frank Whipple's statements, cited below, is remarkable in flatly contradicting Jordan Cove's claims about how it plans to handle a moored LNG carrier during the tsunami, cited and explored on pages 21-23.

Earthquakes and Tsunami's:

The LNG carrier is expected to remain at the berth with mooring lines attached. To provide support, the LNG carrier will be supported by 3 tug boats and its own maneuvering capability. One tug boat will be alongside the ship at all times and the other two are manned and ready to operate immediately adjacent to the ship. The basin and dock will provide stability for the LNG carrier and a secure location ... [11])

"You say: *'I did not think it would happen.'* Do you think there is anything that will not happen, when you know that it is possible for it to happen, when you see that it has already happened?"

Seneca

The first obvious question is how, if during the tsunami it becomes obvious that keeping the ship moored was a really bad idea, it could be unmoored without those doing the unmooring getting killed. The deadly dangers would not only include the tsunami waves and the debris they carry, but the possibility that land subsidence during the earthquake had lowered the moorage dock, as happened during the Alaska quake of 1964. But the strangest part of Mr. Whipple's

[11]) Memorandum dated 25 January 2016, from Frank Whipple of Amergent Techs to Meagan Masten, Subject: *Response to Wim de Vriend on Marine issues.*

statement is its timing, because he wrote it in January 2016. That was years after Jordan Cove had formulated the tsunami plan that was the opposite. Jordan Cove asserted that after the earthquake but before the tsunami there would be plenty of time to unmoor the carrier and have tugboats control it in the moorage slip.[12]) I have serous doubts, both about the timing and the success of that procedure, which could last the better part of a highly unpredictable day or night. But at least Jordan Cove got the unmooring part right, since with water heights fluctuating 30 feet or more, a moored carrier's lines would break or the bollards would be pulled out of the dockside, with unpredictable but probably very bad results. But by 2016 Mr. Whipple no longer saw things that way, and he called for the ship to stay moored to the dock. Strange. But then, neither his plan nor Jordan Cove's has ever been tried. These 'experts' seem to specialize in making senseless noise.

Mr. Whipple also asserted that tsunami studies have demonstrated that:

> ... the water path will flow *[sic]* from the north, cross over the north peninsula and flow into Coos Bay at an angle to the berth. The LNG carrier would remain within the berth protected from rapid moving waters. [13])

What this seems to mean is that no tsunami waves will reach an LNG carrier inside the moorage slip. But it is hard to see why a tsunami generated by the offshore CSZ, which runs parallel to the coast, would come from the north. It may be a necessary assumption if one is determined to declare the moorage slip immune to the tsunami's violence. But the general expectation, which makes a lot more sense, is that the tsunami will come from the west, hence at a 90-degree angle to the coast. After all, both the CSZ and the coast run roughly north-south. Even if Jordan Cove's tsunami berm or the concrete vapor barrier on the moorage slip's western bank reduced the water flow from the west, tsunami waves flowing into and out of the bay would enter and exit the slip for hours, most likely carrying dangerous wreckage into the slip, as seen in the videos from Japan.

As shown in the graph from the Alaskan earthquake on page 28, a tsunami is not just one wave, so that as soon as it's come and gone we can all take a deep breath and go home. Instead it consists of many long and high waves, the first of which is preceded by a drastic lowering of the level in the bay as its water runs out to the ocean. Next comes the first wave, rolling in both across the North Spit and between the two harbor jetties. Both branches will join and inundate low-lying land, causing a lot of destruction. They will also continue flowing into all the tributaries to the Coos Bay estuary, accumulating a lot of debris on the way: boats, planes from the airport, logs from the log export docks, buildings, and other wreckage. Finally outrunning gravity inland, the first tsunami wave will start rolling back, but is likely to run into another one coming in, and this process will go on for half a day or longer. The later waves and troughs in-between may be taller and deeper than the first, and it will be difficult to say which will be more destructive, the water or the wreckage it carries, which may cause its own kind of

> "The great instinct of humanity, even when facing catastrophe, is to do nothing rather than something."
>
> *Allen C. Guelzo*

[12]) Jordan Cove 2015 FEIS, pp. 4-251/4-252. (= pp. 601/602 in the 7891-page PDF).
[13]) Memorandum dated 25 January 2016, op. cit.

destruction, especially to the smaller vessels in the moorage slip. I would not bet the farm on an LNG carrier, moored or unmoored, or on its tug boats, escaping undamaged. And I would not bet a nickel on an LNG carrier that was sailing down the bay during the tsunami. For some reason that scenario has not received much consideration, but it should because odds are very high that a ship in the bay will not be able to reach the safety of the ocean in time. Mr. Whipple does admit:

> Ships moving in the channel are certainly subject to tsunami events both for *[sic]* current ships and LNG carriers. ... The tsunami issue is present in most major ports and with similar questions. [14])

Just because he got the first part right doesn't make the second part true. We're not talking about a cargo of potatoes but a hazardous substance. And even though Coos Bay is not a major port, 'most major ports' are NOT at risk for tsunamis, either. Is Portland exposed? To the earthquake, yes, but the tsunami is not likely to run 90 miles up the Columbia river. Is Seattle/Tacoma exposed? Although an earthquake along the entire length of the CSZ will damage Seattle/Tacoma as well as Portland, the tsunami will affect Puget Sound much less than the Washington coast because it will be partly blunted by the Olympic Peninsula. Are Oakland, Los Angeles, and San Diego exposed to tsunamis? They have entirely different geologic hazards, since their big earthquakes will occur on land, and probably without causing near-shore tsunamis unless they set off an undersea landslide. If any remote tsunamis struck them, they would be minor. And I should not need to ask about the ports of Houston, or New Orleans, or Charleston SC, or Newark. How about Rotterdam then, or how about Hamburg? Whipple's 'facts' are absurd.

> "Stupidity is an elemental force for which no earthquake is a match."
>
> *Karl Kraus*

[14]) Memorandum dated 25 January 2016, op. cit.

> "I'm not trying to scare anyone, but the New Yorker article, it was accurate."
>
> Chris Goldfinger, *being interviewed*

Kathryn Schulz may have written the best article for the general public about the earthquake/tsunami threat, which appeared in *The New Yorker* and was based on all the latest findings, tours of geologically important sites and interviews with key scientists. She wrote that after the CSZ's incredible power has raised a water column above sea level, which then collapses, half of it will rush off to cause a tsunami in Japan and the other half will: "... rush east, in a seven-hundred-mile liquid wall that will reach the Northwest coast, on average, fifteen minutes after the earthquake begins."[15]) Finally, we have clarity about the interval. If the earthquake lasts 5 minutes, that means the tsunami will strike 10 minutes after it ends. But notice that she said "on average". The CSZ is a bit further from the northern Oregon coast than it is here. As the green map on page 22 shows, it gets closer to the coast the further south it gets until, south of Eureka, CA, it looks less than 5 miles away. The point is that the closer the CSZ, the shorter the interval between quake and tsunami arrival is bound to be, so it is reasonable to expect that Coos Bay will be hit in less than Schulz's *average* of 10 minutes.

How much time was there after major offshore earthquakes elsewhere in the world?

> In areas where the coast is located close to the epicenter of a tsunamigenic earthquake, the time that elapses between the generation of the tsunami and its arrival on the coast is often frighteningly short. For example, the first tsunami waves that struck the Chilean coast on May 15, 1960, arrived only 15 min. after the main earthquake struck. [16])

"After it struck" suggests *after the earthquake started,* which would make the Chilean experience agree with expectations of our local event. But however long the interval turns out to be, a maximum of 10 minutes between quake and tsunami seems to be a prudent assumption. Even counting on 5 minutes more could cost many lives.

By now I have used quite a bit of space showing the absurdity of the assumptions of Jordan Cove's FEIS and its RR-13 about the tsunami's timing. Speaking as a local resident, I have trouble deciding whether putting out this kind of information is ignorance, carelessness, incompetence, irresponsibility, plain cheating, or some combination. But whatever the case may be, the $10,000 question is: even in the highly improbable event that Jordan Cove's guesstimate of 25 minutes between quake and tsunami is correct, will the dock- and tugboat crewmen stick around to implement its plan for saving the LNG carrier? Remember, Jordan Cove assured us (on page 21) that after unmooring the vessel from the moorage slip dock,

> ... the three tug boats would hold their position under power to offset the advancing wave and currents.

