CALIFORNIA STATE LANDS COMMISSION REPORT ON

COMMERCIAL VESSEL FOULING IN CALIFORNIA:

ANALYSIS, EVALUATION, AND RECOMMENDATIONS TO REDUCE NONINDIGENOUS SPECIES RELEASE FROM THE NON-BALLAST WATER VECTOR

Produced for the
California State Legislature

By

L. Takata, M. Falkner and S. Gilmore

California State Lands Commission
Marine Facilities Division
April 2006

EXECUTIVE SUMMARY

Fouling community organisms attach or associate with submerged portions of structures. When associated with mobile structures such as vessels, nonindigenous fouling organisms can be moved from port to port and region to region, presenting the potential for a new invasion. Fouling has thus been considered an important mechanism for the introduction of nonindigenous species (NIS) in the marine and estuarine environments.

The Marine Invasive Species Act of 2003 (Act) directs the California State Lands Commission (Commission) to analyze and evaluate the risk of nonindigenous species release from commercial vessel mechanisms other than ballast water (essentially vessel fouling), in consultation with a Technical Advisory Group (TAG). This report summarizes the analysis, evaluation, and consultations conducted by the Commission in accordance with the Act, and offers recommendations to reduce the discharge of NIS from vessel fouling.

Considerations of the Commission and the TAG included the hull husbandry practices of the commercial vessel fleet, environmental conditions and vessel behaviors that influence fouling, and the fouling management frameworks that have been adopted or considered by other regions. The most difficult challenge for evaluating the risk of fouling for species introductions to the state was the limited amount of baseline information on vessel fouling and NIS across the types of vessels that regularly operate in California. A small minority of vessels or platforms that travel at very slow speeds, spend extended periods immobile, and rarely clean or paint hulls could be presumed to pose an elevated NIS risk. However, there was little information on the potential posed by a majority of the fleet that conducts regular vessel maintenance, spends relatively little time in port, and travels at normal speeds. There was also little information on how well the current hull maintenance practices of the majority of the fleet limit the transport and release of NIS.

The Commission believes, however, that these difficulties should not prevent California from moving forward with actions at this time. Some actions can be implemented immediately based on available knowledge, and others may be implemented to build the information and tools to refine management in the future. The Commission therefore recommends that legislation be adopted to:

1. ***Broaden the State program to include the control and prevention of NIS via commercial vessel fouling.*** Current legislation authorizes the Commission to adopt regulations to prevent NIS introduction only through ballast water. The authorization should be expanded to include vessel fouling.

2. ***Broaden the reporting requirements to include mandatory reporting on maintenance practices and other anti-fouling related behaviors of qualifying vessels operating in California waters.*** Information on those factors that tend to exacerbate fouling, coupled with biological surveys of fouling on those vessels, will supply data needed to better characterize the fouling NIS risk for California.

3. ***Expand enforcement components of the Act to address mandatory reporting in Recommendation 2.*** In order for the information collected in Recommendation 2 to yield meaningful results, a high proportion of reports must be submitted. Programs with unenforced reporting requirements experience low reporting rates, making any representative analysis impossible.

4. ***Authorize the Commission to develop and adopt regulations that prevent or minimize the introduction of NIS via vessel fouling.*** Regulations to define regular vessel maintenance practices for the control of NIS fouling on commercial vessels, and requirements or restrictions for vessels that do not adhere to defined practices are needed.

5. ***Expand and coordinate biological research directed towards characterizing the NIS risk posed by commercial vessel fouling with other Federal and State agencies.*** Baseline information on fouling and NIS that arrive on

commercial vessels will be critical for the formulation of future management actions.

6. ***Support continued long-term NIS monitoring in California waters.*** Long-term biological monitoring is necessary to evaluate the effectiveness of management efforts to prevent NIS introductions; particularly as new management actions are implemented.

7. ***Support research promoting technology development.*** A technology that can collect and contain in-water cleaning debris would be a desirable tool to prevent NIS release during in-water cleaning, while also providing commercial operators an avenue to clean hulls without placing a vessel in dry dock. Additionally, the advancement of antifouling coatings that are effective for preventing fouling accumulation and cause little or no water quality impact, will be critical for NIS prevention as regions implement bans on biocidal paints.

8. ***Direct the State and Regional Water Quality Control Boards, in cooperation with the U. S. Environmental Protection Agency, to evaluate the effects of biocidal antifouling coatings from vessels on water quality.*** As authorized by the Clean Water Act, the State and Regional Water Quality Control Boards should conduct a full review to determine if biocidal antifouling coatings contribute to water quality impairments or to the exceedance of water quality criteria in California. Water quality plans and/or Total Maximum Daily Loads should be adopted or amended accordingly.

9. ***Expand the existing Marine Invasive Species Program's outreach and education program to include the fouling vector.*** Nonindigenous species transport and introduction through vessel fouling is a relatively new issue, and there is little to no awareness of its importance amongst key stakeholder groups.

10. ***Direct an appropriate agency to address the risk of fouling NIS introduction and spread in California through vessels under 300 gross registered tons.*** Any vessel or structure of any size may accumulate fouling and may be important mechanisms for the transport of NIS. The release and transfer of NIS through vessel types not included in the Act, including recreational and fishing vessels, should be examined by the agency(ies) with the appropriate authority, and recommendations to reduce NIS introductions from these mechanisms should be provided to the Legislature.

ABBREVIATIONS AND TERMS

Act	Marine Invasive Species Act (Also Assembly Bill 433 of 2003)
ANZECC	Australian and New Zealand Environment Conservation Council
CA	California
CDFG	California Department of Fish and Game
CFR	Code of Federal Regulations
Commission	California State Lands Commission
IACS	International Association of Classification Societies
IMO	International Maritime Organization
KT	Knot
KTS	Knots
LCR	Lower Columbia River
m	Meters
MPH	Miles per hour
NIS	Nonindigenous species
PRC	Public Resource Code
Staff	Staff of the California State Lands Commission
TAG	Technical Advisory Group
TBT	Tributyltin
WSA	Wetted Surface Area

TABLE OF CONTENTS

I. PURPOSE

This report was prepared for the California Legislature pursuant to the Marine Invasive Species Act of 2003 (Act), codified as California Public Resources Code (PRC) Sections 71203-71210.5. The Act enhanced and reauthorized the original law, the Ballast Water Management and Control for Nonindigenous Species Act of 1999. In accordance with the Act, the California State Lands Commission (Commission) was charged with preparing an analysis of vectors (i.e., mechanism or pathway) other than ballast water, and relative risks of those vectors, for the introduction of nonindigenous species (NIS) from commercial vessels (Section 71210.5 of the PRC). Per the law, the analysis shall include the release of NIS from vessel hulls, sea chests (recessed boxes where water may be pumped aboard for engine cooling or for ballast), sea suction grids (grates that cover water intakes), other hull apertures, in-water propellers, chains, anchors, piping, and tanks, and shall be conducted in consultation with a Technical Advisory Group (TAG). This report summarizes the results of this analysis and offers recommendations to reduce the discharge of NIS from vessel vectors other than ballast water.

II. INTRODUCTION: NONINDIGENOUS SPECIES AND VESSEL FOULING

Also known as “introduced”, “invasive”, “exotic”, “alien”, or “aquatic nuisance species”, NIS in marine, estuarine and freshwater environments may be transported to new regions through numerous human activities. Intentional and unintentional releases of fish and shellfish, aquaculture escapes, releases from the aquarium and pet industries, floating marine debris, bait shipping, and accidental release by research institutions are some of the mechanisms, or “vectors”, by which organisms are transferred (U.S. Commission on Ocean Policy, 2004). However, in coastal environments, commercial shipping is the most important vector for the introduction of NIS (Ruiz et al., 2000; Hewitt et al., 2004) in one study accounting for one half to three-quarters of NIS introductions to North America (Fofonoff et al., 2003).

Once established, NIS can have severe ecological, economic and human health impacts to the receiving environment. Pimental et al. (2005) estimated approximately $120 billion worth of losses annually in the United States due to NIS. The most infamous NIS example is the zebra mussel (*Dreissena polymorpha*) introduced to the Great Lakes from the Black Sea. They attach to hard surfaces in dense populations that clog intakes of municipal water systems and electric generating plants, resulting in costs of approximately a billion dollars a year (Pimentel et al., 2005). The Asian clam (*Potamocorbula amurensi*s) spread throughout the San Francisco Bay and its tributaries two years after its introduction, and accounts for up to 95% of living biomass in some shallow portions of the bay floor (Nichols et al., 1990).

Attempts to eradicate NIS after they have become widely distributed are typically unsuccessful and costly (Carlton, 2001; McEnnulty et al., 2001; Meyerson and Reaser, 2002). Control is likewise extremely expensive. Prevention is therefore considered the most desirable way to address the issue. For managers, policy makers, and researchers dedicated to the prevention of marine and estuarine NIS introductions, ballast water has been the major focus during the last decade. However, vessel fouling, which is a less understood mechanism, has been gaining attention as another important vehicle for introductions.

Fouling organisms attach to submerged hard surfaces of both naturally occurring and man-made structures (Railkin, 2004). Fouling organisms such as mussels, seaweed, anemones, and sea squirts have been found on pier pilings, tide pool rocks, and oil platforms (Figure II.1). Barnacles, other seaweeds, and the plant-like limbs of bryozoans may be attached to mussel shells. Mobile organisms such as shrimp, worms, and sea snails may be tucked in nooks created by the larger animals. These associated mobile organisms are also part of this “fouling community”.

Figure II.1: Mussel and Algae Fouling on a Vessel Propeller.

Mariners have long been aware of fouling as a nuisance to vessel operations as it relates to vessel performance, fuel efficiency, and antifouling efficiencies. Fouling on the hull can create drag, increasing fuel consumption and potentially causing engine strain. In pipes, fouling can block inflowing seawater meant to cool machinery. To prevent such problems, vessel operators periodically clean underwater vessel parts, and utilize antifouling paints and antifouling systems.

