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Eastsound, WA 98245

November 18, 2013

Millennium Bulk Terminals-Longview EIS
c/o ICF International
710 Second Avenue, Suite 550
Seattle, WA 98104

Dear Co-Lead Agencies' Representatives for Cowlitz County, WA State Department of Ecology, and U.S. Army Corps of Engineers:

As a resident of Washington state, and more specifically the San Juan Islands, please accept the attached Environmental Impact Statement Scoping Comment on *The Risks of Aquatic Invasive Species* relevant to the Millennium Bulk Terminals Longview (MBTL) permit application, developed in consultation with Al Gillespie.

Based on the findings of significant and unmitagatable adverse impacts, I ask that you deny the permit for the proposed Millenium Bulk Terminals Longview (MBTL).

Sincerely,

Ms. Sophia M. Shoen

Environmental Impact Statement Scoping Comments for the proposed Millennium Bulk Terminals Longview:

The Risks of Aquatic Invasive Species

Sophia Shoen/Alexander Gillespie

November 5, 2013

1. The base problem and the need for a cumulative view

In 2012, around 1428 large (over 300 gross tons) vessels crossed the bar to traverse up the Lower Columbia River. Although this number of transits is currently below higher levels of transit at the turn of the century (2,283 per year),[1] if the proposed Millennium Bulk Terminal (MBT) project at Longview is approved the number of large vessels entering into the Lower Columbia River will increase by nearly a third. That is, when the facility is at capacity and shipping a 'nominal' 44 million metric tonnes of coal per year, 'approximately two vessels per day would be loaded'.[2]

Working on this estimate of two ship visits per day, and given their need to return back over the Columbia River Bar ("Bar"), this equates to 2 transits over the Bar, per day (remembering that the returns are not counted). Multiplied by the amount of days in the year, this could work out to, approximately, 700 additional large vessels entering the Lower Columbia River each year. This increase will be over and above other future expansion in other shipping operations. For example, the Morrow Pacific Project, that is hoping to expand to the export of 8 million metric tons annually, via two barge-tows per day down the Columbia River from the Port of Morro to the Port of St Helens, will also be transferring coal onto ocean-going Panamax vessels.[3] And a proposal by Tesoro and Savage seeks to bring as much as 380,000 barrels of crude per day by train from North Dakota's Bakken shale formation to be stored and later transferred to ships and barges for shipment from the Columbia River to U.S. refineries.[4]

Each of these vessels presents a risk of bringing in invasive aquatic species (AIS). To assess this risk it is necessary that the additional vessels, in addition to all of the existing related vessels involved in this area, be assessed for AIS. This type of evaluation only will reveal the true extent of the significant risk of AIS at hand. A cumulative assessment is essential as it will reveal risks that, while perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk to the Lower Columbia River.[5]

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[1] Washington State Department of Ecology, Spill Prevention, Preparedness and Response Programme. (2013). *Vessel Entries and Transits for Washington Waters: VEAT 2012*. (DoE, State of Washington). 1-5. Bradwood Landing (2006). Columbia River User Impact Discussion. (Bradwood). 5-8.

[2] 2010 Washington State, Joint Aquatic Resources Permit Application: Millennium Bulk Terminals Longview. 2012, February 2nd. Available from, < http://www.ecy.wa.gov/geographic/millennium/20120222_JARPAapplication.pdf> Section 6d.

[3] The Morrow figures are from AmbreEnergy (2013). *The Morrow Pacific Project: Powering America and the World.* (AmbreEnergy). 7.

[4] http://www.efsec.wa.gov/Tesoro-Savage.shtml

[5] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002).