> "It was the wildest story, but no story is too wild for a man who hopes."
>
> Graham Greene, *"The Confidential Agent"*

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[15]) Kathryn Schulz: "The Really Big One - An earthquake will destroy a sizable portion of the coastal Northwest. The question is when." *The New Yorker Magazine*, July 20, 2015

[16]) Maurice Schwarz: *Encyclopedia of Coastal Science, 2006, p. 102.*

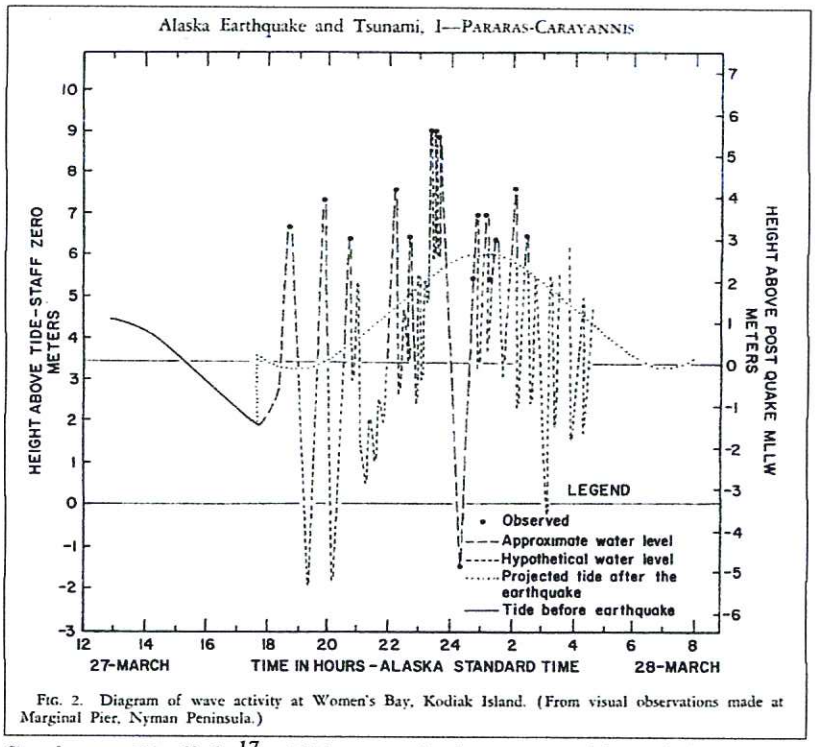

Fig. 2. Diagram of wave activity at Women's Bay, Kodiak Island. (From visual observations made at Marginal Pier, Nyman Peninsula.)

SIGTTO says that a ship's mooring lines can break during waves "approaching from directly ahead or astern, having … heights exceeding 1.5 metres and periods [= lengths] greater than 9 seconds." (Paper No. 14, p. 7)

Our tsunami waves promise to be many times higher and longer. In support, I include the nearby graph from the 1964 Alaskan earthquake-tsunami, recorded by the U.S. Navy Fleet Weather Station at Kodiak.[17]) If the graph shows anything, it is the unpredictable nature of the tsunami. The two horizontal lines indicate the water level before and after the earthquake caused the land to drop 3.5 meters (= 11.5 ft.). This is why the left side of the graph indicates the water level before the quake, and the right side the level after it. The land subsidence was followed by a first tsunami wave, about 3.5 m (= 11.5 ft.) above the new water level. A deep trough followed, dropping the water level by about 9 meters (= 30 ft.). Both wave height and trough depth were closely repeated during the next wave, but from then on it is difficult to see a pattern, especially because the very tallest wave struck halfway through the tsunami's 10-hour duration, followed by a trough as deep as the first two, which altogether caused a water level change of about 11 meters, or 36 feet. After this the fluctuations became less extreme, but they kept coming for another 4 to 5 hours.

If anything like this hits Coos Bay, it defies common sense to believe that 3 or 4 tugboats, no matter how powerful, can control a 950-foot ship that threatens to lift, bump or crush them, while being swamped by huge waves loaded with wreckage — cars, logs, buildings, planes. Those men will know it's a suicide mission, and as soon as they feel the quake they will want to leave, to make sure their homes and families are safe – assuming they can get out, because the only access is by a causeway that may have sunk into the liquefied mudflat.

"There were gentlemen and there were seamen in the navy of Charles the Second. But the seamen were not gentlemen; and the gentlemen were not seamen."

Thomas B. Macaulay

[17]) Taken from George Pararas-Caravannis: "A study of the source mechanism of the Alaska Earthquake and Tsunami of March 27, 1964." *Hawaii Institute of Geophysics Contribution No. 184. Manuscript received June 22, 1966.* The author noted that it was the only reliable record obtained in south-central Alaska, because all the tide gauges in that area had been destroyed.

In the other scenario mentioned by Jordan Cove, tugboats are already assisting a loaded LNG carrier's transit to sea when the earthquake strikes. In that case the crews can't very well leave, but conditions in the bay may be worse than inside the moorage slip. The troughs before and during the tsunami make a ship grounding more likely, and the waves in the bay may carry more dangerous wreckage than those in the slip. We should all hope that the tugboats manage to reach the ocean with the ship, and stay there until the tsunami is spent. But hope is not a policy, except for teenage birth control. Nobody really knows what will happen, but everyone seems willing to make Coos Bay a real-world test case.

> "I cannot conceive of any vital disaster happening to this vessel. Modern shipbuilding has gone beyond that."
>
> Edward J. Smith, *Captain of the White Star Line's Titanic*

The reason why the U.S. Coast Guard has not addressed the tsunami risk to LNG tankers seems to be, as the Coast Guard security specialist (quoted on page 5) lamented, the absence of 'real regulations'. But the lack of a ticket book is a poor excuse for a traffic cop to send a dangerously drunk driver on his way; and anticipating marine dangers is the U.S. Coast Guard's job. Jordan Cove won't mind such moral impotence, and RR-13 is comfortable with it too, assuring us:

> The tug escort would ensure maneuverability and safe operations in all conditions of transit and transit speed. *(RR-13, pp. 305/306)*

In all conditions, including the tsunami? Not even the Coast Guard's 'security specialist' seemed to believe that. When impotence and cluelessness team up, we're in trouble.

Finally we turn to Japan, because Jordan Cove's Boosters and a Jordan Cove official all have asserted that the 2011 Tohoku quake did no damage at all to the 30-odd Japanese LNG import terminals, so we can all rest easy:

> In March 2011, Sendai Japan LNG import facility was only about 80 miles from the epicenter of a 8.9 quake. The resulting tsunami did major damage to the port facilities but did not damage the storage tank. Sendai LNG was repaired and back online at an increased capacity in November 2011. Japan has 29 other LNG facilities that were not damaged. There was no explosion, no ecological disaster and no danger from natural gas to the population. [18])

> Jordan Cove's project manager, Bob Braddock, ... notes that there are more than 30 LNG facilities on the coast of Japan. "They've been through an event close to what we're talking about here, and none of them experienced a problem,' he said.[19])

Both Jordan Cove advocates ruined their case by overstating it. Both implied that every LNG terminal in Japan had been exposed to the Tohoku earthquake/tsunami of 2011 when in reality only one, the Shin-Minato LNG import terminal in the harbor of Sendai,

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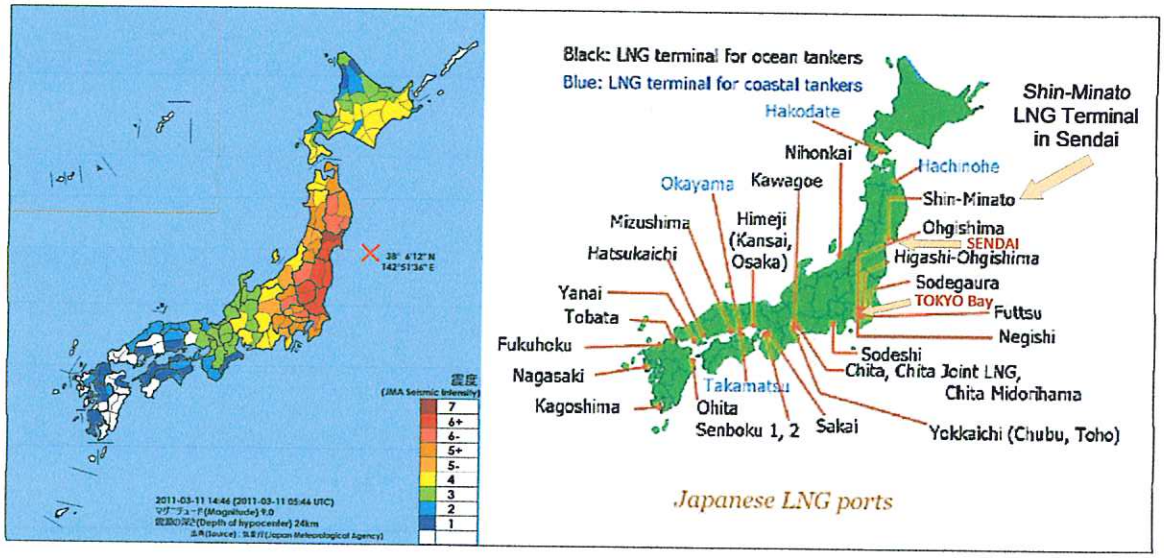
[18]) Letter by Dick Leshley: "LNG Plant Safe Port in a Storm" *The World*, June 10, 2014. More recently Keith Comstock made the same claim, in a letter in *The World* of December 21, 2018.

[19]) "Jordan Cove LNG terminal at Coos Bay designed for Cascadia quake, tsunami though hazards remain," *The Oregonian/Oregon Live*, June 26, 2014.

had been in the real danger zone and had been damaged badly enough so it took until the end of 2011 to put it back into operation. (Although it is true that its LNG storage tank(s) was/were undamaged.) I tried hard to find out if an LNG carrier had been present in the Sendai harbor during the tsunami, but was unable to obtain that information. I suspect that if there had been one and it survived undamaged, we would have heard about it. But I have to accept that an absence of evidence is not evidence.



Clearly the most essential part of this, and the ultimate goal of the Jordan Cove Boosters' mendacity, is to convince us that all 30 Japanese LNG plants survived grave danger without a scratch. In fact, the 2011 Tohoku quake, bad as it was, seriously affected only the northeast coast of Japan's main island Honshu (the areas in various shades of red on the left map, indicating high shaking intensities). The epicenter of the quake is indicated by the red cross, and the length of the subduction zone involved was about equal to the length of the red areas, from north to south – less than half the length of our CSZ. If it had been as long as our CSZ, then the 2011 earthquake/tsunami could have devastated all of Japan's east coast, but it wasn't and it didn't. And even if such had been the case, then their protected locations would have saved most Japanese terminals. Jordan Cove will be more exposed.