Though much of the outer surface of vessel hulls are treated with paints designed to discourage fouling growth, certain locations have been found to be more prone to fouling: dry docking support strips, waterlines, propellers, rudders, sea chests, and worn or unpainted areas (Coutts et al., 2003; Minchin and Gollasch, 2003; Coutts and Taylor, 2004; Ruiz et al., 2005) (See Section V, "Review of Current Knowledge on Vessel Fouling and Nonindigenous Species").

Despite efforts by the maritime industry to minimize vessel fouling, recent studies indicate that fouling is still an important mechanism by which nonindigenous organisms can be transported to new regions. Vessels that move at slow speeds, spend long periods in port, or are repainted infrequently, tend to accumulate more fouling (e.g. Coutts, 1999). Unlike the laminar areas of the hull that experience strong water motion, sheltered recesses of vessels appear to be more hospitable for fouling organisms.

Thus, studies have documented extensive fouling communities on towed vessels, in sea chests, and on recreational vessels. In Hawaii, fouling is believed to be responsible for more successful marine introductions than any other mechanism (Eldredge and Carlton, 2002). For North America, one study estimated that at least 36% invertebrates and algae introduced through the shipping vector arrived via fouling (Fofonoff et al., 2003).

In addition, the nature of fouling observed on vessels may change as restrictions on biocidal antifouling paints are adopted. Biocidal antifouling coatings deter the attachment of fouling organisms by leaching toxic compounds, such as those that contain tributyltin (TBT), copper, and zinc. Because these compounds are also detrimental to non-target organisms, many regions have adopted or are considering restrictions on their use. Tributyltin (TBT) is a highly effective antifouling agent that has been restricted by many nations in line with the 2001 International Maritime Organization (IMO) Convention on the Control of Antifouling Systems on Ships. Most non-TBT coatings available utilize copper compounds as biocides, though they are generally less effective and their longevity is shorter than TBT (Lewis, 2002). In addition, bans and restrictions on copper-based paints are being considered in a number of places, including the San Diego region. Biocide-free silicon-based coatings are available, but are more costly to apply and are currently only practically effective for active, swift vessels (those that cruise over 15 knots [KTS]) (Lewis, 2002; International Marine Coatings, 2006). As new coatings are developed and vessels shift to different antifouling coatings with potentially lower efficacies, there are concerns that the risk posed by fouling as a transport mechanism for NIS may increase (Nerhing, 2001).

Since 2000, the Commission has administered California's ballast water management program. In 2003, the Act expanded these responsibilities, directing the agency to formulate recommendations to prevent introductions through non-ballast, commercial vessel vectors – essentially vessel fouling. As required by the legislation (PRC Section 71210.5), Commission Staff (Staff) assembled a Technical Advisory Group (TAG) composed of representatives from state and federal resource agencies, the commercial shipping industry, and the scientific research community.

III. TECHNICAL ADVISORY GROUP PROCESS

The Act (PRC Section 71210.5) requires Staff to consult with a TAG to prepare an analysis of non-ballast commercial vessel vectors for NIS introductions. Staff convened and facilitated a multidisciplinary TAG made up of representatives from the shipping industry (Chevron Shipping Company LLC, Pacific Merchant Shipping Association, Matson Navigation), academia (Portland State University, University of California at Davis), research institutes (Cawthron Institute, Smithsonian Environmental Research Center, San Francisco Estuary Project), government agencies (California State Water Resources Control Board, U.S. Fish and Wildlife Service), and other interested parties (See Appendix B for a list of Commission TAG participants). Input was received during facilitated meetings that began with a collaborative workshop, followed by three TAG meetings. Discussions and areas of agreement were then considered by Staff to help guide recommendations put forward in this report.

Discussions began in May 2005 with a cross interest one-day workshop co-sponsored and conducted by the Staff and the California Sea Grant Extension Program. The workshop objective was to share information and evaluate hull borne transport of invasive species for both the commercial maritime industry and recreational boating community. Attendees included scientists, and representatives from California ports and harbors, state and federal Agencies, environmental organizations, universities, hull coating companies, the commercial maritime industry, and the recreational boating community (See Appendix A for a list of workshop participants).

The workshop began with informational presentations from several experts on fouling issues to inform attendees prior to their participation in afternoon break-out discussions. Speakers included vessel coating and maintenance professionals, a legal expert from the Sea Grant Law Center, and scientific experts from Hawaii, New Zealand, and the Smithsonian Environmental Research Center (See Appendix C for a workshop summary). Topics presented included:

- Overviews of hull borne aquatic invasive species in North America, Hawaii and New Zealand
- Management strategies that have been adopted or considered for fouling NIS in New Zealand and Hawaii
- Information on how various antifouling coatings prevent fouling growth, and the water quality problems presented by some coatings
- Hull husbandry practices of commercial vessels
- International, federal and state policies related to vessel fouling and antifouling coatings

Speakers participated in a panel-style question and answer session following the formal presentations. During the afternoon session, attendees were placed into break-out groups and asked to provide input on potential management considerations. These group sessions identified data gaps and outreach needs related to vessel fouling and NIS.

Three additional TAG meetings were convened by Staff between August and December of 2005, which focused on commercial vessel fouling. These meetings included representatives from the shipping industry, scientists, government agencies, and other interested parties (See Appendix B for a list of Commission TAG participants).

The objective of the August TAG meeting was to continue information sharing begun during the May workshop, but focused exclusively on commercial vessels. TAG members discussed the definition of "Non-ballast vessel-based vectors," as stated in the Act. Further discussions addressed how environmental characteristics, and vessel behaviors and maintenance practices may influence vessel fouling (See Appendix D for summary of August TAG meeting).

The October and December TAG meetings focused on the development of potential management frameworks to prevent NIS introductions via vessel fouling. During the October meeting, the TAG reviewed fouling management frameworks of other regions including codes of practice, regulations, informational surveys, and risk assessment techniques, and began to discuss their potential for application in California. The TAG additionally began discussing and prioritizing information and research needs (See Appendices E and F for meeting summaries).

At the final meeting in December, the TAG considered the pros and cons of hypothetical management options that ranged from industry education and outreach to potential regulations. This final meeting culminated in an informal list of areas where more information would be beneficial for the development of future management actions (See Figure III.1).

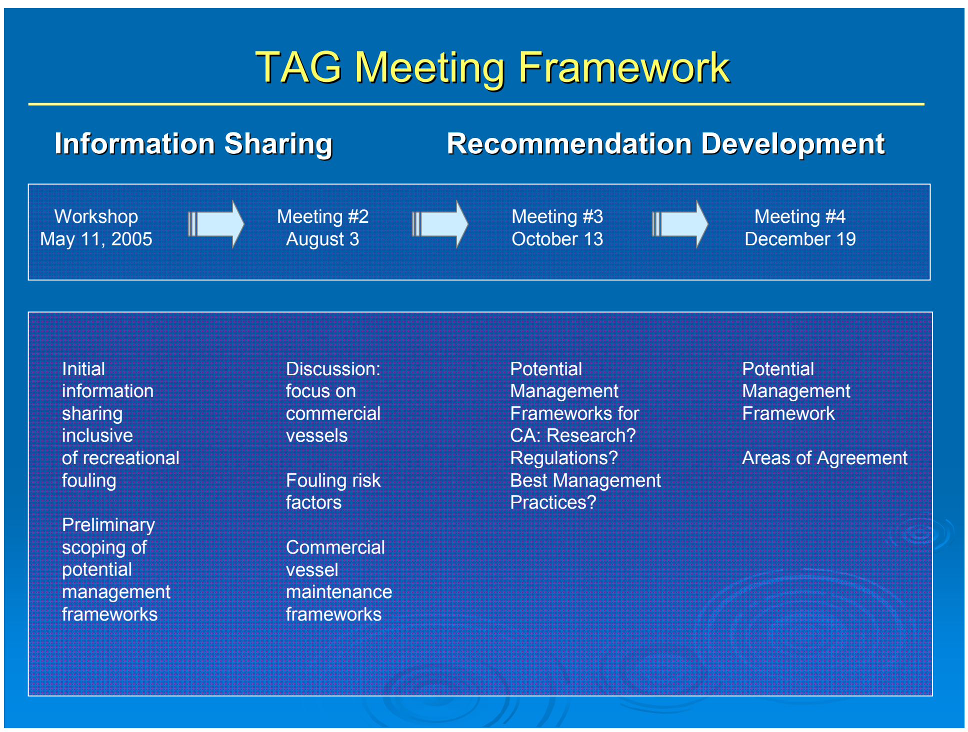

Figure III.1: Overview of major discussion areas and timing during Vessel Fouling Technical Advisory Group meetings.

Staff compiled and organized meeting notes to assist in the analysis of non-ballast commercial vessel vectors (See Appendices C-F for meeting summaries). The following list summarizes the major points that emerged during TAG discussions, and that framed the development of priority information gaps and action items. (These items are listed in the next portion of this section):

- Vessel fouling poses an NIS risk that needs to be addressed.
- Much of the merchant fleet is well maintained, and likely poses lower risk.
- There is generalized knowledge on factors that facilitate fouling accumulation on vessels.
- The extent of fouling risk in North America is unclear. There has been limited modern research conducted primarily in other regions, and it may be difficult to apply this data directly to California.
- Dry dock facilities are in high demand and booked well in advance. There is little flexibility for unplanned dry docking events for the purposes of out-of-water hull cleaning.
- Biocidal antifouling paints pose water quality concerns.

As a result of the considerations listed above, several items were identified during the TAG process that members believed deserved priority attention. These are listed below and discussed further in focused sections of this report:

- Compile additional data and research to develop a comprehensive and effective framework to prevent NIS introductions via vessel fouling in California. Specific data and research needs identified by the TAG were:
    - How the periodicity and type of commercial vessel maintenance relates to the accumulation and composition of fouling communities (e.g. dry dock vs. in-water cleaning frequency, type of antifouling paint).
    - The quantity of fouling and characterization of species found on vessels that call to California.
    - Specific conditions that constitute a high risk vessel (e.g. vessel speed, husbandry, route, sedentary time, etc…).
- Develop protocols that may be used to flag a high risk vessel arrival to California.