2. The reasonably foreseeable risk of Aquatic Invasive Species

According to Presidential Executive Order 13112, an invasive species is, 'an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health'.[6] It is not a species which migrated naturally in accordance with usual background rates of migration. Plants, animals, and pathogens can all be invasive. Typical traits of an invasive species include it being able to survive in a variety of physical and biological situations, rapid reproduction, growth, and dispersal ability, and lacking natural predators or pests in the invaded ecosystem. Thus, invasive non-native species are successful competitors in new ecosystems, usually displacing native species and disrupting ecosystem processes.[7]

Collectively since the year 1600, species introductions are responsible for more extinctions than any other cause, claiming 39% of all extirpated species. In a contemporary global context, invasive species are responsible for 15% of all threatened plants and 10% of all threatened mammals. In the United States, about 42% of the species on the Threatened or Endangered Species Lists are at risk primarily because of the 50,000 alien-invasive species that have already established themselves. Before the point of species extinction occurs, local ecosystems face a reduction of genetic diversity, loss of functions, processes, and habitat structure, and biotic homogenization.[8]

While all isolated and relatively stable ecosystems, such as islands and fresh-water systems, are at risk, coastal estuarine and marine ecosystems are among the most heavily invaded systems in the world.[9] This heavy invasion, often aided by habitats which are already stressed by other factors, has resulted in a considerable amount of attention being directed towards AIS.[10] These species (also known as Aquatic Nuisance Species) are defined in the

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6 Executive Order 13112 of February 3, 1999. Section 1. Note also, the definition of alien species, 'means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem'.

7 Bauer, J. (2012). 'Invasive Species: ''Back-seat Drivers'' of Ecosystem Change?'. *Biological Invasions* 14:1295–1304. With, K. (2002). 'The Landscape Ecology of Invasive Spread'. *Conservation Biology* 16:1192-1203.

8 IUCN (2012) *100 of the World's Worst Invasive Species* (Gland, IUCN); IUCN (2011) *A Global Species Assessment: The IUCN Red List of Threatened Species (*Gland, IUCN) xxii; Galil, R. (2007). 'Loss or Gain? Invasive Aliens and Biodiversity in the Mediterranean Sea'. *Marine Pollution Bulletin.* 55: 314–322; McNeely, J (2004) 'Strangers in Our Midst' *Environment (July/August) 15, 21–22;* Gurevitch, J.. (2004). 'Are Invasive Species a Major Cause of Extinctions?'. *Trends in Ecology & Evolution* 19:470-474.

9 Grosholz, E. (2002). 'Ecological and Evolutionary Consequences of Coastal Invasions'. *Trends in Ecology & Evolution* 17:22-27.

10 Crooks, A. (2011). 'Aquatic Pollution Increases the Relative Success of Invasive Species'. *Biological Invasions* 13:165–176. Occhipinti, A. (2011). 'Alien Species Along the Italian Coasts: An Overview'. *Biological Invasions* 13:215–237. Hulme, P. (2009). 'Trade, Transport and Trouble: Managing Invasive Species Pathways in an Era of Globalization'. *Journal of Applied Ecology* 46*:* 10–18. Westphal, M. (2008). 'The Link Between International Trade and the Global Distribution of Invasive Alien Species'. *Biological Invasions* 10:391-398. Garcia-Berthou, E. (2005). 'Introduction Pathways and Establishment Rates of Invasive Aquatic Species in Europe'. *Canadian Journal of Fisheries and Aquatic Sciences* 62(2): 453-463. Westphal, M. (2008). 'The Link Between International Trade and the Global Distribution of Invasive Alien Species'. *Biological Invasions* 10:391–398. Walther, G. (2009). 'Alien species in a warmer world: risks and opportunities'. *Trends in Ecology and Evolution* 24(12): 684-690. EPA (2008). *Effects of Climate Change on Aquatic Invasive Species and Implications for Management.* (EPA, Washington, EPA/600/R-08/014). Grevstad, F. (1999) 'Factors Influencing the Chance of Population Establishment: Implications For Release Strategies in Biocontrol'. *Ecological Applications*, 9: 1439–1447.

Aquatic Nuisance Prevention and Control Act as, 'non-indigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters'.[11] These species are, as the international community noted at the Rio+20 conference in Brazil in 2012, a 'significant threat …to marine ecosystems and resources'.[12] This position was agreed following a series of reports which have shown the magnitude of this problem. For example, the first global assessment of AIS, in 2008, found that 84% of the world's coasts have been invaded. There are an estimated 500 alien marine species already within the coastal waters of the United States. These problems are replicated at the local leveland are causing particular concern on the north-west coast in California, Washington State and Oregon.[13] In the case of the latter, the threat to already endangered species, such as some species of salmon, in already challenged habitats, such as the Lower Columbia River, is becoming paramount.[14]