> "Even with a 1000-year head start … the best-prepared country in the world got hammered. It's a lot to expect us to do better on our first time out."
>
> Chris Goldfinger, *marine earthquake scientist who led the Cascadia Subduction Zone research published by OSU in 2012. Goldfinger was in Japan when the 2011 Tohoku earthquake-tsunami struck.*

The Shin-Minato terminal in Sendai (identified on the right map), was damaged by tsunami waves of 25-30 feet, although even higher ones were reported in the area. Tokyo Bay, on the red area's southern tip, did experience serious shaking, but tsunamis no higher than 5.3 feet, so its 5 LNG terminals (follow the red lines on the right-hand map) were undamaged. Although small, the map makes clear that Tokyo Bay and many other Japanese harbors and LNG terminals are protected by peninsulas or capes, or by their locations on Japan's inland sea. Those locations explain why their tsunamis were only a few feet high.

On January 15, 2019, at a meeting of the Port of Coos Bay's 'Harbor Safety Committee', a Pembina representative, a Mr. Schaedel, explained their plans for handling LNG ships during the tsunami. Besides being clearly ill-informed about tsunamis and about our area's geography, he cited the 25-minute interval again. I challenged him, both about the 25 minutes and the practicality of the tugboat plan, and demanded a real-world precedent, so Coos Bay would not serve as a guinea pig. As evidence he then cited a tsunami that had hit the Arun LNG terminal in Indonesia, where (according to him) an LNG carrier had remained moored at the dock and survived unscathed. He was either uninformed or too confident that I would not bother to verify this, for his claim turned out to be as false as those about the Japanese tsunami. Indonesia was struck by offshore earthquake-tsunamis in 2004 and in 2007, but they did not affect Arun, apparently because of the complex geography of that island nation – much like the Japanese situation.[20])

The Coos Bay LNG terminal proposal is unique in that it faces geologic hazards that are not present along the American Gulf coast and east coast, where all other LNG export terminals have been planned and built so far. This may explain why despite the many existing Coast Guard provisions for LNG carrier traffic, no regulations have yet been formulated to deal with, or minimize, the damage from the earthquake/tsunami that is almost certain to strike Coos Bay during the life of the Jordan Cove terminal and, most importantly, an LNG carrier then present. But it would be highly immoral and irresponsible to let the absence of Coast Guard regulations mandate an approval of this project – even if the incineration of Coos Bay could prove helpful in drafting regulations or prohibitions after the fact.

[20]) "Indonesian oil and gas sector suffers little tsunami damage", *ENB (Energy News Bulletin*, Australia), 30 December 2004; "Earthquake hits near Aceh, no reports of damage", *Reuters*, November 22, 2007.

CHAPTER 4: **The Hazard Zones' dangers to schools and residential areas are being misrepresented.** Jordan Cove obfuscates and denigrates the dangers posed by LNG spills, especially from breached LNG carriers. This is done by misstating the science about LNG's fire hazards, and the risks to Coos Bay residents and schools. Contrary to Jordan Cove's claims, many different terrorism scenarios look feasible, but the company's poor documentation inhibits transparency. Public safety may require a large number of permanently staffed protective bunkers, but those needing shelter may lack time to reach them.

Jordan Cove's RR-13 describes Hazard Zones 1 and 2 in these dispassionate terms:

> **1. Zone 1:** The area with the most severe consequences around the LNG facility and tanker, where an LNG spill could pose a severe public and property hazard and could damage or significantly disrupt critical infrastructure and key assets located within the area. This zone extends 500 meters (.3 miles) or .26 nautical miles from the source. *(RR-13 p. 162)*
>
> **2. Zone 2:** The area with less severe consequences than Zone 1 and is *[sic]* considered to extend from 500 meters (0.3 miles) to 1,600 meters (1 mile) for an intentional breech *[sic]* of an LNG carrier. The maximum extent of Zone 2 is one mile or .87 nautical miles. *(RR-13 p. 163)*

Throughout RR-13, the Hazard Zones are called 'Zones of Concern', implying that somebody is concerned, but in a primly restrained way. More seriously, RR-13 glosses over the real dangers to **people** inside the Zones. The phrase ***'less severe consequences'*** in Zone 2's description may sound good, but isn't. Even so, says RR-13:

> The criteria ... in NVIC 05-05, with regards to the Sandia Zones of Concern and mitigation strategies proposed can be ... successfully applied. The demographics of this area do not meet the Sandia criterion for high population density ... Zone 1- the measure *[sic]* with the most severe impact on the local population does not affect any significant population area, public or government centers such as schools and hospitals ... This statement is not a comment on the significance or the importance of any area along the route and population ... It is intended to conclude the risk of LNG movement through the waterway using criteria set by the U.S. Coast Guard and Sandia Laboratory has been evaluated and has been determined to be within acceptable limits. *(RR-13 p. 20, § 2)*

Despite the disclaimer *("This statement is not a comment on ... ")*, this amounts to a glib dismissal of the risk of LNG spills killing and injuring many of our **people**. And this is enabled by insinuating that Zone 1, though potentially having "the most severe consequences", is the only serious Hazard Zone around a pool fire, but few people live there – so the risk is "within acceptable limits". Which limits, and acceptable to whom?

In popular parlance, Zone 1 is often described as the 'Death Zone' because of the extreme heat produced by a ***pool fire***, which is the Hightower/Sandia-described scenario in which LNG from an intentionally breached carrier spills onto water, quickly warms above its – 265° F (= −160° C) liquid temperature, and turns into an enormous gas cloud which is

ignited almost immediately. Compared to the alternative Hightower/Sandia scenarios of the gas cloud's behavior, which assume ignition later on and further away (in Zone 2 or 3), a pool fire will have the largest volume of gas, and burn the hottest. As mentioned on page 10, thermal radiation at its center may reach 200 to 300 kilowatts per square meter (kW/m^2) but it is expected to *drop*, at Zone 1's outer limit of 500 meters or ⅓ mile, to 37.5 kW/m^2. At that distance, in RR-13's interpretation, 'less severe consequences' prevail. But for any humans present, ***'less severe consequences'*** still means ***death***.

The Hightower report mentions that heat radiation of 22.1 kW/m^2, less than the 37.5 kW/m^2 expected at that 500 meter, or ⅓ mile, outer edge of Zone 1, can weaken structural steel.[21]) That being so, a pool fire anywhere in Zone 1 will see the instant death and no-charge cremation of any **people** inside it. It also seems safe – if you'll pardon the expression – to assume that the certainty of death inside Zone 1 will apply to the crew of the breached LNG carrier, the crews of its escort vessels, and of the U.S. Coast Guard vessels, since all are likely to be exposed to this extreme heat. It's mind-boggling to consider what might be the effects of all that on the now-unmanned, breached LNG carrier, and on people living close to the bay.

Although the graph on this page, from Jordan Cove's very first FEIS, has not appeared in later EIS editions, it seems accurate as a depiction of the Hazard Zones around the terminal and the Coos Bay channel. (I added the big zone numbers for clarity.) I consider it superior to the many Hazard Zone charts in RR-13, which merely draw circles around various points in the bay where a fire is assumed to be burning; an example of this, done for Zone 1, is on the next page. Circles are misleading, because we cannot assume that the fire will be stationary. Instead, if it originates from LNG spilling from a damaged moving LNG carrier, the carrier may keep moving even if its entire crew is dead, and the fire will likely move with it, though perhaps not on the exact same course. While we cannot predict winds and currents at the time of such a catastrophe, both