- Develop response measures to prevent NIS release.
- Develop technologies that contain and collect fouling effluent during in-water cleaning.
- Develop standardized data collection protocols and procedures for diver or ROV surveys.
- Increase outreach and education regarding vessel fouling as a vector for NIS introductions.

Areas of agreement from the collaborative workshop and TAG meetings provided valuable multi-disciplinary input to Staff during its evaluation of vessel fouling. TAG discussions confirmed that many questions remain regarding vessel fouling as an NIS vector, although discussions did offer some guidance for where future efforts should be focused. The information and suggestions provided by the TAG were considered and incorporated into this report by Staff.

IV. MERCHANT FLEET EFFORTS TO KEEP VESSELS CLEAN

Vessels travel faster through water when their hulls are clean and smooth, free from fouling organisms such as barnacles, algae, or mollusks. Fouling control is important to protect the hull from corrosion, reduce drag, and save fuel. Vessel owners and operators have long understood these relationships, utilizing various mechanisms to prevent or reduce fouling, including regular dry docking where hulls are mechanically cleaned and antifouling compounds are applied, and periodic in-water hull cleaning.

Antifouling compounds such as lime, arsenic, mercury, and pesticides (e.g. DDT) were used to coat vessel hulls prior to the 1960’s (IMO, 2002). Unfortunately, frequent reapplication of these compounds was necessary, increasing operating costs, and arsenic and DDT have since been shown to have significant negative impacts on the environment. In the 1960’s, the chemical industry developed biologically effective and cost-efficient organotin-based antifouling paints (e.g. tributyltin), that were believed to be less harmful than the biocides used at the time. These antifouling paints were designed to slowly release biocide, allowing vessels to go for as long as five years before reapplication.

By the mid-1970's, most oceangoing vessels had tributyltin (TBT)-based antifouling paints applied to their hulls. Tributyltin was found to be highly effective at keeping the hull smooth and clean, however, subsequent studies have shown TBT to have significant environmental impacts. Tributyltin and other organotin compounds leach into the water, persist in waters and sediments, and contaminate a range of non-target aquatic organisms. Tributyltin causes shell deformation in sea oysters, reduces resistance to infection in fish, is absorbed throughout the food chain, and has been found to be highly toxic to humans. As a result, several countries imposed rules to limit the use of TBT in antifouling paints. In 1999, the IMO adopted Resolution A.895 (21) "Antifouling Systems Used on Ships". The Resolution prohibited the application of organotin compounds on ships after January 2003 with a complete prohibition by January 2008. With the impending TBT-ban, paint manufactures have been developing TBT-free antifouling and fouling-release (non-biocidal) coatings. Many vessels currently utilize coatings with copper or zinc as the active biocide in place of TBT. Some use slippery silicon-based coatings which contain no biocides but make it difficult for organisms to adhere, or remain attached to the vessel.

The application of antifouling compounds is generally conducted in conjunction with regularly scheduled hull maintenance operations required by classification societies, though hull coating and cleaning is not explicitly required. Classification societies, such as American Bureau of Shipping, Det Norske Veritas, and Lloyd's Register, are organizations that establish and apply technical standards related to the design, construction, and survey of vessels. The majority of vessels are built and surveyed based on classification society standards, which are published as rules. Ninety four percent of all commercial vessels operating in international trade belong to one of several societies that are part of the International Association of Classification Societies (IACS) (IACS, 2004).

Vessels built in accordance with IACS rules are assigned a class designation and are subject to regular surveys to ensure that ships remain in compliance with those rules. Classification society rules include requirements for periodic hull surveys. While these rules are directed at ensuring safety and structural integrity rather than NIS prevention, they incidentally serve to control vessel fouling to a certain degree. The frequency that most vessels routinely clean hulls and reapply antifouling paints is associated with the hull maintenance rules of their classification. In general, each classed vessel is subject to a specified program of periodic surveys. These specific programs are based on a five-year cycle that consists of annual surveys (in-water), intermediate surveys (in-water or dry dock), and class renewal special surveys (dry dock) that take place every fifth year. As a vessel ages, the rigor of each survey increases. For example, older vessels generally require more frequent out-of-water surveys and some vessels operating in certain areas, such as Alaska’s Prince William Sound, are subject to more frequent inspections (see Appendix D). Additionally, an incident that may have compromised the integrity of the hull (e.g. collision, grounding or allision) generally requires an out of water dry dock survey.

Vessels generally dry dock only as frequently as needed or required because dry docking facilities are limited, making scheduling difficult and costly. While reapplication of antifouling compounds is normally not required by societies, vessel owners commonly take advantage of required dry dockings and elect to clean and reapply antifouling compounds at the same time. Because fouling continues to accumulate between required dry dockings and can reduce fuel efficiency, most companies also conduct interim in-water cleanings. These are conducted as needed, according to the results of frequent fuel consumption and speed performance tests (see Appendix E).

Most commercial vessel owners operating in California waters conduct regular hull maintenance for structural and economic reasons, not for NIS prevention. Therefore, while we may speculate that frequently dry docked and cleaned vessels pose “less” risk than those that are not maintained according to classification society rules, there is still a great deal of information needed on how much NIS prevention is achieved through adherence to these practices.

V. REVIEW OF CURRENT KNOWLEDGE ON VESSEL FOULING AND NIS

Staff and TAG members reviewed existing scientific information in order to evaluate the risk posed by commercial vessel fouling for NIS introductions in California, and to provide informed considerations for potential management recommendations. Information examined included peer reviewed and gray literature studies and discussions with scientists on the TAG with research expertise on NIS and commercial vessel fouling. Unfortunately, little research has been conducted on vessel fouling and its role as an NIS transport mechanism, particularly for North America. In the U.S., one limited study was conducted in the Port of Oakland, two are underway for the Pacific Coast, and a handful of studies have been completed in the Hawaiian Islands. The majority of research consists of smaller studies conducted on a combination of commercial and recreational vessels in Australia and New Zealand. In light of the limited amount of information, the TAG and the Commission examined generalized factors that affect fouling accumulation on vessels, the relative risk posed by vessels exhibiting those factors, and how factors may or may not apply to merchant traffic in California. Emphasis was placed on topics that could guide the development of ship-based management strategies that may help prevent NIS introductions via vessel fouling to the State.

Vessel Movement and Maintenance Effects on Fouling

Certain vessel movement patterns and maintenance practices have been observed to affect the diversity (variety of species) and quantity of fouling observed on commercial vessels. These factors influence the ability of free swimming or floating organisms to attach to a vessel, the ability of fouling organisms to remain affixed, or affect the ability of the organism to survive voyages.

<u>*Immobile Periods:*</u> The amount of time a vessel spends in port or at anchor has a notable influence on fouling. Many floating or free swimming organisms are better able

to attach or "settle" on surfaces while vessels are immobile, and vessels that spend long stationary periods have been observed to have heavier fouling communities (Skerman, 1960; Rainer, 1995; Coutts, 1999). One study also indicated that fouling accumulates more quickly and more heavily in enclosed basins (e.g. marinas) likely because water and organisms are flushed out less frequently in comparison to inshore coastal areas (Floerl and Inglis, 2003).

Vessel Speed: Vessel speed influences the quantity and diversity of fouling species observed on vessels. At high speeds, many organisms are unable to remain attached to vessels, or are less able to endure forceful water moving past the surface. Less robust organisms may be dislodged or may be unable to survive. Slow speeds are less stressful, allowing many fouling organisms to remain attached or continue settling on the vessel surface (Foster and Willan, 1979; Carlton and Hodder, 1995). Thus, slower moving vessels have been observed to accumulate thicker fouling than do faster vessels that travel over 18-20 KTS (Michin and Gollasch, 2003; Coutts and Taylor, 2004).

Voyage Duration: Shorter voyages have been observed to be more advantageous for the survival of fouling communities than longer voyages. The prolonged exposure to harsh physical conditions of the open ocean during a long voyage may be detrimental to fouling organisms, or they may be deprived of food for an untenable length of time (Coutts, 1999).

Age of Antifouling Paint: As discussed in Section IV, "Merchant Fleet Efforts to Keep Vessels Clean", commercial vessels regularly utilize antifouling coatings to discourage hull growth that can create drag. The majority of coatings in use today function by slowly releasing biocidal toxic agents (e.g. copper or zinc compounds) that kill fouling organisms or affect their ability to attach to the treated surface. The age of antifouling paint is strongly related to the diversity and amount of fouling organisms on both commercial vessels and recreational boats (Coutts, 1999; Floerl and Inglis, 2005). Older coatings have been observed to be less effective, presumably because the activity of the biocidal toxins decreases with time.

In-water cleaning: In addition to periodic application of antifouling paints, vessel operators and owners may also have fouling growth removed through scrubbing while the vessel remains in the water, in between paint applications. While in-water cleaning is effective for removing fouling organisms in the short term, research on recreational vessels suggests that it may increase the amount of fouling in the long term. It is suspected that this may occur because the mechanical removal of fouling leaves traces of scraped organisms, including shell or tissue (Floerl, 2005; Floerl et al., 2005). For some fouling species, these remnants act as a signal for unattached fouling organisms in the water column to settle (Railkin, 2004). Additionally, in-water cleaning can dislodge viable organisms at a destination port which may facilitate introductions of NIS (see discussion in this section, "Transfer from Vessel to Port").

Environmental Factors that Influence Fouling – Salinity and Temperature

As vessels transit from one port to another, they typically pass through changing salinity and temperature conditions, and these factors are believed to be important determinants of the survival of fouling organisms. While some organisms are able to survive a wide range of environmental conditions, many are not. Dramatic or rapid changes in either salinity or temperature are stressful for many organisms. In one case, this attribute was utilized to treat a heavily fouled vessel that had been moored for five years at a high salinity location (33-35 parts per thousand) in Washington State. Freshwater immersion resulted in approximately 90% removal of the original fouling growth (Brock et al., 1999). Organism intolerance to wide salinity and temperature fluctuations may also partially explain why higher levels of fouling are observed on vessels traveling on short voyages at similar latitudes where salinity and temperature levels tend to be more consistent (Coutts and Taylor, 2004).