The economic costs of such invasions are vast. Invading alien species in the United States cause major environmental damage and losses adding up to over $100 billion per year. Associated damages and costs of controlling AIS are estimated to be $9 billion annually, with the Zebra mussel alone, being responsible for over $1 billion in the decade leading up to the end of the 20th century.[15] In a state like Washington, the risks are particularly high. Washington is a top seafood supplier, producing about 12 million pounds of fresh finfish and 8 million pounds of oysters, and an estimated $77 million in sales of farmed bivalve shellfish each year. Comparable economic impacts have also been adduced for Oregon.[16]

(i). The Pathways of Aquatic Invasive Species

The two dominant sources for the introduction of AIS are ballast water and hull fouling. With regards to ballast water, an estimated 10,000 species including, amongst others, fish, zooplankton species and planktonic taxa, including copepod species, are transported in

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Grevstad, F. (1999) 'Experimental Invasions Using Biological Control introductions: the Influence of Release Size on the Chance of Population Establishment'. *Biological Invasions*, 1: 313–323.

[11] Section 4702. (1), of Aquatic Nuisance Prevention and Control Act, 16 USC, 4700.

[12] *Report of the United Nations Conference on Sustainable Development, Rio June 22nd, 2012*. A/CONF.216/16. Paragraph 164.

[13] IUCN (2012). *Marine Menace — An Overview of the Marine Invasive Species Issue* (IUCN, Gland). 7-8. Washington Invasive Species Council (2011). *Annual Report to the Legislature* (WISC, Olympia). Phillips, C. (2008). *Spartina Eradication Program 2007 Progress Report.* Washington State Department of Agriculture. Williams, S. (2007). 'Introduced Species in Seagrass Ecosystems: Status and Concerns'. *Journal of Experimental Marine Biology and Ecology* 350:89-110. Grevstad, F. (2003). 'Biological control of Spartina alterniflora in Willapa Bay'. *Biological Control* 27:32-42.

[14] Sanderson, B. (2009). 'Nonindigenous Species of the Pacific Northwest: An Overlooked Risk to Endangered Salmon ?' *Bioscience*. *59*(3): 245-256. Williams, S. (2008). 'The Invasive Species Challenge in Estuarine and Coastal Environments'. *Estuaries and Coasts*. 31(1); 3-20. Harvey, C. (2005). 'Community Context and the Influence of Non-Indigenous Species on Juvenille Salmon Survival'. *Biological Invasions*. 7(4): 651-663. Cambray, J. (2003). 'Impact on Indigenous Species Biodiversity Caused By the Globalisation of Alien Freshwater Fisheries'. *Hydrobiologia*. 500(1): 217-230.

[15] IUCN (2012). *Marine Menace — An Overview of the Marine Invasive Species Issue* (IUCN, Gland).

18. Pimentel, I. (2004). 'Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States'. *Ecological Economics* 52: 273– 288.

[16] Washington Invasive Species Council (2011). *Annual Report to the Legislature* (WISC, Olympia). 3. Oregon Invasive Species Council (2009). *The Economics of Invasive Species*. (OIS Council, Eugene). 2-4. Pimentel, I. (2004). 'Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States'. *Ecological Economics* 52: 273– 288.

roughly 4 billion gallons of the ballast water that is moved around the world each year.[17] Within this bracket, Washington receives an annual average of 7.5 x 106 m3 of ballast water from both foreign (mostly trans-Pacific) and domestic waters. Foreign trans-Pacific vessels carried significantly fewer propagules ($p < 0.001$) compared to ships on domestic west coast routes. Of the propagules detected, trans-Pacific ships contained almost twice as many non-native species (19 species) than those from ships on west coast routes (10 species), with seven species being common to both. However, even though trans-Pacific vessels had higher diversity of non-native species, densities of non-natives were 100-200% greater in domestic ballast water.[18]