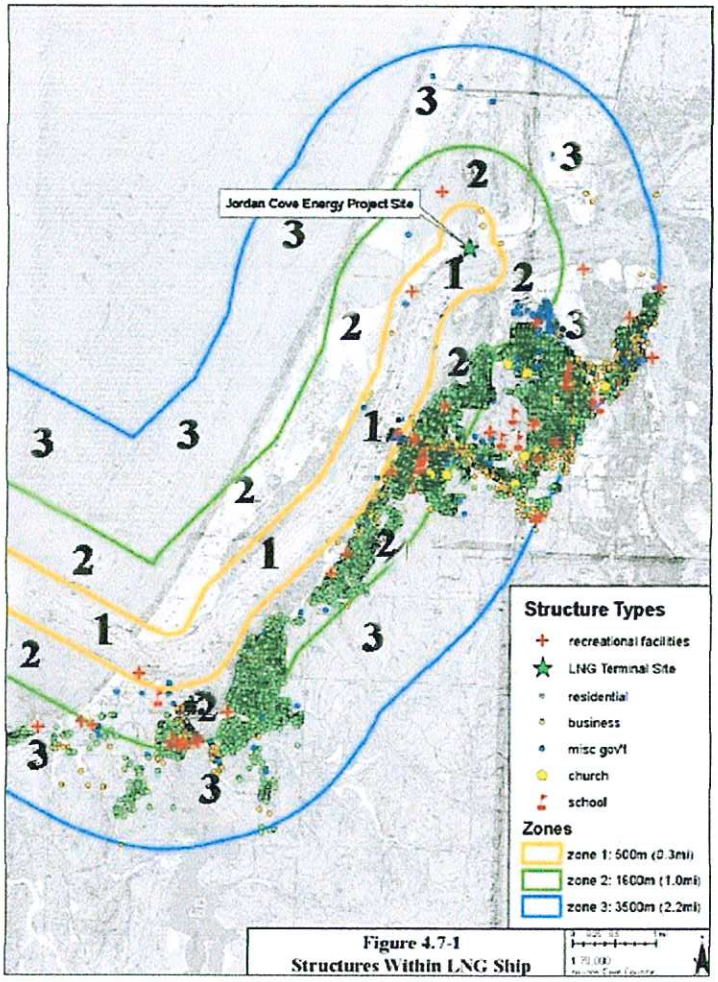
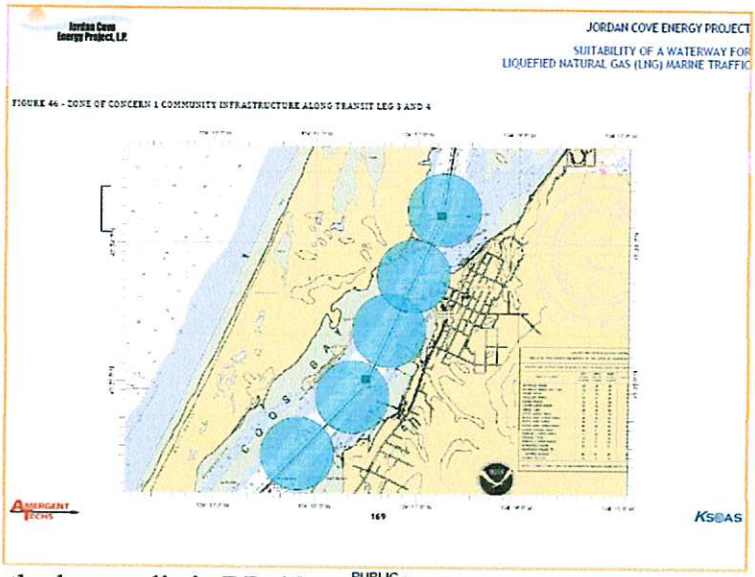


Figure 4.7-1
Structures Within LNG Ship

[21]) Hightower, Mike, and 11 other researchers: "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) spill over Water", *Sandia Report SAND 2004-6258*, produced for the US Department of Energy, p. 85.

are bound to influence the course of the stricken ship and of the gas cloud; and then there are the scenarios that envisage the failure of several of the LNG carrier's storage tanks in succession, due to the melted insulation causing a huge temperature gap between the pool fire and the LNG cargo, thus causing the ship's other tanks to burst and spill.[22])

Conclusion: even though nobody can exactly predict the extent of an LNG fire from a breached carrier in the bay, the Hazard Zones outlined on the previous page's map come much closer to reality than the circles, which seem to assume that as soon as the pool fire starts the ghosts of the carrier's crewmen will drop anchor, in a revival of the Flying Dutchman legend; and, even more improbable, that its extreme heat radiation will stay confined inside only one of the circles shown on page 169 of RR-13, reproduced below.



Although the map on the previous page, with the Zones outlined, is not very sharp, its little green dots, which represent homes, do confirm that few residents are living inside Zone 1, in a very small part of Coos Bay's Empire district, fronting the bay.[23]) Going by the heat projections for Zone 1, those folks may be dead and burned before they know it. This is confirmed by the second circle from the top in the less realistic RR-13 map of Zone 1, above. But unlike RR-13's other insinuations, that doesn't mean that the rest of the 16,922 people [24]) living inside the 3 Hazard Zones will be out of danger, as if Zone 1 were confined by a Berlin wall, blocking the heat's escape attempts. If a pool fire occurs in Zone 1, then Zone 2's residents living near Zone 1's outer limit of ⅓ mile will have almost the same deadly heat exposure as if they were just inside it, which is the deadly 37.5 kW/m^2. Those people are numerous, and live, from north to south, in North Bend's Airport Heights, in Coos Bay's Empire neighborhood, and in unincorporated Barview and Charleston, further down the bay.

Heat radiation in Zone 2 is expected to decline from the quoted 37.5 kW/m^2 at its ⅓ mile inner limit to '*only*' 5 kW/m^2 at its 1-mile outer limit, and the latter has often been taken to apply throughout Zone 2: another misrepresentation or, to be charitable, a convenient misunderstanding. But even at Zone 2's 1-mile outer limit where 5 kW/m^2 heat is

---

[22]) This scenario has been identified as plausible by prominent LNG fire scientists Jerry Havens and James Venart, who express puzzlement at assertions that this could cause only 2 or 3 of a 5-tank Moss-type LNG carrier to fail. That information is found on page 29 of this letter.

[23]) This takes no account of the people working at industries on the other side of the bay, i.e. D.B. Western, Southport Lumber, and the Roseburg Timber Chip terminal, all if which are inside Zone 1.

[24]) This number is mentioned in Jordan Cove's FEIS of 2015, page 4-1031 (= p.1381 in the 7891-page PDF).

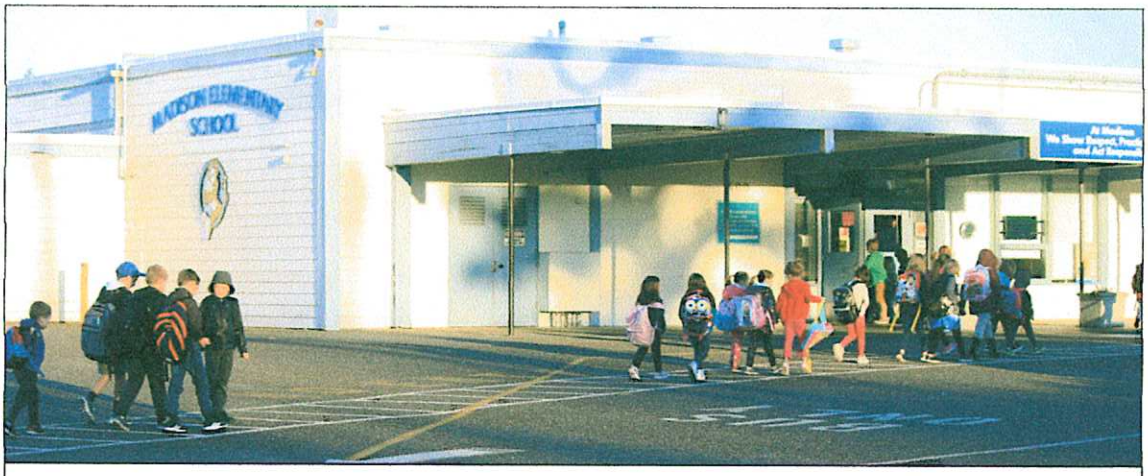
predicted to prevail, anyone on either side – just inside Zone 2 or just inside Zone 3 – will still be at serious risk of burns, because the Hightower report states that radiation only slightly lower than 5 kW/m^2, of 4.73 kW/m^2, can cause second degree skin burns after just 30 seconds of exposure.[25]) As LNG fire scientist Jerry Havens has pointed out:

> ... the use of a thermal flux criterion that would result in second-degree burns in 30 seconds is not necessarily appropriate to ensure public safety, as such exposure essentially ensures that serious burns will occur at that distance to persons who cannot gain shelter within 30 seconds. Aside from questions about the ability of even the most able to gain shelter in such a short time, questions are also raised about the safety of those less able.[26])

To recap: people on either side of the 500 meter or ⅓ mile boundary between Hazard Zones 1 and 2 will suffer roughly similar deaths. The heat radiation of 37.5 kW/m^2 at that location will decline to 5 kW/m^2 at Zone 2's 1-mile outer limit, so people on either side of that 1-mile limit will still be subject to the 2nd degree/30-second rule – and that will be the best possible prospect facing thousands inside Zone 2. Others inside Zone 2 but closer to that Zone's inner border may incur fatal burns, and at its outer border many others unable to seek shelter within that very short interval may still be toast.

About the hazards in Zone 3, between Zone 2's 1-mile outer limit and Zone 3's 2.2 mile outer limit, the scientific literature says that they will diminish to none if the gas cloud has ignited before reaching Zone 3. But they may be worse if, as is possible but less likely, the gas cloud doesn't ignite until reaching Zone 3. In summary, the numbers show that rather than causing only minor harm, an LNG spill in the bay can cause many deaths and burns in Zone 2, and Zone 3 is not exempt. To suggest otherwise is contemptible.

Zone 3's outer limit of 2.2 miles is also called the LFL, or Lower Flammability Limit of the gas cloud. It's where the scientists expect the gas to be so diluted that it makes up



Early morning, when pupils arrive at Madison elementary school. The school's 400 children will be only ⅓ mile from the Coos Bay waterfront and ⅔ mile from future passing LNG carriers.

[25]) Hightower, *"Guidance on Risk Analysis and Safety Implications"*, op. cit., p. 85.

[26]) Jerry Havens: "LNG and Public Safety Issues - Summarizing current knowledge about potential worst-case consequences of LNG spills onto water." *Proceedings (US Coast Guard)* Fall 2005.

less than 5% of the air, so it can no longer burn.[27]) But as mentioned, Zone 3 can suffer greater harm if ignition of the gas cloud is delayed until it reaches that Zone (although in that case people inside Zones 1 and 2 may be harmed less than expected).

The Hightower report (on page 75) urges that civilian protection in Zone 2 include:

> ... emergency response measures such as ensuring areas of refuge (enclosed areas, buildings) are available, development of community warning signals, and community education programs to ensure persons know what precautions to take.