In addition to voyage route, temperature and salinity also vary depending on other interacting variables. Season, amount of precipitation, and depth of a vessel's submerged surfaces are some of the major components that influence both temperature and salinity levels in any given location, and thus may affect vessel fouling.

Location on a Vessel

Fouling is not uniformly distributed on submerged portions of vessels. Some areas are particularly prone to fouling even on vessels with behaviors not generally conducive to fouling (e.g. travel at high speeds, spend little time in port). Areas sheltered from strong water forces, where antifouling coatings are less frequently renewed, or where antifouling systems may be irregularly utilized tend to exhibit higher levels of fouling (Coutts and Taylor, 2004). The Act specifically directs that the Commission include an analysis of specific vessel components. These "…shall include but not be limited to…hulls, sea chests, sea suction grids, other hull apertures, in-water propellers, chains, anchors, piping and tanks," (Public Resources Code (PRC) Section 71210.5). The TAG and Staff therefore considered and prioritized the relative fouling risk associated with specific vessel areas.

Areas on a vessel that are shielded from strong water flow have been noted to foul even in cases where main portions of the hull are clean. Studies have noted higher numbers and/or diversity of fouling organisms in sheltered areas and in crevices around rudders or propellers, intake pipes, gratings, and bow thrusters (Figure V.1) (Ranier, 1995; Coutts and Taylor, 2004). In particular, recent research has documented extensive fouling communities in the sea chests of some vessels (Dodgson and Coutts, 2002,

Figure V.1: Intake opening on a vessel hull.

Note that fouling is visible, though surrounding exposed areas are clean.

Coutts et al., 2003). Larger mobile organisms, such as crabs, snails, and shrimp have been found in sea chests, in addition to immobile, attached fouling organisms.

For vessels that are well maintained (cleaned and painted frequently) lowest risk areas are portions that are exposed to strong water movement such as the main hull, and areas of the rudder exposed to the intense flows generated by the propeller. There was no information available regarding fouling of propellers and anchors, which were explicitly listed in the Act.

As noted earlier in this section, older antifouling coatings appear to be less effective at preventing fouling accumulation. Portions of a vessel that are coated less frequently may thus pose a higher risk, even if they are subjected to strong water motion. Studies in Tasmania and New Zealand have found high diversities of organisms on localized parts of the hull where support blocks prevented cleaning and/or painting during the most recent dry dock service (Coutts, 1999; Coutts and Taylor, 2004). These “dry dock support blocks” are placed at intervals under the length of the hull to suspend a vessel when it is brought into dry dock for repairs, maintenance, cleaning, or painting (Figure V.2). Though many dry dock operations alternate the location of the blocks so hull

Figure V. 2: Vessel on dry dock blocks. The rectangular blocks suspend the vessel for maintenance, repair, and paint re-application.

areas beneath them are serviced during every other docking, the antifouling coating is older at those locations in comparison to the rest of the hull.

Transfer from a Vessel to Port

Because fouling communities consist of organisms that are either physically attached or that associate with vessel surfaces, NIS must be transferred from the vessel to a recipient port for possibility of introduction. This may occur through:

- Spawning or Egg Release
- Detachment (drop off a vessel)
- Mechanical removal (dislodged from a vessel)

Spawning or egg release can expose a recipient site to the young of fouling organisms even if the adults are otherwise unable to detach from a vessel. For example, egg-bearing crabs too large to escape sea chests have been found in vessels arriving to New Zealand and Tasmania (Dodgshun and Coutts, 2002; Coutts et al., 2003). For many marine invertebrates, certain environmental events such as changes in salinity or temperature can trigger spawning. In particular, rises in sea temperature can cause spawning for many temperate species (Michin and Gollasch, 2003), and likely triggered spawning of an NIS mussel species found attached to a vessel that had been towed from the Washington-Oregon area to Hawaii (Apte et al., 2000).

For mobile organisms in particular, transfer to a recipient port may be accomplished by simply dropping off a vessel. Organisms capable of independent detachment associated with fouling communities include crabs, fishes, sea stars, shrimp, snails and plankton (Foster and Willan, 1979; Carlton and Hodder, 1995, Dodgshun and Coutts, 2002; Coutts et al., 2003). Even in some documented cases involving the introduction of immobile fouling organisms, detachment is suspected as the only mode of transfer (Michin and Gollasch 2003).

Organisms can be dislodged if the vessel is bumped or during the process of in-water or dry dock cleanings. In-water cleaning is typically conducted between dry dock maintenance intervals to ensure that drag caused by fouling is kept to a minimum, and to meet classification society maintenance requirements (See Section IV, Merchant Fleet Efforts to Keep Vessels Clean). During in-water cleaning, fouling material is scraped or scrubbed from the underwater portions of the vessel, and can result in organisms dropping to the seafloor (Michin and Gollasch, 2003). A study in New Zealand on in-water scraping of smaller vessels (less than 49 meters [m]) indicated that 72% of the discarded organisms remained alive (Floerl et al., 2004), though it is not clear if other cleaning techniques (e.g. brushing) on larger commercial vessels would yield similar results.

During cleaning in a dry dock, fouling is often removed via abrasive blasting or hydroblasting. Though organisms dislodged during dry dock pose a theoretical NIS threat, increasing concerns over toxic substances entering the water have resulted in strict disposal requirements for effluent from dry docks. For example, the National Point Source Discharge Permit issued to the commercial dry dock in San Francisco prohibits the direct discharge of particulates and effluent into waters of the State (California Regional Water Quality Control Board, San Francisco Bay Region, 1999). Fouling material along with other waste particulates are generally placed in holding tanks and/or discharged to municipal wastewater systems or to a landfill. Thus, the potential for fouling introductions from dry docks theoretically presents limited risk (Godwin et al., 2004; Davidson et al., 2005).

Studies Conducted on U.S. Pacific Coast

Because fouling appears to be affected by factors that vary in relation to the type of commerce and environmental conditions of a specific region, it is important to consider field research conducted locally. A summary of studies conducted in the U.S. Pacific region are reviewed here.

Port of Oakland, 2004

A pilot study on nine containerships arriving to the Port of Oakland in 2004 found patterns of fouling that varied in some aspects from studies conducted in other regions. As in other studies, the most fouling was observed in sheltered, non-hull locations on each ship. In contrast, the overall amount of fouling was much lower than had been observed on vessels in New Zealand (Coutts and Taylor, 2004; Ruiz et al., 2005). This is likely partially due to the high average speed of the vessels in the study (24-28 MPH, or 21-24 KTS) and their short port residency time (less than 24 hours). In contrast to other studies, little fouling was found in dry dock support strip areas though the condition of antifouling paint there was poor. The authors suggest that containerships arriving to Oakland may have lower levels of fouling in comparison to other vessel types with differing movement patterns. However, they caution that the limited number of vessels examined and the focus on only one ship type make any generalizations premature.

Wetted Surface Area (WSA) of Commercial Vessels Arriving to California Ports

Any submerged portion of a vessel represents a potential for fouling accumulation. Thus, an estimate of total amount of submerged surface area from all vessels that arrive to a region can provide some indication of the rate and pattern with which individual organisms may arrive (propagule pressure), and how they may contribute to NIS establishment. As part of a larger study to investigate fouling NIS potential on vessels arriving to the West Coast, the Aquatic Bioinvasions Research and Policy Institute provided preliminary data on hull "wetted surface area" (WSA) of vessels arriving to California for this report. This analysis was based on vessel arrivals from the ballast water reporting forms submitted to California between July 2003 and June 2005.

For the two years analyzed, 189.5 million square meters (m^2) of hull surface area has arrived to ports in the State (≈ 95 million m^2 per year). Forty-one percent arrived from Pacific Coast ports of North America (California, Oregon, Washington, British Columbia and Alaska). The remaining 59% (111.8 million m^2) arrived from overseas ports in 71 countries throughout the Pacific, Atlantic and Indian Oceans, highlighting the global scale of possible introduction via this mechanism. Containerships dominated California arrivals, accounting for 55% of the total WSA for the state, and were the most frequent visitor and one of the largest ship types on average (second only to tankers in terms of average WSA) (Figure V.3).

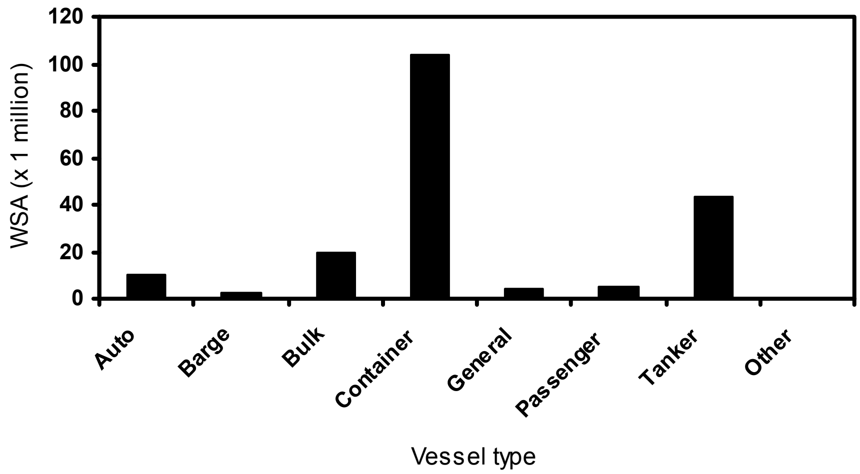

Figure V.3: Total wetted surface area (WSA) arriving to ports from July 2003 - June 2005 in California by vessel type.

The magnitude of the threat of invasion to California's coastal waters from hull fouling is significant. The two-year total of WSA entering California waters equates to 1½ times the area of San Francisco County. However, without reliable data on biofouling densities across different vessel types, the ability to determine the full extent of propagule pressure to the State from commercial hull fouling is limited. A first effort at gathering this data will be made later in 2006, with the longer term aim to determine how different vessel types, voyage routes, hull husbandry regimes, and recipient port conditions influence hull fouling transfers and species establishment.