In addition to being transported in ballast water, AIS are also carried across the seas attached to the outside of the vessels. This is known as hull-fouling, vessel-fouling, or bio-fouling. Fouling is defined by the International Maritime Organization (IMO) as the, 'unwanted growth of biological material, such as barnacles and algae, on a surface immersed in water'.[19] Studies suggest that a vessel bottom which is exposed to the water without any treatment could attract up to 300 pounds of material on each square yard of the ship's hull over just a six-month period. This could add up to 6,000 tons of weight on a deep draft vessel.[20]

Hull fouling is also one of the foremost ways that aquatic invasive species transport themselves from one place to the next. Left unmanaged, a fouled vessel can pose a biosecurity risk through the detachment and dispersal of viable material and through spawning by adult taxa upon arrival in a recipient port or region. Even vessels that are meant to have been cleaned and treated, so as not to allow AIS to attach themselves, have proven problematic. For example, a 2007 study of five vessels going to Antarctica that had practised hull-fouling found they had nevertheless acted as transport vectors for at least 18 species, including a number known to be invasive and had managed to survive in the Antarctic conditions.[21] Examples such as these which will be repeated many times over show that hull-fouling creates a clear risk as a direct pathway for the introduction of invasive aquatic species. Moreover, the possibility that hull-fouling, as opposed to ballast water, is a greater source of AIS has become increasingly contended.[22] Research has shown that 70% of the 250 AIS in Australia and 74% of Hawaii's AIS have arrived via hull-fouling.[23] Similarly, it has been reported that 36% of AIS in the United States can be attributed to hull-fouling while

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[17] European Communities (2008) *The Economics of Ecosystems and Biodiversity* (Berlin, Welzel) 6; Anon (2008) 'Alien Stowaways' *New Scientist* (Feb 23) 4; Chivian, E (ed) (2008) *Sustaining Life: How Human Health Depends on Biodiversity* (Oxford, OUP) 49; Williams, R. (1988). Cargo Vessel Ballast Water as a Vector for the Transport of Non-Indigenous Marine Species'. *Estuarine, Coastal and Shelf Science.* 26: 409-420. Bax, N. (2003). 'Marine Invasive Alien Species: A Threat to Global Biodiversity'. *Marine Policy* 27: 313–323.

[18] Lawrence, D. (2010). Relative Contributions of Domestic and Foreign Sourced Ballast Water to Propagule Pressure in Puget Sound'. *Biological Conservation* 143: 700–709.

[19] See the International Convention on the Control of Harmful Anti-fouling Systems on Ships, article 2.

[20] See Rep Cummings Issues Statement on Control of Anti-Fouling Systems of Ships. Recorded in US Fed News Service, Including US State News 11 June 2009.

[21] SCAR (2007) 'Hull Fowling as a Source of Marine Invasion in the Antarctic' ATCM XXX (New Delhi, IP37); Anon (2008) 'Alien Stowaways' *New Scientist* (Feb 23) 4.

[22] Gollash, S. (2002). 'The Importance of Ship Hull Fouling as a Vector of Species Introductions into the North Sea'. *Biofouling* 18 (2), 105–121. Ferreora, C. (2006). 'Ship Hulls and Oil Platforms as Potential Vectors to Marine Species Introduction'. *Journal of Coastal Research.* 1340-1345.

[23] Godwin, S (2003). ' Hull Fouling of Maritime Vessels as a Pathway for Marine Species Invasions to the Hawaiian Islands'. *Biofouling*, 19 (1), 0892-7014.

ballast water represented only 20% of the total.[24] Similarly, within Puget Sound, evidence suggests that whilst ballast waters have contributed 25 taxa of invasive species, ship-fouling has contributed a greater amount at 35 taxa.[25] Likewise, research at Portland State University has shown that eight of the 81 established introduced species in the Lower Columbia River were possibly hull mediated invasions. This figure may be an underestimate, as surveys of some of the commercial vessels in this region suggest that even the best maintained vessels have between 5% and 20% of their hulls covered in biofouling, whilst the worst are up to 90% fouled.[26]

3. Indicators of significant risk

In order to be approved, the MBT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies, all of which address issues of potential significant risk. The broad obligations to control alien invasive species are solidly entrenched in multiple areas of international environmental law.[27] Specific international and national laws and standards that need to be reconciled are:

- The Aquatic Nuisance Prevention and Control Act
- The National Invasive Species Act
- The Presidential Executive Order 13112
- The Convention for the Control and Management of Ships' Ballast Water and Sediments
- The Washington Ballast Water Program
- The Oregon Ballast Water Program
- The Convention on the Control of Harmful Anti-fouling Systems on Ships.