This is repeated almost verbally in Zone 2 and 3's descriptions in the Coast Guard NVICs from 2005 and 2011, which make the same suggestions. I suppose that is why RR-13 could not avoid hinting at the need for protecting people in the ~~Zones of Concern~~ Hazard Zones. But it is hazy about which Zones, and it ignores several public schools at risk:

> For schools, shelter-in-place is currently practiced for emergency incidents at the two schools located in the Zones of Concern. There are no bunkers in the area to handle local residents. The North Bend school district houses their buses needed for evacuation inside the Zone of Concern. *(RR-13, p. 22 § 11)*

As can be seen on the map outlining the Hazard Zones on page 33, especially if the reader has sharp eyes and/or a magnifying glass, the two schools that RR-13 mentions are inside Zone 2 (schools are marked by tiny red rectangles with tiny red flags), but several more schools in the Hazard Zones are unmentioned and uncounted. The Coos Bay School district's schools in Hazard Zone 2, Madison elementary and Sunset middle school, are about ⅔ mile from a potential LNG fire in the bay. But the North Bend School District has two more schools, the High school and Middle school, 2 miles from the terminal site, hence inside Hazard Zone 3. There's also the community college, whose numerous buildings, individually marked by red flags, are inside Zone 3.

Despite its errors, misstatements and evasions – which of these apply depends on the

[27]) In order to ignite with the oxygen in the air, natural gas needs to make up between 5 and 15% of the surrounding air. Once its concentration falls below that 5% it is expected to dissipate without burning.

reader's credulity – I should credit RR-13 for noticing that "There are no bunkers in the area to handle local residents." *(previous page, and RR-13 p. 22 § 11).* That one caught my eye because I grew up with 'bunkers' in my hometown. To prepare for an allied invasion that ended up happening elsewhere, the Germans had built them all over the place, and because they were built very stout, many survived for a long time after the war, even though by then the public was often using them for disreputable purposes. The ones that the Germans had built to serve as temporary shelters had concrete walls about a foot thick, but others had much thicker walls and ceilings, offering greater protection.

Those with thicker walls and ceilings were provided with elemental comforts for those living or working inside. I am not aware of plans for building either type of bunker inside the Zones, but given the acknowledged potential lethality of living in Zones 2 and 3, it would seem prudent to require building one bunker in every residential block in both Zones 2 and 3 – because the window of opportunity may close in seconds.

The bunkers wouldn't have to be eyesores; we could follow the Germans' example and paint doors and windows and bricks on them, or siding to harmonize with local styles, and by putting on fake roofs. The remains of such a roof is visible on the bunker on the previous page. That one, built to shelter injured German soldiers, had concrete walls 2 meters thick, or more than 6 feet, and survived intense allied shelling and bombing quite well, except for its imitation roof. The ambulance, identified by the photo's source as a Mercedes 170V, didn't hold up nearly as well either.

LETTERS TO THE EDITOR

Accidents will happen at Jordan Cove

Regarding Jordan Cove, please remember one thing.

When they built Three Mile Island and Bhopal★ India, they said the same thing:

"Don't worry, it will be perfectly safe."

Accidents happen ... one will happen at Jordan Cove ... and Coos County residents will die.

Joe Gleich
North Bend

The World (Coos Bay), November 12, 2018.

★*It's usually spelled "Bhopal"; the reference is to a Union Carbide plant that exploded in 1984, spreading poisonous gas over a large, inhabited area in India. The death toll was close to 4,000, although thousands more are said to have died within 2 weeks. The number of injured was over half a million, of whom several thousands were permanently disabled.*

Once suitable bunkers have been constructed, it will be necessary to have a system to open them instantly and activate their generators, air conditioning, water systems etc., the very second an LNG mishap occurs. This will inevitably call for a permanent organization of fire bunker wardens, who will need to subject the population to frequent drills. On the positive side, between construction of the bunkers and their staffing, the area could see an increase in employment, paid for, I would hope, by Jordan Cove.

So far, while dwelling on the possible effects of an LNG fire in the bay, I have not mentioned possible causes. They include human error, deliberate sabotage, ship collisions and groundings, but the most likely ones seem to be a ship damaged during the expected tsunami, or by a terrorist attack. The previous chapter dwelt at some length on RR-13's and Jordan Cove's misrepresentations and obfuscations about the tsunami

danger, but not the terrorism risk. In part this is because a considerable volume of material has been removed from RR-13 and other documents for security reasons, which I assume was done with the terrorism issue in mind; but by the same token that keeps us, the potential victims, from judging those measures' effectiveness.

The widely used Hightower/Sandia Report made some assumptions about terrorist attacks:

1.2.3. Intentional Breach Scenario Conclusions.

1. Several credible, intentional LNG cargo tank damage scenarios were identified that could initiate a breach of between 2 m² to approximately 12 m², with a probable nominal size of 5 – 7 m².

2. Most of the intentional damage scenarios identified produce an ignition source and an LNG fire is very likely to occur. [28])

The picture above shows the USS Cole after the terrorist attack in 2000, which occurred in the port of Aden, Yemen, while it was being refueled. Two suicide bombers in a fiberglass boat blew a hole about 40 x 60 feet into the vessel. 40 x 60 feet makes a hole of 240 square feet, which equals 22.3 square meters, or m². Perhaps the Hightower group, with its maximum size hole of 12 m², did considered the possibility of a USS Cole-style attack, but assumed that the hole in the ship's LNG tank would be smaller than the 24 m² hole in the hull. That report was published in 2004, four years after Cole.

The substantial volume of materials removed from RR-13 does suggest that some authorities take the terrorism risk seriously, which is why I cannot appreciate the insouciant way that RR-13 dismisses and denigrates it. For example, on pages 228/229, it lists as possible causes of LNG spills collisions, groundings, allisions and 'releases during transfer operations'. But not a word about the twin elephants in the room, the earthquake/tsunami risk and terrorism, or of a third one also unmentioned: sabotage by insiders. Elsewhere, however, RR-13 grudgingly admits:

3.32. Navigation Route Security Concerns
The security assessment conducted in association with this Waterway Suitability Assessment demonstrates the lower security risk. Typically, terrorists would be

[28]) Hightower, Mike, and 11 other researchers: "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) spill over Water", *Sandia Report SAND 2004-6258*, produced for the US Department of Energy, p. 21; see also page 17.

> targeting high population areas or targets that would create disastrous consequences. Given the very low population density and the remote nature of the proposed terminal, both may be possible but are not probable. *(RR-13 p. 142)*

Not being privy to the complete security assessment, I am unable to criticize it. But what has been reported about security measures shows that the U.S. Coast Guard does accept the possibility of terrorist attacks in Coos Bay.

Continuing its practice of disdain, RR-13's page 234 lists the variables that influence the size of a breach in a cargo tank. Again it leaves terrorism off its list, even though it is the method expected to cause the largest breaches. Also it states, on page 235:

4.3.4. Breach Consequence Measures - Cascading:

> The Sandia Report concludes that cascading damage (multiple cargo tank failures) due to brittle fracture from exposure to cryogenic liquid or fireinduced *[sic]* damage to foam insulation was considered. Such releases were evaluated and, while possible under certain conditions, are not likely to involve more than two or three cargo tanks for any single incident.
>
> (*Sandia Report, Page 78)*

Given the high probability that the pool fire's extreme heat will melt the insulation around all the LNG carrier's tanks, it is hard to understand why not all of them would end up bursting. Jerry Havens and his colleague James Venart have observed:

> ... Sandia National Laboratory ... research (thus far) concludes that the radiant heat fluxes from large LNG fires on water, which burn without much smoke, can exceed 300 kW/m^2, and that there are potential failure modes regarding LNG carriers that could lead to a ship being at risk of sinking.[29])

Havens himself is one of the scientists who have objected to Sandia's '3-tanks maximum' guesstimate:

> ... the Sandia report states that cascading events, ... cannot be ruled out. Foamed plastic insulation, widely used on LNG carriers, would be highly susceptible to failure by melting or decomposition. It is a cardinal safety rule that the pressure limits on tanks carrying flammable or reactive materials should not be exceeded, as such excess portends catastrophic rupture of the containment. While the Sandia report concludes that such cascading events would be very unlikely to involve more than three of the five tanks on a typical LNG carrier, the report's optimism in this regard is unexplained. Once cascading failures begin, what would stop the process from resulting in the total loss of all LNG aboard the carrier? [30])