Wetted Surface Analysis and Vessel Fouling Surveys in the Lower Columbia River

In a preliminary study, vessel fouling and its potential for introductions in the Lower Columbia River (LCR) was evaluated through: WSA calculations for vessels arriving between July 2002 and June 2005, a biological analysis of fouling on 10 vessels surveyed in dry dock and on 7 vessels surveyed on video, and an evaluation of the suitability of the Lower Columbia River for invasion.

Over 40.5 million m^2 of WSA arrived in the region between July 2002 and June 2005. The scale of potential introductions was global – vessels arrived from 377 different ports in 66 countries. The vast majority (85%) of overseas arrivals came from Asian ports of the Northwest Pacific. Vessel WSA was dominated by bulk carriers (>50%). Fouling on vessels examined on dry dock was highly variable; it ranged between >90% and <1% of the WSA. High levels of fouling tended toward vessels that remained within either marine or freshwater conditions and had not been cleaned within the last two years. Minimal fouling levels were associated with vessels that commonly traversed a range of salinity conditions, such as barges that frequent the LCR. Two vessels with the highest number of species had traveled to the LCR from overseas and had not spent much time in freshwater. Many of the taxa on these vessels were probably nonindigenous to the Pacific Northwest region. Finally, the authors conjecture that the dramatically varying salinity and highly variable flow rates in the LCR may serve to limit some invasions (Davidson et al., 2005).

Implications of Current Knowledge

The review of current research provided in this section allows for broad generalizations regarding NIS invasion risk posed by fouling on commercial vessels. However, the extent to which these principals apply to the U.S. West Coast and California are unclear due to the limited amount of information available. Fouling and associated NIS introductions are highly dependent on environmental conditions, vessel maintenance practices, type of shipping traffic, and vessel movement patterns, which can be regionally unique. Fouling factors also interact. A single vessel may exhibit behaviors that fall into both higher and lower risk categories, resulting in fouling NIS risk that can be complex and difficult to evaluate. This is especially the case for North America and California, where very little locally based research has been conducted on vessel fouling and its relationship to NIS introductions.

In a minority of instances where vessels or maritime structures exhibit exaggerated characteristics that contribute to fouling accumulation, the NIS risk has been observed to be high. For example, the decommissioned *USS Missouri* was observed to have accumulated at least 116 fouling species during its five-year residency in Bremerton, Washington (Brock et al., 1999), before it was to be relocated to Hawaii. Towed vessels or maritime structures that move extremely slowly and spend very long periods immobile have been observed to be problematic in New Zealand and Hawaii (Rainer, 1995; Godwin, 2003; Coutts, 2005 (a)). In 2001, a barge that had arrived in New Zealand from the Philippines before 1991 and which had not been dry docked since its arrival, was observed to have accumulated over 28 tons of fouling organisms (Coutts, 2005(b)). A heavily fouled floating dry dock that was towed to Hawaii in 1992 from the Philippines is thought to be responsible for the establishment of several NIS to Pearl Harbor (Coles et al., 1999). An oil platform towed for 68 days at an average of 3.7 MPH (3 KTS) from Japan to New Zealand arrived with over a ton of fouling (Foster and Willan, 1979). A floating dry dock towed to Hawaii from San Diego in 1999 had high levels of fouling the included 34 NIS, and an algal species became established as a result (Godwin, 2003).

The majority of vessels in regular operation, however, do not exhibit similarly extreme characteristics. As noted in Section IV, most companies clean and paint hulls regularly for operational safety, to reduce maintenance costs, and to minimize drag-related fuel costs. Many minimize time in port and maximize transit speed in order to move cargo quickly for maximal profit. Because there have been no fouling studies across a broad range of vessel types, vessel movement patterns, and maintenance practices, it is not known what kinds of fouling patterns result on vessels that exhibit more common behaviors or that engage in a combination of behaviors with differing fouling effects (e.g. a swift vessel that typically spends three days in port; a freshly painted vessel that has been moored for two weeks). Thus, while it may be possible to identify irregular situations that likely pose a high risk, it is not clear what level of risk is presented under more typical commercial vessel behaviors.

It is also notable that any vessel or structure of any size may accumulate fouling, and if mobile, can serve to transport NIS. Factors that influence fouling on commercial vessels also apply to other structures, including private boats or yachts, fishing vessels, and navigational buoys (Railkin, 2004). For example, the historical replica ship of the Golden Hinde transported over 64 species at various legs of its voyage from Yaquina

Bay, Oregon to San Francisco Bay, California in 1987. The vessel spent 30-day layovers at three ports prior to and during its 4-4.5 MPH (3.5-4 KT) trip (Carlton and Hodder, 1995). In a Hawaii study, 21 NIS were found on 12 overseas personal craft, though all but one of the NIS had already become established in the state (Godwin et al., 2004). In New Zealand, recreational yachts have been suspected as a probable introduction vector for several problematic NIS (Floerl and Inglis, 2005). Though the Act explicitly directs the Commission to evaluate the NIS risk posed by vessels over 300 gross registered tones able to carry ballast, it is important to note that a complete picture of the fouling NIS vector extends beyond commercial vessels.

VI. EXISTING FRAMEWORKS FOR THE MANAGEMENT OF VESSEL FOULING

A range of strategies for minimizing NIS introductions through commercial vessel fouling have been proposed or adopted by various countries, states/territories and regions. To date, no country has adopted national regulations for commercial vessels explicitly for the prevention of NIS introductions through vessel fouling. The types of management frameworks vary widely because there is little information on the efficacy of management strategies for the vector. In some cases, the primary impetus for management is not fouling NIS prevention, but the minimization of toxic antifouling paint release into the water as residues are scraped off during hull cleaning. The TAG and Staff examined the benefits and drawbacks of these strategies, and their potential for the prevention of fouling NIS in California.

Federal and California Codes and Statutes

The Federal code (Code of Federal Regulations [CFR] Section 151.2035 (5) and (6)) and the California statue (California Public Resources Code Section 71204 (e) and (f)) contain nearly identical language prescribing minimum maintenance actions to control fouling. However, both are limited in scope and specificity. They require that anchors and anchor chains be rinsed upon retrieval at their place of origin, and that fouling organisms be regularly removed from hulls, piping and tanks and be disposed of according to local, State or Federal regulations. Parameters are not defined regarding the "regular" removal of fouling. Despite this, the U.S. Coast Guard was able to use the federal regulation to intervene when decommissioned Suisun Bay Reserve Fleet vessels were moved from one Captain of the Port Zone to another for dismantling. Much of the Suisun Bay fleet has been immobile for years, if not decades, with little or no hull maintenance.

Hawaii

In Hawaii, a draft information framework for the management of fouling NIS was developed by the Alien Aquatic Organism Task Force, a stakeholder group formed by the Hawaii Division of Aquatic Resources. The framework has not yet been officially adopted, and the State currently monitors maritime arrivals for high risk vessels through an informal network of state, federal, academic and private groups. Response is conducted through this informal network as much as possible.

The draft framework separates fouling NIS management into three components. "Pro-active measures" are geared towards minimizing high risk arrivals to Hawaii, and include education and outreach, maritime activity monitoring, and the evaluation of arrivals for potential high risk vessels. The second component addresses the response to a high risk event, and these "reactive measures" may involve an investigation of the identified vessel, and/or a determination of actions to minimize the potential for NIS introduction. The third component, "post-event measures", involves the development of long term management measures once it is determined that they are needed (Godwin, 2005).

In order to assist with the identification of potentially high risk vessel arrivals during the pro-active stage, an evaluative risk matrix was developed (See Figure VI.1). Its components are based on vessel movement and maintenance patterns that influence fouling, though some of its specific parameters have not yet been defined (Godwin et al., 2004) (see Section V, "Review of Current Knowledge on Vessel Fouling and Nonindigenous Species"). In the proposed matrix, vessels arriving from outside of the state that do not adhere to international maintenance codes of practice, and spend long periods immobile would be flagged. In addition, certain vessel types are designated as high risk, based on prior NIS fouling surveys conducted in Hawaii. These would include vessel types that often travel at slow speeds and spend long periods inactive (e.g. barges, platforms, floating dry docks). Potential reactive measures for high risk vessels include restricting time in port to essential operations, quarantine, or out of water cleaning for those intent on an extended stay.

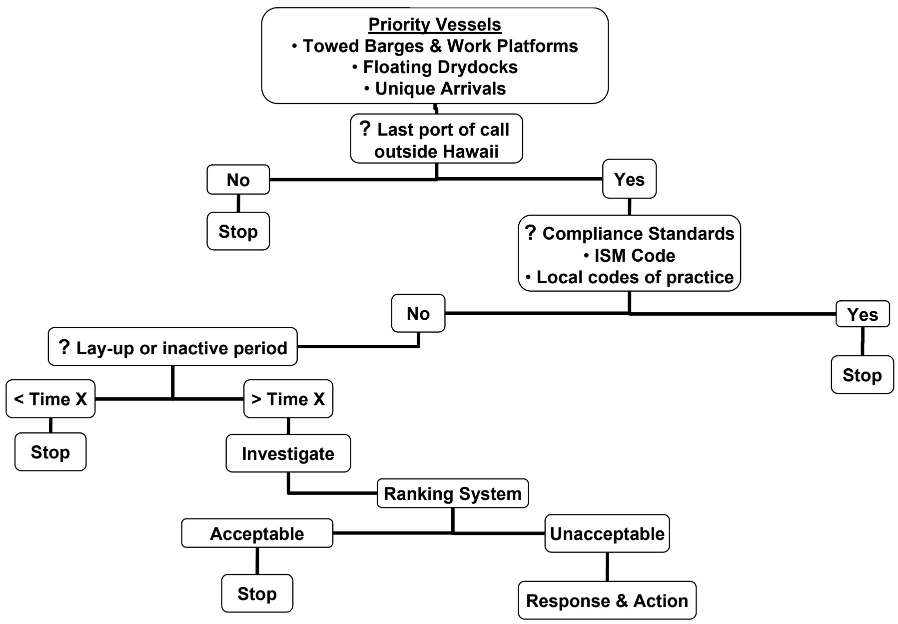

Figure VI.1: Preliminary "risk matrix" developed in Hawaii to assist with the identification of arrivals that pose a high fouling NIS risk to the state. From: Godwin, 2005.