4. The Gap in Confronting the Significant Risk of AIS

(i). Ballast Water

With regards to ballast water, the global process began in 1997 when the IMO implemented mid-ocean exchange regulations. Seven years later, in 2004, the IMO adopted the

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[24] Savarese, J. (2005). 'Preventing and Managing Hull-Fouling: International, Federal, and State Laws and Policies'. *Proceedings of the 14th Biennial Coastal Zone Conference (*New Orleans, Louisiana July 17 to 21*).* 1-10.

[25] Escapes from commercial activities, such as aquaculture, contribute the dominant source of 39 taxa. Simkanin, C. (2009). 'Intra-Coastal Ballast Water Flux and the Potential for Secondary Spread of Non-Native Species on the US West Coast'. *Marine Pollution Bulletin* 58:366-374.

[26] Chapman, J. (2013). 'Port-by-Port Accumulations and Dispersal of Hull Fouling Invertebrates Between the Mediterranean Sea, the Atlantic Ocean and the Pacific Ocean'. *Aquatic Invasions* 8(3): 249–260**.** For the University report, see http://www.clr.pdx.edu/abrpi/projects/mechanisms/fouling.php.

[27] See Gillespie, A. (2011). *Conservation, Biodiversity and International Law*. (Edgar, London). Chapter 7.

International Convention for the Control and Management of Ships' Ballast Water and Sediments.[28] The Parties to the Ballast Water Convention resolved to:

[P]revent, minimise and ultimately eliminate the risks to the environment, human health, property and resources arising from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.[29]

This goal was been achieved by a system of certification, inspection and verification of the uptake and deposit of ballast water from ships covered by the regime. The regime includes special requirements for certain areas, such as near sewage outfalls, where ballast water may not be collected. The Convention sets both a universal standard for ballast water management and establishes ballast water control areas to be designated where additional measures to control the possible entry of alien species are required.[30] Complementing these international efforts, after a slow start in coming to terms with the problem of AIS and ballast water, the United States is now consistent with international best practice in this area.[31] The most recent manifestation of this status is the new regulations promulgated by the Coast Guard in mid-2012.[32] While some questions remain over the general adequacy of the standards in this area, assuming compliance is achieved, the ballast controls around Washington State and Oregon are of good standing and are adequately managing the risk. However, a greater degree of coordination between the two of them, such as via a Columbia River Commission for Bioinvasions, could help them move to uniform regulations to accommodate their share management responsibilities on the Columbia River.[33]

(ii). Hull-Fouling

Most owners go to various lengths to prevent the build-up of aquatic species on their vessels, as they directly impact upon the efficiency of the vessel by increasing its drag/friction and thus demanding more use of fuel. Accordingly, most ships maintain prescribed schedules for hull husbandry, including the cleaning of the hull and application of antifouling paints, to reduce the colonization of underwater surfaces. It was this application of anti-fouling paints, and the highly effective tributyltin in particular, that brought the issue of hull-fouling attention to the international community. Unfortunately, tributyltin had not been fully studied before it was released into the marine environment and it has proven to be highly toxic to marine life, including crustaceans, mollusks, fish and even marine mammals. Due to such

28 BWM/CONF/36 (16 February 2004). Anon (2004) 'New Convention on Ballast Water: Preventing Alien Invaders' 34(3) *Environmental Policy and the Law* 120–130.

29 Ballast Water Convention, Preamble. Also, Art 2(1).

30 MEPC (2000) 'Report of the MEPC on its 45th Session' MEPC 45/20, 10; MEPC (2001) 'Report of the MEPC on its 46th Session' MEPC 46/23, 23–29; MEPC (2002) 'Report of the MEPC on its 47th Session' MEPC 47/20, 6–8.