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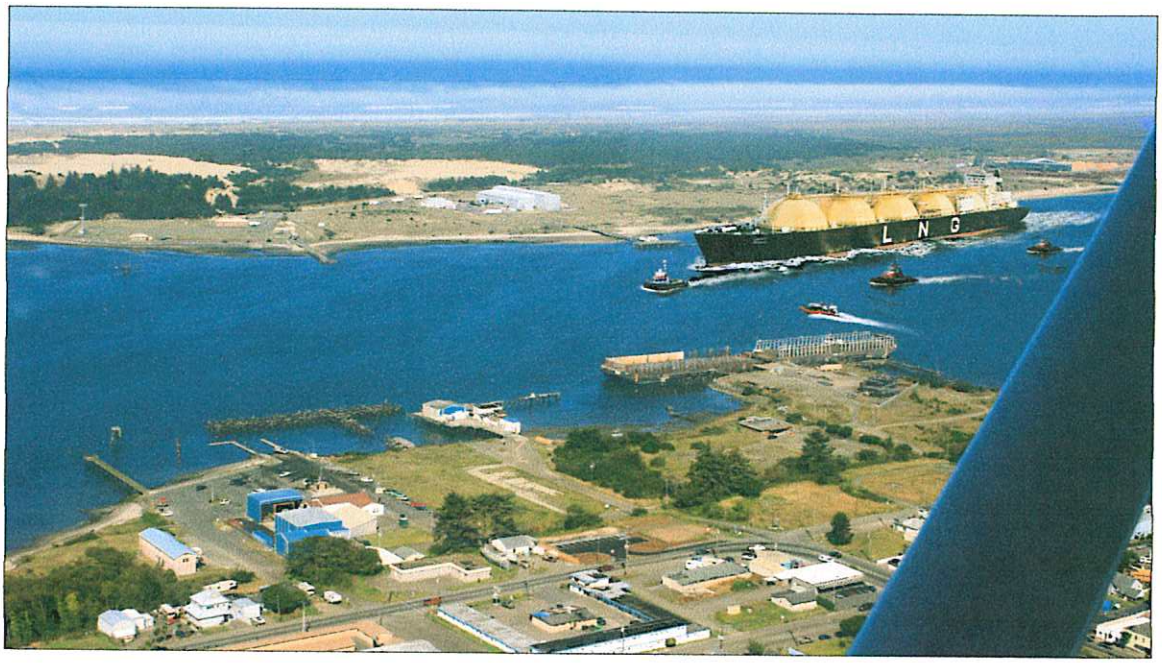
[29]) Jerry Havens and James Venart: *Regarding the Jordan Cove Export Terminal Draft Environmental Impact Statement, Docket No. CP13-483: UNITED STATES LNG TERMINAL SAFE-SITING POLICY IS FAULTY*. January 14, 2015, p. 27.

[30]) Jerry Havens: "LNG and Public Safety Issues - Summarizing current knowledge about potential worst-case consequences of LNG spills onto water." *Proceedings (US Coast Guard)* Fall 2005. In 2007 it was reported that other experts also disagreed with the 3-tank scenario. See "Public Safety



In January this year it was reported that the chief of Jordan Cove's new, company-owned sheriff's department echoed RR-13 in asserting that Coos Bay is "not an attractive target" for terrorists. He also said that he did not expect Coos Bay to be attacked by Somali pirates.[31]) With that I can agree, for geographical reasons; sailing 10,000 miles to Coos Bay in a 16-foot skiff sounds too onerous, even for determined pirates.

Regardless of the piratical menace, however, my answer to his assessment must be: **IT DEPENDS**. As Coos Bay is today, terrorists are unlikely to consider it; that is true. But they could change their minds if it were enhanced by a new attraction that they could exploit to cause a lot of collateral damage. But the name of that attraction must not be spoken, because the sheriff's employer, the Jordan Cove terminal, is already being sited in violation of all of the LNG industry's key safety rules, as detailed in chapters 1, 2 and more. And the violated SIGTTO recommendations could be very helpful to the terrorists.

On 9/11, box cutters were the only weapons used to kill 3,000 people, a casualty number not seen since. But it demonstrated the terrorists' method: use simple means to exploit big vulnerabilities, and inflict many unexpected deaths.

Looked at it this way, a terrorist strike could exceed 9/11's results. By Jordan Cove's own admission in its 2015 EIS, almost 17,000 living targets will be inside the 3 'Hazard Zones' surrounding its terminal and the long narrow channel through which its LNG tankers must sail. If terrorists cause LNG spills from the terminal or from a tanker, they can cause huge fires, 15 times hotter than any gasoline fire. If those kill only a quarter of the 17,000 people living in the Hazard Zones, deaths will exceed 9/11's.

Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification," GAO for Department of Energy, February 2007; GAO 07-316 Maritime Security, p. 8.

[31]) "The reality is, in Coos Bay, Oregon, we're not an attractive target", KCBY, January 2, 2009.

And here are six ways of doing it:

SCENARIO 1: Despite the denials of the new sheriff in town, an attack on the terminal, or more likely on a loaded LNG tanker, by a small boat loaded with explosives, is the main reason why the Coast Guard has mandated exclusion zones and armed escorts around the ships. Havens and Venart warn that a hole half the size of that blown into the USS Cole, but into one tank of an LNG carrier, could cause a fire so hot that the foamed insulation around all other tanks melts, so the LNG inside turns into gas much too fast. A chain-reaction of bursting tanks leads to the loss of the entire ship – not to mention the lives of the folks in the Hazard Zones.

While Scenario 1 seems possible, law enforcement's obsession with waterborne threats may cause the terrorists to favor others, thus preserving the element of surprise:

SCENARIO 2: While a loaded LNG tanker heads for the ocean, a small plane, pretending to be in distress but loaded with explosives, overshoots the airport runway and hits the ship. LNG pours out, causing a pool fire that kills thousands in the Hazard Zones, along with the crews on the still-moving ship, the Coast Guard's and the sheriff's boats.

At a recent public meeting I inquired if the LNG tankers' security escort would have any anti-aircraft missiles, and was told no. But time may not allow their use, anyway, since the airport is so close.

SCENARIO 3: Terrorists take over a home on a bluff, with a nice view of the bay. They attack the passing tanker with rocket-propelled grenades or similar ordnance.

SCENARIO 4: Before the loaded LNG tanker departs, frogmen have attached a couple of limpet mines, which can be remotely set off or set to blow when it reaches the bay's narrowest part, at Empire.

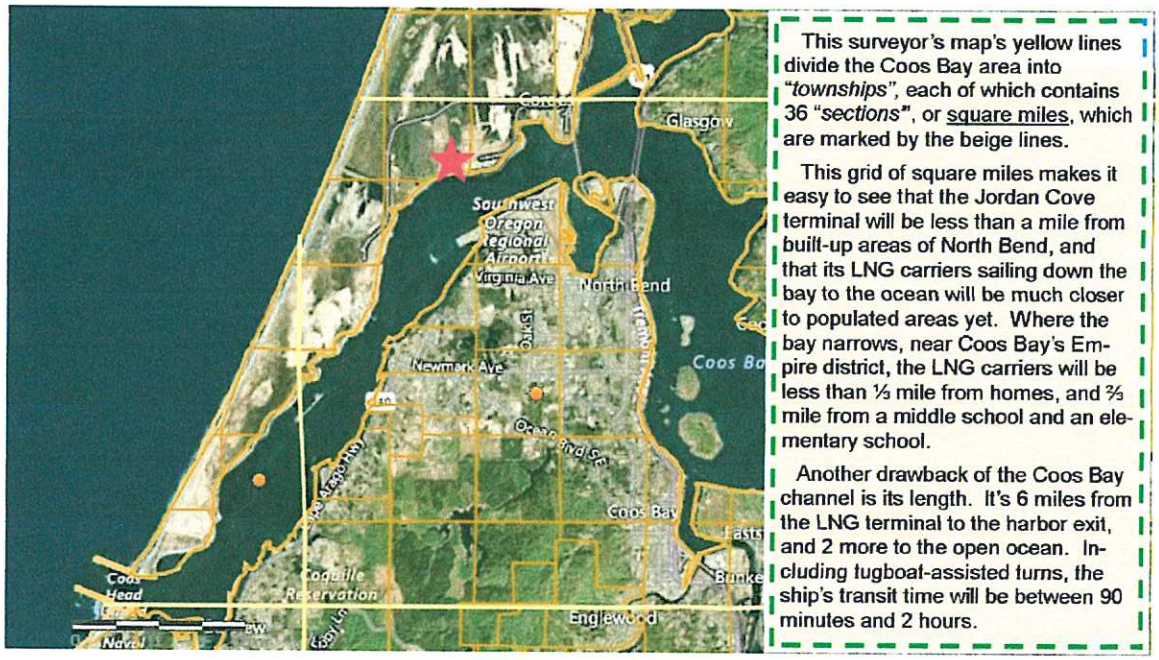
SCENARIO 5: Terrorists attack the terminal itself, using 50 cal hunting rifles with bullets of depleted uranium, whose extreme hardness enables them to easily go through a tank – a military tank. They could shoot holes into gas tanks and pipes, hoping that the fire will spread to other parts of the terminal. (Besides natural gas the terminal will store large quantities of other gases, all flammable or explosive or poisonous, in steel tanks.) Chapter 5, starting on page 43, explains how Jordan Cove's 'vapor barriers' may facilitate the destruction of the entire terminal.

SCENARIO 6: Drones remotely controlled from the dunes drop hydrochloric acid on the terminal's gas lines and gas storage. Hydrochloric acid eats through steel in no time. The gas pouring from the breaches could be ignited by rifle fire.

One objection to Scenario 6 could be that the airport, or the FAA, has installed some kind of electronic system to make drone flights impossible in the Coos Bay area. But drones can also be programmed to run themselves, using a video guidance system, which is what early cruise missiles used. First, a plane would fly over the target, capturing video of the route to be flown, and the target to be destroyed. The video images would then be loaded into the guidance system of the missile, which would compare the prerecorded video to the video signal from an on board camera. The flight control system would then cause the missile to fly the same path. This is a proven technology that doesn't need GPS.

Half a dozen possible scenarios is not bad, especially since some could also be used on the pipeline, and with fewer chances of discovery or interference.

And as pointed out earlier, the death toll of a terrorist attack in Coos Bay could exceed that of 9/11 – once Jordan Cove is here and operating.



This surveyor's map's yellow lines divide the Coos Bay area into "*townships*", each of which contains 36 "*sections*", or square miles, which are marked by the beige lines.

This grid of square miles makes it easy to see that the Jordan Cove terminal will be less than a mile from built-up areas of North Bend, and that its LNG carriers sailing down the bay to the ocean will be much closer to populated areas yet. Where the bay narrows, near Coos Bay's Empire district, the LNG carriers will be less than ⅛ mile from homes, and ⅔ mile from a middle school and an elementary school.