New Zealand

The Biosecurity New Zealand (formerly New Zealand Ministry of Fisheries) is the primary agency responsible for the prevention and management of marine NIS in New Zealand. There are currently no regulations in place related to the prevention of fouling NIS, however information gathering efforts are conducted through a survey. The survey is included on the ballast water declaration form required of all arriving vessels, and asks three questions relating to vessel maintenance and activity:

- When was the vessel last dry-docked and cleaned?

- Has the vessel been laid up for three months or more since it was last dry docked and cleaned? If yes, state when and where.
- Do you intend to clean the hull in New Zealand? If yes, state when and where.

In addition, New Zealand's fishing industry adopted voluntary codes of practice in December 1996, following the highly publicized arrival of a fishing vessel in 1994 with approximately 90 tons of fouling (Hay and Dodgshun, 1997; Coutts, 2005(a)). The code requests that foreign owned or sourced vessels be free from growth prior to entering New Zealand's Exclusive Economic Zone. If this cannot be assured, the vessel should be inspected, and either cleaned before departure or have fouling removed in a manner that does not allow organisms to enter the marine environment.

Biosecurity New Zealand is currently considering several options for the regulation of hull cleaning practices. Proposed rules may require that out-of-water cleaning facilities contain, collect and dispose of or treat fouling material in a manner that prevents discharge of organisms to the marine environment. Additionally, proposed rules may include a ban on in-water cleaning, regulations targeting high risk vessels only, or the adoption of codes of practice for in-water cleaning operations (Coutts, 2005 (a); New Zealand Ministry of Fisheries, 2006).

Australia

Though Australia has not implemented nationwide regulations related to fouling on vessels larger than 25 m, all states and territories prohibit in-water cleaning on commercial-sized vessels (Hirst, 2006; New Zealand Ministry of Fisheries, 2006). Most of these prohibitions are variants of the Australian and New Zealand Environment Conservation Council (ANZECC) codes of practice (See discussion that follows on ANEZCC codes of practice), and in some cases have been adopted primarily to prevent biocidal antifouling paint flakes from entering the water or dropping to the sea floor. Currently, protocols tailored to specifically address fouling NIS are in very early stages of development (Hirst, 2006).

In late 2005, Australia announced the implementation of national regulations to prevent fouling NIS introductions on internationally traveling vessels under 25 m. Though the regulation does not apply to commercial vessels, it is reviewed in this report because it represents the first legal regime specifically aimed towards the prevention of NIS introductions through the hull fouling vector in the marine environment (Australian Quarantine and Inspection Service, 2005). The rule will become mandatory in October of 2006 after a one year voluntary period, and requires that vessel gear and seawater systems are clean of marine pests and growths. In addition, operators must perform one of three antifouling measures:

- Clean the hull one month prior to arrival
- Apply antifouling paint within one year before arrival
- Book the vessel to be slipped and cleaned within one week of arrival

The Australian and New Zealand Environment Conservation Council (ANZECC)

The Australian and New Zealand Environment Conservation Council (ANZECC) was a Ministerial Council that operated from 1991 to 2001 to develop coordinated policies between member nations. The Council produced codes of practice to minimize pollution problems caused by toxic antifouling paints and to reduce the release of fouling NIS. In-water cleaning is prohibited, except in extraordinary circumstances. The codes do allow the cleaning of sea chests, grids, and hull apertures under permit if debris was not allowed into the water or onto the seafloor, and also allow propeller polishing under permit (ANEZCC, 1997).

Merchant Classification Society Requirements

As discussed earlier, classification societies require periodic hull inspections and dry docking of commercial vessels (See Section IV, “Merchant Fleet Efforts to Keep Vessels Clean”). Though requirements vary slightly depending on the age of a vessel and classification, they generally require vessels to be dry docked at least once every five years. None of the societies requires the hull to be cleaned while dry docked. Nevertheless, because of the increased fuel consumption that can result from fouling, and because the dry docking process is costly and difficult to schedule, most companies take the opportunity to clean and paint vessel hulls during these periods. Most companies also conduct interim in-water cleanings according to fuel performance tests, in order to maintain cost effective fuel efficiency.

Due to the lack of scientific knowledge on the most effective and practicable options for the prevention of NIS from commercial vessel fouling, no national policies have been adopted. For similar reasons, strategies that have been implemented in select regions range widely (See Table VI.1.). Clearly, more research will be needed to evaluate where the highest risks of NIS introduction lie and which preventative actions might be most protective.

Country/State/ Port	Management Strategy	Details
U.S. Federal California	Embedded in ballast water regulation Embedded in ballast water statute	Rinse anchor chains and anchors at place of origin Remove fouling from hull, piping and tanks on a regular basis. Dispose wastes in accordance with local, state, and federal law.
Hawaii	Information Framework Targeting High Risk Vessels (Proposed)	Pro-active measures: Education/outreach, vessel arrival monitoring, evaluation for high-risk arrivals (See Figure VI.1.) Re-active measures: Rapid response/investigation of high risk event Post-event measures: Long term regulations for high-risk events • Limit time in port • Vessel quarantine • Out of water cleaning
New Zealand	Survey (On Ballast Water Declaration Form)	1. When and where was the vessel last dry-docked and cleaned? 2. Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If YES, state when and where. (Also requests start and end date laid up) 3. Do you intend to clean the hull of the vessel in New Zealand? If YES, state when and where
	Voluntary Codes of Practice (Fishing Industry)	Chartered foreign owned or sourced fishing vessels must be substantially free from plant or animal growth prior to entering New Zealand's EEZ. If no assurance, vessel inspected and cleaned before departure. Otherwise inspected in NZ and if necessary, fouling removed so no foreign organisms enter the marine environment

Table VI.1: Summary of Current Management Frameworks for Vessel Fouling. Various regulations, proposed management actions, recommendations, guidelines, and codes of practice aimed towards preventing NIS introductions through fouling are summarized below.

Country/State/ Port	***Management Strategy***	***Details***
Australia	Prohibition (States/Territories/ Ports)	States& territories prohibit in-water cleaning. Many require containment and disposal regulations of fouling debris removed during out-of-water cleaning.
	Regulation (Vessels less than 25 m)	Keep ancillary gear and internal seawater systems clean of marine pests and growths, and Before departing your last port for Australia… o Clean hull within one month before arrival OR o Apply antifouling paint within one year before arrival OR o Book vessel for slipping and cleaning within one week of arrival (cleaning should be in a shipway where material removed can be collected and disposed of away from the sea)
Australia and New Zealand Environmental Conservation Council (ANZECC)	Codes of Practice	In-water hull cleaning prohibited, except under extraordinary circumstances. Sea-chests, sea suction grids, other hull apertures may be allowed under permit, if debris not allowed to pass to water column or sea bed. Polishing propellers may be allowed under permit.
Merchant Classification Societies	Requirements (Applies to majority of merchant fleet)	Dry dock requirements vary somewhat depending on classification society. Generally: o Dry dock every 5 years. Cleaning and painting is usually conducted, but is at the discretion of the company. o Interim in-water cleanings: Periodicity at the discretion of the company. Typically dependent on results of fuel consumption tests.

Table VI.1 (Continued): Summary of Current Management Frameworks for Vessel Fouling

VII. CONCLUSIONS AND RECOMMENDATIONS

The most difficult challenge to developing recommendations that reduce the introduction of NIS from fouling is the limited amount of direct research that has been conducted on the vector. While studies in a number of regions indicate that fouling is an important mechanism through which modern invasions occur, few modern baseline studies have been conducted to characterize the vector, particularly in North America. Although generalizations can be made on factors that influence the degree of vessel fouling based on studies in regions outside of the mainland U.S., the information is not adequate to evaluate the specific NIS potential of the majority of vessels calling to California. While vessels with extreme characteristics that exacerbate fouling likely pose a risk, there is little information on the potential risk posed by the majority of the fleet that conducts regular vessel maintenance and exhibits more common behaviors.

The Commission believes, however, that these difficulties should not prevent the State from moving forward with actions at this time. Staff approached the development of recommendations by considering which actions can be implemented now to reduce NIS introduction via fouling based on the knowledge currently available, and what actions are needed to build information and the tools needed to refine management measures in the future.

Legislation should be adopted to:

1. Broaden the State Program to include the control and prevention of NIS release via commercial vessel fouling.

The Act currently focuses on the prevention of NIS introduction through ballast water discharges, and does not authorize the Commission to adopt regulations to prevent NIS introduction through vessel fouling. This lack of explicit authority prevents the Commission from implementing regulatory actions related to the vessel fouling vector.

2. Broaden the reporting requirements to include mandatory reporting on maintenance practices and other fouling-related behaviors of qualifying vessels operating in California waters.

Both vessel movement patterns and maintenance practices are factors that strongly influence the degree of fouling found on vessels. Long mooring periods, slow transit speeds, and infrequent use of antifouling paint and systems have been found to facilitate fouling accumulation. However, there is currently no information on which characteristics are representative of the vessels that arrive to and/or operate in California, and how many of these vessels exhibit potentially higher risk characteristics.

It is known that the vast majority of vessel operators clean and paint hulls every five years, and perform periodic in-water cleaning during the interim. Most strive to minimize fouling due to operational dangers and increased fuel costs. Most also aim to maximize transit speeds and minimize time in port. However, case studies outside of California have observed that a small minority of vessels do not follow these maintenance schedules and/or do not exhibit these transit behaviors, and some have been found with excessive fouling. For example, a decommissioned military vessel that had been moored in Washington State for 5 years was observed to have accumulated over 112 species prior to its relocation to Hawaii (Brock et al. 1999). With such contrasting profiles, it will be critical to characterize vessels in California waters to better evaluate the nature of the risk posed by commercial vessels. Coupled with biological surveys of NIS fouling on vessels that operate in the State, vessel maintenance and behavior information will provide a better understanding of the actual NIS risk posed by fouling, and will be key for identifying appropriate management solutions that minimize the risk of NIS introductions via this pathway. The adoption of this recommendation would lead to an increase in the cost of the Commission Program associated with increased staff requirements for data entry, compilation, and analysis; as well as additional vessel inspections and monitoring.