31 Cangelosi, A. (2003). 'Blocking Invasive Aquatic Species'. *Issues in Science and Technology* 19(2): 69-75.

32 See the Federal Register /Vol. 77, No. 175 /Monday, September 10, 2012 /Rules and Regulations.

33 Butron, A. (2011). 'Potential Risk of Harmful Algae Transport by Ballast Waters: The Case of Bilbao Harbour'. *Marine Pollution Bulletin* 62: 747–757. Larsson, I. (2006). *Ballast Water Management on the Columbia River*. (Portland State University, Portland). 3-4. Cordell, J., et al (2009). 'Factors Influencing Densities of Non-Indigenous Species in the Ballast Water Of Ships Arriving at Ports in Puget Sound, Washington, United States'. Aquatic Conservation: *Marine And Freshwater Ecosystems* 19: 322–343. Smayda, T. (2007). 'Reflections on the Ballast Water Dispersal — Harmful Algal Bloom Paradigm'. *Harmful Algae* 6: 601–622.

problems, anti-foulant paints were directly regulated at the national level in the United States with the Organotin Anti-Fouling Paint Control Act of 1998 and then at the international level with the 2001 International Convention on the Control of Harmful Anti-Fouling Systems on Ships (which came into force in 2008). These laws, rules and policies have been supplemented at the local level with many States, including Washington, adding further restraints in this area.[34] One of the short term impacts of this ending of the persistent pollutant of tributyltin is that there has been a short-term increase in fouled hulls until the replacement anti-fouls have fully come on stream and reached similar levels of effectiveness as their very poisonous predecessor.[35] At the same time, a fundamental gap exists in both international and national law in the United States in that there are no specific rules requiring the adoption of particular measures to confront AIS from hull-fouling sources. The only guidelines that exist in this area, where the United States mirrors the IMO, is the recommended Guidelines on fouling maintenance and the required documentation of the anti-hull fouling maintenance for verification of the work undertaken.[36]

5. Mitigation

While the IMO Guidelines are a good first step, the leading work in this area is being carried out in Australia and New Zealand. The core of this work has been through detailed risk assessments that work on both the possible AIS and the vulnerable habitats. This risk analysis is then cross-referenced with those high risk vessels that are most likely to be the pathways for hull-fouling AIS. Once identified, the vessels are inspected and, if necessary, diverted.

With regards to the possible AIS and vulnerable habitats, the emphasis is upon identifying areas that are especially vulnerable to invasion and particularly aggressive species and their likelihood of arriving, which therefore merits greater attention.[37]

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[34] Washington Department of Ecology, 2010. Hull Cleaning and Boat Washing. http://www.ecy.wa.gov/programs/wq/nonpoint/CleanBoating/hull.html
Washington State Legislature, 2011. RecreationalWater Vessels Antifouling Paints. Substitute Senate Bill 5436. Chapter 248, Laws of 2011. http://apps.leg.wa.gov/ billinfo/summary.aspx?bill¼5436&year¼2011

[35] Piola, N. (2009). 'The Influence of Antifouling Practices on Marine Invasions'. *Biofouling* 25 (7): 633–644. Floerl, O. (2005). 'A Risk-Based Predictive Tool to Prevent Accidental Introductions of Nonindigenous Marine Species'. *Environmental Management* 35(6): 765–778.

[36] See the 2011 Guidelines for the Control and Management of Ships Biofouling for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species. Resolution MEPC. 207 (62), Annex 26. For the consistency in the United States with this, see 33 CFR 151.2050(g).

[37] Murray, C. (2012). 'Adapted for Invasion? Comparing Attachment, Drag and Dislodgment of Native and Nonindigenous Hull Fouling Species'. *Biological Invasions* 14:1651–1663. Gordon, D. (2011). 'Risk Assessment for Invasiveness Differs for Aquatic and Terrestrial Plant Species'. *Biological Invasions* 13:1829–1842. Pysek, P. (2010). 'Invasive Species, Environmental Change and Management, and Health'. *Annual Review of Environmental Resources* 35:25–55. Zaiko, A. (2007). 'Vulnerability of Benthic Habitats to the Aquatic Invasive Species'. *Biological Invasions* 9:703–714. Suedel, B. (2007). 'Application of Risk Assessment and Decision Analysis to Aquatic Nuisance Species'. *Integrated Environmental Assessment Management*. 3: 78-89. Keller, R. (2006). 'Risk Assessment for Invasive Species'. *Proceedings of the National Academy of Sciences*. 104(1): 203–207. Leung, B. (2002). 'An Ounce of Prevention or A Pound of Cure: Bioeconomic Risk Analysis of Invasive Species'. *Proceedings of Biological Science*. 269: 2407-13.