Another drawback of the Coos Bay channel is its length. It's 6 miles from the LNG terminal to the harbor exit, and 2 more to the open ocean. Including tugboat-assisted turns, the ship's transit time will be between 90 minutes and 2 hours.

CHAPTER 5: The Jordan Cove LNG terminal's siting and design increase chances of a major disaster in which the entire facility could be destroyed, along with any LNG carrier present. Prominent LNG fire scientists warn that the devices proposed to control vapor clouds at the Jordan Cove LNG terminal greatly increase chances of catastrophic fires and explosions.

Although parts of the proposed LNG terminal – especially the two big LNG storage tanks – have not changed much since the original import terminal was proposed, the production processes in the abandoned import terminal and the proposed export terminals, both the first and the second one, are very different, with serious consequences for public safety. This ought to mandate that the operations of the export plant be documented more accurately than is done in documents like the cited, reality-challenged RR-13.

The import terminal would have warmed LNG received by sea, in order to turn it back into gas to be fed into local pipelines, a fairly simple operation, usually performed by burning gas coming off the LNG. But contrary to RR-13's many persistent assertions, export terminals don't feed natural gas into pipelines; instead they receive gas from one, and turn it into a liquid that takes up only 1/600th of its volume: *Liquefied Natural Gas, or LNG*. To achieve that, export terminals need expensive, powerful 'liquefaction trains' to chill the gas to −265°F (−160°C). The liquefaction trains not only cool the gas to achieve this low temperature, but they also purify it by removing water, dirt, other gases and pollutants. LNG liquefaction/export terminals are more dangerous than import terminals because they store those gases, along with others used for the chilling process.

The final part of RR-13 consists of many pages of vapor cloud spill projections from hypothetical LNG and gas spills. These projections show 'vapor barriers' up to 100 feet high, to be built around the terminal's equipment and moorage slip. Those 'vapor barriers', actually tall concrete walls, were not part of the original design, but were added in response to concerns about gas clouds from spilled LNG drifting onto the adjacent Roseburg Chip terminal. Through these vapor barriers, whose height seem to have been reduced to 40 feet since, Jordan Cove tacitly admits that its property is neither large enough nor far enough from other industries and people, not to endanger them.

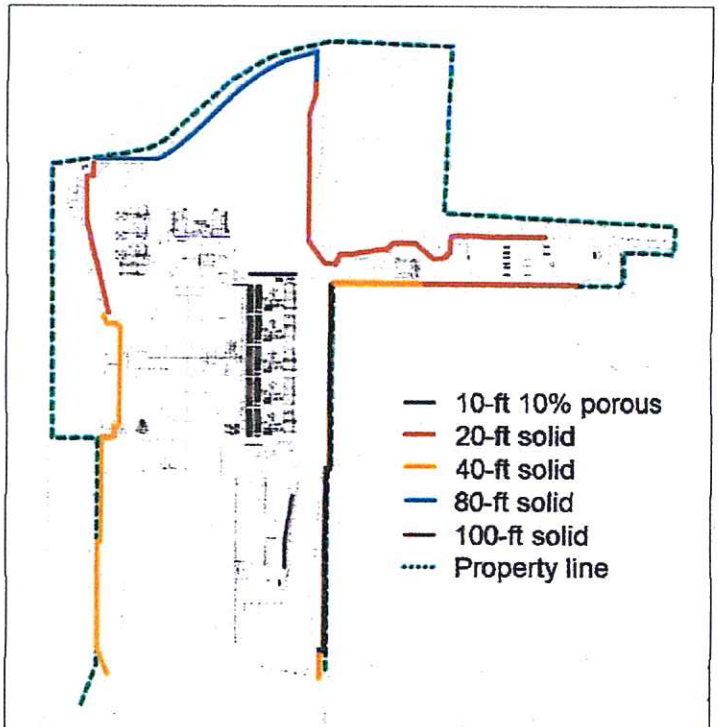


Figure 4. Proposed vapor dispersion mitigation measures.

In having vapor barriers, Jordan Cove may be unique among LNG

export terminals; I am not aware of any others that have them. Of course, your typical LNG terminals are far from towns, and they sit on large enough tracts of land not to need vapor barriers. After all, if gas from spilled LNG at such terminals is left free to rise into the air and dissipate, that is the best outcome. For one good example of a terminal without vapor barriers, see the photos of Cheniere LNG at Sabine Pass, on page 13. Jordan Cove's proposed vapor barriers follow its property boundaries fairly closely. Near the liquefaction trains and on both sides of the moorage slip they will be right on the property line, which is identified by green dotted lines wherever the vapor barriers don't overlap it. According to the graph, taken from page 11 of the 115-page GexCon report (= PDF page 698 in the 802-page RR-13), the concrete vapor barrier to the east of the slip and of the liquefaction trains will be 100 feet high, and the one on the western side of the slip 40 feet.[32]) However, other documents assert that these heights have been reduced; this may be yet another way in which RR-13 is outdated.

> "What all the wise men promised has not happened and what all the dammed fools said would happen has come to pass."
>
> Lord Melbourne, *British Prime Minister*

A 40-foot height for the vapor barriers is cited by Jerry Havens and James Venart, two LNG safety experts with global reputations who have done a lot of work for the U.S. Department of Energy and the U.S. Coast Guard. I believe that James Venart, formerly of the University of New Brunswick, has recently died, but Jerry Havens is still active, and has been Distinguished Professor of chemical engineering at the University of Arkansas since 1970. As director of that university's Chemical Hazards Research Center, he developed and verified mathematical models for the prediction of atmospheric dispersion of toxic or flammable gases. Those models are in the public sector so they can be freely used, and have been so used. Somewhat ominously, however, Jordan Cove, has used 'proprietary' mathematical models that are kept secret, so they cannot be verified.[33])

The Jordan Cove DEIS that Professors Havens and Venart refer to below was the Draft EIS published in 2014, for the export terminal turned down by the FERC in 2016, which is likely being recycled largely unchanged, as suggested by the also-recycled RR-13.

Havens and Venart assessed the Jordan Cove LNG export proposal as posing much greater hazards to the public, to itself, and to any moored LNG carriers, than the original LNG import proposal. They asserted that storage at the terminal of large quantities of more flammable, more explosive and heavier hydrocarbons than methane, confined by vapor barriers, could lead to an area-wide disaster. In January 2015 they wrote:

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[32]) The colors in the drawing are confusing. The 10-ft high, 10% porous walls are 2 short ones inside the terminal, one near the eastern bank of the slip and one at the end of the liquefaction trains. Those walls' color is difficult to tell from that of the 100-foot tall wall on the eastern side of the slip, sitting on the property line. As stated, however, the height of that particular concrete wall seems to have been changed from 100 to 40 feet. For this discussion the height differences may not make much difference.

[33]) Jerry Havens' models are the DEGADIS gas dispersion model and the FEM3A computational fluid dynamics (CFD) gas dispersion model, both of which are the only gas dispersion models currently approved for the determination of vapor cloud exclusion zones as required by the Code of Federal Regulations (49 CFR 193) and the National Fire Protection Association (NFPA) 59A which govern the siting of LNG import terminals in the United States.

> ... we believe ... the Draft Environmental Impact Statement (DEIS) for the Jordan Cove Export (JCE) Terminal Project ... fails to provide for protection of the public from credible fire and explosion hazards. The conversion of the Jordan Cove facility for export, including provision of gas treatment technology utilizing mixed hydrocarbon refrigerants for liquefaction and removal of heavy hydrocarbons from the natural gas feed to the plant, presents hazards to the project more serious (on a unit weight basis) than with LNG.

One big problem with 'heavy hydrocarbons' being kept at an LNG terminal is that unlike methane, the main component of natural gas, they are heavier than air, so if released they won't rise and disperse within 2.2 miles, as natural gas from spilled LNG is expected to do. Instead, especially if accidentally released in an enclosed space, they are likely to stay put and accumulate, creating a suffocation and fire hazard, along with chances of explosion:

> We believe these additional hazards have been discounted without sufficient scientific justification in spite of multiple international reports during the last decade of catastrophic accidents involving unconfined (hydrocarbon) vapor cloud explosions. It is clear that the increased hazards due to the presence of significant amounts of heavier-than-methane hydrocarbons ... have been seriously under-estimated in this DEIS. We believe the hazards attending the proposed operations at the Jordan Cove export facility could have the potential to rise, as a result of cascading events, to catastrophic levels that could cause the neartotal *[sic]* and possibly total loss of the facility, including any LNG ship berthed there. Such an event could present serious hazards to the public well beyond the facility boundaries. [34])

In addition to about 90 million gallons of LNG to be stored at the Jordan Cove terminal, Professors Havens and Venart listed smaller but still sizable volumes of other gases, from 14,000 gallons of ethylene to 31,000 gallons of Isopentane, along with similar volumes of Propane.[35]) These gases will be at the plant either because they are needed for the refrigeration & liquefaction process, or they are by-products of that process, which has separated them from the incoming natural gas, leaving mostly methane to be turned into LNG.