3. Expand enforcement components of the Act to address mandatory reporting in Recommendation 2.

The California Marine Invasive Species program is supported by active reporting compliance monitoring, outreach to the shipping community, and the authority to apply penalties for non-compliance, which has yielded reporting rates that have exceeded 90% since 2000 (Falkner, 2003; Falkner, et al. 2005). In contrast, mandatory reporting for the federal ballast water program is not similarly reinforced, and reporting rates were approximately 30% during 1999-2001 (Ruiz et al., 2001), making a sound assessment of the data impossible. The Commission therefore believes that the authority to apply penalties for non-reporting coupled with outreach to and monitoring of the shipping community, will ensure higher reporting rates. This authority will help assure that information collected through the survey provides representative information on the vessels operating in California ports or places. The adoption of this recommendation is not expected to increase the cost of the Commission Program above those anticipated with the adoption of Recommendation 2.

4. Authorize the Commission to develop and adopt regulations that prevent or minimize the introduction of NIS via vessel fouling.

Regulations to define regular vessel maintenance practices for the control of NIS fouling on commercial vessels are needed. These should place requirements or restrictions on vessels that do not adhere to the defined practices. Though there is a limited amount of scientific knowledge on the quantity and NIS risk presented by fouling that may be present on well maintained vessels operating in California, case studies show that a minority of vessels do not follow minimal “good housekeeping” practices. For example, a barge that had not been dry docked for at least 10 years was found in New Zealand with over 28 tons of fouling (Coutts, 2005(b)). Such vessels have been found with extensive amounts of fouling and present high risk scenarios for NIS introduction (See Section V, “Review of Current Knowledge on Vessel Fouling and NIS” for further discussion).

Both the Act and the federal ballast water regulation (33 CFR 151.2035(a)(6)) require that vessels remove fouling on a regular basis, however, no definition or criteria is provided for the term "regular". Given the high NIS risk posed by vessels that are not adequately maintained, the intent of the Act would be better served if criteria were placed on a definition for regular inspections and cleaning, and if vessels that do not adhere to defined criteria are subject to further examination.

The Commission should therefore be authorized to adopt regulations that define parameters for regular husbandry practices for fouling control, and should be authorized to place requirements on vessels that do not follow such practices. Vessels that are not regularly maintained should be compelled to notify the Commission prior to their entry into or movement within California waters. Such a framework would serve to flag potential high risk vessels, providing an opportunity for the Commission to gather information on the frequency of arrivals of potentially high-risk vessels to California ports, and to work with vessel operators on actions that can minimize the adverse impacts of a highly fouled vessel. Adoption of this recommendation is not expected to increase the cost of the Commission Program above those anticipated with the adoption of Recommendation 2.

5. Expand and coordinate biological research directed towards characterizing the NIS risk posed by commercial vessel fouling with other federal and state agencies.

The limited amount of scientific research on vessel fouling and NIS in California and the West Coast is the most prominent obstacle to a clear evaluation of the overall risk faced by the State. Existing studies have been conducted on limited numbers and types of vessels, in regions largely outside of North America. Though relative generalizations from these studies regarding factors that influence fouling likely apply to vessels operating in California waters, the magnitude of the NIS risk cannot be extrapolated to the State. For example, while it may be presumed that a vessel that travels at an average of 7 KTS likely has more fouling than one that travels at 17 KTS, it is not known how much fouling, how many NIS, or the level of NIS risk that may be presented on each.

A number of questions critical for the development of effective, scientifically grounded management remain. At a minimum, information is needed to address the most basic, but most important question: How many fouling organisms and how many NIS arrive to and move within California via vessel fouling? Such information is critical for a characterization of the NIS risk faced by California. When coupled with vessel maintenance and movement patterns linked to fouling accumulation, research would lay the foundation to fill additional information gaps such as which kinds of vessels harbor notably more fouling than others, what criteria can be used to flag a potentially high risk vessel, and which vessels pose a negligible amount of risk. Answers to these kinds of management-based research questions can guide the formulation of preventative management actions in the future. Funds necessary to support such a research program could be obtained through three mechanisms: general funds, grants, or through the existing fees assessed on ships. The cost to adopt this recommendation to the Commission Program could be as much as $500,000 annually.

6. Support continued long-term NIS monitoring in California waters.

Long-term biological monitoring is necessary to evaluate the effectiveness of management efforts to prevent NIS introductions; particularly as new management actions are implemented. Surveys are also crucial for determining how to modify or enhance management actions so they are optimally effective for reducing invasions. As mandated by the Act, the California Department of Fish and Game (CDFG) administers a statewide monitoring program for NIS within California's estuaries and along its coast. Legislation should support the CDFG's continued long-term survey efforts so data may be used to evaluate the effectiveness of management measures implemented to prevent NIS introductions via vessel fouling. Adoption of this recommendation is expected to increase the cost of the CDFG Program.

7. Support research promoting technology development.

Vessel owners and operators strive to maintain clean hulls in order to minimize fuel costs, maximize vessel speed, meet classification society requirements, and to help ensure the structural integrity of their vessels. Available information indicates that hull cleaning at dry docks in California presents a lowered NIS risk because these facilities are required to prevent fouling debris from entering the water column. Complete cleaning and re-coating with antifouling paint may provide better long-term antifouling protection than does in-water cleaning. However, dry dock facilities capable of accommodating commercial class vessels are limited, expensive, and scheduled well in advance. Most owners and operators therefore conduct in-water cleaning between required dry dockings.

In-water cleaning is one of several ways through which fouling NIS can be transferred from a vessel to a recipient port, and the activity poses some NIS introduction risk. Because of the potential for in-water cleaning to release NIS and toxic antifouling paint debris, Australian territories and states have banned the practice. However, in the absence of in-water cleaning, fouling organisms are still capable of transfer through spawning or by detachment from a vessel, and it has been contended that spawning or brood release may be the most important release mechanism (Michin and Gollasch, 2003; Davidson et al, 2005). There has been no direct research to indicate if the fouling NIS risk is lower if in-water cleaning is banned or if it is allowed it to proceed. Clearly, NIS release can occur under either situation, and neither is optimal.

A technology that collects and contains in-water cleaning debris would be a desirable avenue to prevent NIS release during in-water cleaning, while also providing commercial operators an avenue to clean hulls without placing a vessel in dry dock. In addition, a containment-based in-water cleaning technology could provide at tool to handle cases where a heavily fouled, high NIS risk vessel arrives to the State, and dry docks are not available. Prototype technologies have been under development to contain both fouling debris and toxic antifouling paint residuals: however, none are currently available for commercial application.

As a result of current and impending bans on toxic antifouling coatings, many commercial vessel paint manufacturers are developing non-toxic antifouling coatings. However, currently available products are only effective for a minority of vessels that travel at very high speeds. As more regions adopt bans on coatings that release biocides, it will be important that alternative antifouling tools are available to prevent the accumulation of fouling and minimize NIS introductions.

Legislation should therefore facilitate the advancement of in-water cleaning technologies that collect and contain fouling debris. The long-term goal of these technologies would be to phase out in-water cleaning activities in California that are not contained. Legislation should also facilitate the advancement of antifouling coatings that create little or no water quality impacts, and which are effective for preventing fouling accumulation on vessels. The advancement of both of these technologies would fulfill the intent of the Act to move the state towards the elimination of NIS discharge into waters of the State in a manner that also addresses water quality issues that may be generated by the antifouling practices of vessels. Funds necessary to support such a research program could be obtained through three mechanisms: general funds, grants, or through the existing fees assessed on ships. The cost to the Commission Program could be as much as $500,000 annually.

8. Direct the State and Regional Water Quality Control Boards, in cooperation with the U. S. Environmental Protection Agency, to evaluate the effects of biocidal antifouling coatings from vessels on water quality.

Copper enters California’s freshwater, estuarine, and marine environments from a variety of sources, including copper-based antifouling paints on vessels. Due to copper contamination, California’s major ports are included on California’s 2002 list of impaired waters as defined by the Clean Water Act Section 303(d).

Though outside of the intent and scope of the Act to "…move the state expeditiously towards the elimination of the discharge of nonindigenous species into the waters of the state…," the Commission feels that water quality impairments that may be caused by vessel antifouling practices warrant attention. The Commission recommends that the State and/or Regional Water Quality Control Board(s) investigate the issue in cooperation with the United States Environmental Protection Agency, under the authority and jurisdiction granted to them by the Clean Water Act. Full chemical constituent identification and toxicological literature reviews should be conducted to assess the potential aquatic toxicities of all antifouling paints now in use in California's waters, including their propensity for bioaccumulation, leaching potential, and general environmental fate. More specifically, it should be determined if copper leachate from antifouling practices is contributing to:

- The impairments in the 2002 California list developed pursuant to the federal Clean Water Act Section 303(d).
- An exceedance of water quality criteria as provided under the California Toxics Rule (40 CFR Part 131) for inland surface waters, enclosed bays, and estuaries.
- An exceedance of criteria for priority pollutants as provided in the 2005 California Ocean Plan for near coastal ocean waters.

If it is determined that antifouling practices of vessels do contribute to water body impairment or exceedance of water quality criteria, the boards should adopt or amend water quality plans and or Total Maximum Daily Loads accordingly, as directed by the federal Clean Water Act. SWRCB Program costs may increase and the appropriate funding source needs to be identified.

9. Expand the Marine Invasive Species Program's existing outreach and education program to include the fouling vector.

The goal of expanding the Program's existing outreach and education program would be to inform ports, the merchant shipping industry, the military, resource agencies and policy makers about vessel fouling and its role as an NIS vector. Nonindigenous species transport and introduction through vessel fouling is a relatively new issue for many of these entities, and there is little to no awareness of its importance amongst these groups. The problem was underscored during the TAG meetings by a coincidental controversy over the proposed establishment of a ship breaking operation in Oregon, and the associated transfer of vessels from the Suisun Bay Reserve Fleet to the proposed operation or to an established operation in Texas. Though vessels in the reserve fleet exhibit exaggerated, high risk characteristics for fouling accumulation, there had been no consideration for the potential for NIS transfer prior to the public opposition and media attention that emerged over the controversy.