In relation to the possible pathways associated with hull-fouling AIS, the focus has been upon identifying (and controlling if suspicions are confirmed) particular vessels which are:

- 'Slow-movers' (vessels with a cruising speed of c. 5 knots, thus including barges and tugs when towing) as species can stick, and stay, for longer, although even faster commercial vessels can be subject to hull-fouling;[38] and/or plying non-traditional shipping routes, possibly linked with unique AIS;[39] and/or
- spending extended periods of time idle between voyages, potentially accumulating fouling biomass;[40]
- examination of the adequacy (especially in terms of covering all possible areas) and timing of the last coat of anti-fouling paint;[41] and/or
- which can be allowed to defouling in dry-docking so as to controlling wet-defouling whilst in sensitive places.[42]

8. Recommended research programs

Based on the assessment of the various risks posed by increased shipping from the proposed MBT and the consideration of potential mitigation options that are identified in this report, two research programs are recommended to assist in developing an understanding and evaluation of the impacts of the MBT. Such programs should enable a full and informed decision to be reached with regards to assessing the significant risk of AIS associated with the existing, proposed and reasonably foreseeable vessel traffic in the area.

Research program to support decision-makers

Create a cumulative risk assessment for AIS, related to hull-fouling and ballast water on all vessels transiting through the Columbia River, including barges and tugs, and especially those that are docking. This study should establish what the baseline is, how the proposed expansion will impact upon the baseline and what additional reasonably foreseeable growth in this area would look like in terms of increased volume and increased risk.

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38 Mineur, F. (2007). 'Hull Fouling on Commercial Ships as a Vector of Macroalgal Introduction'. *Marine Biology* 151:1299–1307.

39 Ministry of Agriculture and Fisheries (2010). *Vessel Biofouling as a Vector for the introduction of Non-Indigenous Marine Species to New Zealand: Slow-Moving Barges and Oil Platforms*. (MAF Biosecurity New Zealand Technical Paper No: 2010/12, Wellington).

40 Johnson, A. (2011). 'A Binational, Supply-Side Evaluation for Managing Water Quality and Invasive Fouling Species on California's Coastal Boats'. *Journal of Environmental Management* 92: 3071-3081. Murray, C (2011). 'Recreational Boating: a Large Unregulated Vector Transporting Marine Invasive Species'. *Diversity and Distributions*. 17: 1161–1172. Davidson, I. (2008). 'The Potential for Hull-Mediated Species Transfers by Obsolete Ships on Their Final Voyages'. *Diversity and Distributions*. 14: 518–529. Coutts, A. (2004) 'A Preliminary Investigation of Biosecurity Risks Associated with Biofouling on Merchant Vessels in New Zealand'. *New Zealand Journal of Marine and Freshwater Research* 38:215–229. Coutts, A. (2003) Ships' Seachests: an Overlooked Transfer Mechanism for Non-Indigenous Marine Species?'. *Marine Pollution Bulletin*, 46:1504–1515. Coutts, A. (2002). A Biosecurity Investigation of a Barge in the Marlborough Sounds. (Cawthron Report No. 744, NZ).

41 Minchin, D. (2003). 'Fouling and Ships' Hulls: How Changing Circumstances and Spawning Events may Result in the Spread of Exotic Species'. *Biofouling*, 19 (Supplement), 111–122.

42 Hopkins, (2008). 'Management Options for Vessel Hull Fouling: An Overview of Risks Posed by In-water Cleaning'. *International Council for the Exploration of the Sea*. 56: 712-720.

Research program to investigate mitigation options

The utility of adopting best international practices to prevent AIS related to hull-fouling and ballast water with particular regard to the utilization, in this particular area, of detailed risk assessments that both work on the possible AIS and the vulnerable habitats and then cross-referencing this risk analysis with the high risk vessels that are most likely to be the pathways for hull-fouling AIS within the Lower Columbia River.