> "The history of the twentieth century was dominated by the struggle against totalitarian systems of state power. The twenty-first will no doubt be marked by a struggle to curtail excessive corporate power. The great challenge now facing countries throughout the world is how to find a proper balance between the efficiency and the amorality of the market."
>
> Eric Schlosser: *"Fast Food Nation"*

I mentioned that unlike methane, these other gases are heavier than air and poisonous; they are also flammable, and more likely to explode. Professors Havens and Venart *continued:*

> Instead of considering the findings of extensive LNG Safety research conducted at the direction of

[34]) Jerry Havens and James Venart, "UNITED STATES LNG TERMINAL SAFE-SITING POLICY IS FAULTY" - Jordan Cove Export Terminal Draft Environmental Impact Statement Docket No. CP13-483 January 14, 2015, page 1.

[35]) Havens & Venart, *op.cit.* January 14, 2015, p. 3.

> Congress during the last decade... of the worst case events that should be considered for this proposed terminal, the present JCE DEIS appears to largely ignore those findings ... [and it] focuses principally on arguments directed to meeting the "letter" of the federal regulations governing a single index of public safety – mathematical *[sic]* modeled exclusion zones (safe separation distances) intended to keep the public out of harm's way. [36])

These mathematically modeled exclusion zones are not the Hazard Zones calculated for LNG fires discussed in Chapter 4, starting on page 32. Instead they have been calculated for the Jordan Cove terminal by using computer models that are not publicly available, so that not even professors Havens and Venart can say if they are valid or not:

> "No, we don't cheat. And even if we did, I'd never tell you."
>
> Tommy Lasorda, *baseball player*

> ... this DEIS relies, for prediction of exclusion zone distances, on the use of mathematical models which have not been subjected to adequate ... validation ... either by comparison with experimental data or independent scientific peer review. Furthermore, the calculations of the exclusion distances for vapor dispersion and vapor-cloud-explosion hazards do not provide any evidence of applicability in near calm conditions coupled with reliance on impermeable (concrete) vapor fences designed to retard vapor cloud travel. Until ... (Jordan Cove produces) evidence of the accuracy and applicability-for-purpose of these modeling techniques, and that information is made available ... it must be considered (possible) that the ... hazards of storage, handling, and shipping of such massive quantities of energy ... have been seriously underestimated. [37])

> "Most people sell their souls, and live with a good conscience on the proceeds."
>
> *Logan Pearsall Smith*

The professors' point about 'applicability in near calm conditions' refers to the importance of wind speed at the time of any release, accidental or deliberate, of LNG, natural gas or other gases. Normally, the harder the wind blows, the faster the gas will disperse, so won't build up. But in near-calm conditions gas, especially heavier-than-air gas, is more likely to stay in place and amass; and this raises chances of people being suffocated or poisoned, and chances of explosions and hot fires occurring. Much will depend on location, type of gas and degree of confinement. In Coos Bay the wind factor is a big, big unknown; conditions vary a great deal with time of year and time of day, but the prevailing direction is from the west, towards the area's population centers.

Professors Venart and Havens reminded their readers of the very short history of the LNG business, which started with the very first LNG shipment in 1959, when a converted World War II Liberty ship, the 5,000 ton *Methane Pioneer*, made a delivery of LNG from the U.S. Gulf coast to Great Britain. Then in June 1964, the world's first purpose-built LNG carriers, the 'Methane Princess' and the 'Methane Progress', entered service, bringing LNG from an export/liquefaction plant in Algeria. The Methane Princess and

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[36]) Havens & Venart, *op.cit.* January 14, 2015, pp. 1/2.
[37]) Havens & Venart, *op.cit.* January 14, 2015, p. 2.

Progress could each carry 27,000 cubic meters (m^3) of LNG. Today, 55 years later, the largest LNG carriers can haul 266,000 m^3 of LNG. Given this impressive growth, Havens and Venart wrote that the regulations governing LNG were "overdue for careful review and assessment":

> "... LNG Storage and Handling Facilities have increased in size by an order of magnitude (factor 10). At the same time it appears that the regulatory guidelines have not been continually reviewed and updated ... (including those for) the ships that service them. Most importantly, the regulations that are being applied to [Jordan Cove] appear to give only cursory attention to the additional hazards [created] by the proposed expansion of the terminal for export service. [38])

The traditional view of methane, the main ingredient of natural gas, has been that it is less risky than the 'heavier hydrocarbons' of the petroleum industry. This is true, Havens and Venart said, but facts on the ground have changed. The first fact is that the volumes of LNG (and hence natural gas) being shipped and stored have grown so much that the potential of releases, accidental or deliberate, has grown much larger too. But:

> ... our more serious concerns relating to the JCE Terminal result from the combined storage and handling, in gaseous and liquid forms, of methane and heavier hydrocarbons including ethylene, propane, pentane, and amines in such large amounts. [39])

In addition to the risks increased by larger-scale operations, Havens and Venart claimed that regulations designed for LNG import facilities, like Jordan Cove's original proposal, had started being used for LNG liquefaction/export terminals while nobody was looking. Perhaps this should not be surprising because prior to February 2016, when Cheniere's Sabine Pass terminal in Louisiana shipped out its very first cargo of LNG, there were no functioning LNG liquefaction/export terminals anywhere in the lower United States. But the existing regulations, Havens and Venart insisted, are inadequate

> ... for regulating large-scale projects involving heavier-than-methane hydrocarbon chemicals and fuels in volumes ... that involve significantly greater hazard potential than do import-only LNG terminals. With the current concerns for terrorist activity, and in view of the recent international experience of

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[38]) Havens & Venart, *op.cit.* January 14, 2015, p. 2.
[39]) Havens & Venart, *op.cit.* January 14, 2015, p. 3.

> catastrophic accidental unconfined vapor cloud explosions of hydrocarbon fuels, it is time for a careful review.[40])

They related how through the years, aspiring builders of LNG terminals were allowed to use smaller and smaller 'design spills' of LNG for their safety calculations:

> In our opinion these developments can only be understood as resulting from pressures on the applicants to seek approval of smaller and smaller required exclusion distance determinations. But the requirements placed on the applicant to demonstrate the probability or lack thereof of the different kinds of releases ... are not sufficiently quantified – the process appears to be largely a "good-faith" decision reached jointly by the applicant and the DOT/FERC staffs. In our judgment this is not good science or engineering; it is indicative of regulation that facilitates facility approval – potentially at the expense of public safety. [41])

And with particular reference to Jordan Cove's plans, they warned:

> 5. The methods used to determine vapor-cloud exclusion zones, particularly the use of "mitigation" methods such as gas-impervious concrete fences to prevent advance of vapor clouds beyond the applicant's property lines, could increase the potential for serious, even catastrophic, vapor cloud explosions. The JCE Terminal DEIS appears to ignore international experiences of catastrophic unconfined vapor cloud explosions (UVCE), at least four of which occurred in the last decade, destroying the facilities involved as a result of cascading events. [42])

Of these UVCEs, the first occurred at Buncefield, England, in December 2005; damages were around $2 billion. Next came two more in 2009: Jaipur, India, and San Juan, Puerto Rico, the last shown in the photo above. Then came one in Amuay, Venezuela in 2012.

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[40]) Havens & Venart, *op.cit.* January 14, 2015, p. 3.
[41]) Havens & Venart, *op.cit.* January 14, 2015, p. 4.
[42]) Havens & Venart, *op.cit.* January 14, 2015, p. 5.

A layman like I might object that all those catastrophes involved petroleum products, mostly gasoline, not gas or LNG; so their relevance might be questioned. But Havens and Venart point out that every one of the four UVCEs was facilitated by a combination of conditions that could occur at Jordan Cove as well. Those conditions were (1) the rapid evaporation of spilled liquid fuel leading to the formation of a very large flammable vapor cloud; (2) near wind-still conditions, preventing dispersal and promoting concentration of the flammable vapor cloud; and (3) an ignition source:

> In all four cases these clouds were ignited (presumably accidentally) and the explosions resulted in cascading events leading to catastrophic damages to the facilities (refineries/tank-farms) and injury/and/or deaths in the public sector. The following facts are a matter of record for all four:
>
> - The events occurred in very low wind (near calm or calm) weather conditions.
> - The maximum linear extents of the flammable clouds were at least 250 meters, ranging to at least 650 meters at Amuay.
> - UVCEs occurred in every case that registered above 2.0 on the Richter Scale.
> - The initiating explosions resulted in cascading events leading to total loss of the facilities. [43])

"You're an old-timer if you can remember when setting the world on fire was a figure of speech."

Franklin P. Jones

Surrounding a potential source of flammable vapor clouds, i.e. the LNG dock, with tall concrete fences might initially protect Jordan Cove's neighbor, the Roseburg chip export terminal, but it would also keep the cloud from dispersing, increasing chances of an explosion.[44]) Besides warning that this could lead to much larger problems including a UVCE, Havens and Venart remind us of what could happen to a docked LNG carrier being loaded:

> 4. There are numerous potential hazards from fires and explosions that could result in cascading events involving ... LNG ships berthed at the facility. ... the worst-case hazard potential for the marine side of the proposed terminal should be considered before approval in view of the public concerns recently addressed in research required by Congress. [45])

We wonder what an LNG ship's Master would say if she were informed that a flammable cloud of hydrocarbons was about to surround her ship.[46])

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[43]) Havens & Venart, *op.cit.* January 14, 2015, p. 18.

[44]) It is widely agreed that LNG vapors are unlikely to explode unless they are "in a confined space," which they would be if surrounded by concrete walls. "Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification," GAO for Department of Energy, February 2007; GAO 07-316 Maritime Security, p. 7.

[45]) Havens & Venart, *op.cit.* January 14, 2015, p. 4.

[46]) Havens & Venart, *op.cit.* January 14, 2015, p. 14.