Outreach to the stakeholder community should clearly be part of the early steps in any NIS prevention program. Such efforts allow affected parties to come up to speed on an issue, to become educated participants in the search for preventative strategies, and provide the opportunity to take voluntary action to prevent NIS introductions and spread. There was strong agreement amongst TAG members that outreach should be a high priority, particularly in light of the limited knowledge of fouling and NIS on the majority of the fleet that operates in California waters. Operations engaged in theoretically high fouling risk operations should be high priority targets of outreach. These would include (but are not limited to) the military, the Maritime Administration, salvage operators, companies operating oil platforms, and vessel towing companies. Awareness should also be raised amongst those involved with policy development, so well informed decisions can be made as emerging science provides a better understanding of the problem, and effective solutions for it. Adoption of this recommendation is not expected to increase the cost of the Commission Program.

10. Direct appropriate agencies to address the risk of fouling related NIS introduction and spread in California waters by vessels under 300 gross registered tons.

The Act explicitly directs the Commission to evaluate the risk of NIS introductions by vessels over 300 gross registered tones, able to carry ballast. However, it is important to recognize that any vessel or structure of any size, with or without ballast water tanks, may accumulate fouling and subsequently transport NIS. Factors that influence fouling on commercial vessels described in this report also apply to other structures, including private boats or yachts, fishing vessels, and navigational buoys (Railkin, 2004).

Though vessels and structures under 300 gross registered tones are not encompassed by the Act, the Commission and the TAG believe that they are likely an important means for the introduction and spread of marine, estuarine and freshwater invasive species within California waters. The Commission recommends that the release and transfer of NIS through vessel types not included in the Act, including recreational and fishing vessels, be examined by the agency(ies) with the appropriate authority and jurisdiction. Recommendations for the reduction of NIS introductions from non-commercial shipping, non-ballast water vectors should be provided to the Legislature.

VIII. LITERATURE CITED

Apte, S., B.S. Holland, L.S. Godwin, J.P.A. Gardner. 2000. Jumping ship: A stepping stone event mediating transfer of a non-indigenous species via a potentially unsuitable environment. Biological Invasions. 2: 75-79.

Australian and New Zealand Environment Conservation Council (ANZECC). 1997. Code of practice for antifouling and in-water hull cleaning and maintenance. 12 pgs.

Australian Quarantine and Inspection Service. 2005. New biofouling laws to protect Australia. Accessed October 15, 2005. Website:http://www.affa.gov.au/content/output.cfm?ObjectID=7FBA840F432449E3B22BCB2C4A3B28E8.

Brock, R., J.H. Bailey-Brock, J. Goody. 1999. A case study of efficacy of freshwater immersion in controlling introduction of alien marine fouling communities: The USS Missouri. Pacific Science. 53: 223-231.

California Regional Water Quality Control Board San Francisco Bay Region. 1999. Waste discharge requirements for: San Francisco Drydock Inc. Order No. 99-035. NPDES Permit No. CA0005321. 15 pgs.

California State Water Resources Control Board. 2005. California Ocean Plan. Water quality control plan, ocean waters of California. 57 pgs.

Carlton, J.T. and J. Hodder. 1995. Biogeography and dispersal of coastal marine organisms: experimental studies on a replica of a 16th-century sailing vessel. Marine Biology. 121: 721-730.

Carlton, J.T. 2001. Introduced Species in U.S. coastal waters: Environmental impacts and Management Priorities. Pew Oceans Commission. Arlington, VA. 28 pp.

Coutts, A.D.M. 1999. Hull fouling as a modern vector for marine biological invasions: Investigation of merchant vessels visiting northern Tasmania. Thesis. Australian Maritime College. 283 pgs.

Coutts, A.D.M., K.M. Moore, C.L. Hewitt. 2003. Ships' sea-chests: an overlooked transfer mechanism for non-indigenous marine species? Marine Pollution Bulletin 46: 1504-1515.

Coutts, A.D.M. and M.D. Taylor. 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.D.M. 2005 (a). Managing marine biosecurity in New Zealand: From a research provider's perspective. *In* Hull fouling as a mechanism for marine invasive species introductions. *Proceedings of a workshop on current issues and potential management strategies*. February 12-13, 2004. pp. 36-46. Godwin, L.S. (ed).

Coutts, A.D.M. 2005 (b). Slow-moving barge introduces biosecurity risk to the Marlborough Sounds, New Zealand. Pp. 29-35. *In* Hull fouling as a mechanism for marine invasive species introductions. *Proceedings of a workshop on current issues and potential management strategies.* L.S. Godwin (ed.) Honolulu, HI. February 12-13, 2003.

Coles, S.L., R.C. DeFelice, L.G. Eldredge, J.T. Carlton. 1999. Historical and recent introductions of non-indigenous marine species into Pearl Harbor, Oahu, Hawaiian Islands. Marine Biology. 135: 147-158.

Davidson, I., Sytsma, M., Ruiz, G. 2005. ANS Investigations in the Columbia River, Task IV Final Report: Preliminary investigations of biofouling of ships' hulls. Draft report to the US Coast Guard Research and Development Center. 63 pgs.

Dodgshun T. and A. Coutts. 2002. Ships' sea chests: a "side door" for marine pests? Cawthron Institute. 9 pgs.

Eldredge, L.G. and J.T. Carlton. 2002. Hawaiian marine bioinvasions: A preliminary assessment. Pacific Science. 56: 211-212.

Falkner, M.B. 2003. Report on the California ballast water management program. Produced for the California State Legislature. California State Lands Commission. 82 pgs.

Falkner, M., Takata, L., S. Gilmore. 2005. Report on the California Marine Invasive Species Program. Produced for the California State Legislature. California State Lands Commission. 45 pgs.

Floerl, O. and G.J. Inglis. 2003. Boat harbour design can exacerbate hull fouling. Austral Ecology. 28: 116-127.

Floerl, O., N. Norton, G. Inglis, B. Hayden, C. Middleton, M. Smith, N. Alcock, I. Fitridge. 2004. An investigation of hull cleaning and associated waste treatment options for preventing the spread of non-indigenous marine species. Final research report for Ministry of Fisheries Project ZBS2002-04. 40 pgs.

Floerl, O. 2005. Factors that influence hull fouling on ocean-going vessels. Pp. 6-13. *In* Hull fouling as a mechanism for marine invasive species introductions: *Proceedings of a workshop on current issues and potential management strategies.* L.S. Godwin (ed.) Honolulu, HI. February 12-13, 2003.

Floerl, O. and G.J. Inglis. 2005. Potential for the introduction and spread of marine pests by private yachts. Pp. 22-28. *In* Hull fouling as a mechanism for marine invasive species introductions: *Proceedings of a workshop on current issues and potential management strategies.* L.S. Godwin (ed.) Honolulu, HI. February 12-13, 2003.

Floerl, O., G.J. Inglis, H.M. Marsh. 2005. Selectivity in vector management: an investigation of the effectiveness of measures used to prevent transport of non-indigenous species. Biological Invasions. 7: 459-475.

Fofonoff, P.W., G.M. Ruiz, B. Steves, J.T. Carlton. 2003. In ships or on ships? Mechanisms of transfer and invasion for nonnative species to the coasts of North America. *In* Invasive species: Vectors and management strategies. G.M. Ruiz and J.T. Carlton (eds). Pp. 152-182.

Foster, B.A. and R.C. Willan. 1979. Foreign barnacles transported to New Zealand on an oil platform. New Zealand Journal of Marine and Freshwater Research. 13: 143-149.

Godwin, L.S. 2003. Hull fouling of maritime vessels as a pathway for marine species invasions to the Hawaiian Islands. Biofouling.19 (Supplement): 123-131.

Godwin, L.S., L.G. Eldredge, K. Gaut. 2004. The assessment of hull fouling as a mechanism for the introduction and dispersal of marine alien species in the main Hawaiian Islands. Bishop Museum Technical Report No. 28. Honolulu, HI.

Godwin, L.S. 2005. Development of an initial framework for the management of hull fouling as a marine invasive species transport mechanism. *In:* Hull fouling as a mechanism for marine invasive species introductions. *Proceedings of a workshop on current issues and potential management strategies*. February 12-13, 2004. pp. 47-54. Godwin, L.S. (ed).

Hay, C. and Dodgshun, T., 1997. Ecosystem Transplant? The case of the Yefim Gorbenko. Seafood N.Z. May 1997: 13-14

Hewitt, C.L., Campbell, M.L., Thresher, R.E., Martin, R.B., Boyd, S., Cohen, B.F., Currie, D.R., Gomon, M.F., Keough, M.J., Lewis, J.A., Lockett, M.M., Mays, N., MacArthur, M.A., O'Hara, T.D., Poore, G.C.B., Ross, D.J., Storey, M.J., Watson, J.E., Wilson, R.S. 2004. Introduced and cryptogenic species in Port Philip Bay, Victoria, Australia. Marine Biology. 144: 183-202.

Hirst, J. (personal communication, 3/22/2006)

International Association of Classification Societies (IACS). 2004. Classification societies – What, why, and how? Accessed March 2006. http://www.iacs.org.uk/.

International Maritime Organization (IMO). 1999. Antifouling systems on ships. Resolution A.895 (21).

International Maritime Organization (IMO). 2002. Focus on IMO: Anti-fouling systems. 31 pgs.

International Marine Coatings. 2006. TBT free antifoulings and foul release systems. Accessed October 15, 2005. http://www.international-marine.com/newbuilding/brochures/AF_Range_Brochure.pdf.

Lewis, J. 2002. Hull fouling as a vector for the translocation of marine organisms, Phase 3: The significance of the prospective ban on tributyltin antifouling paints on the introduction and translocation of marine pests in Australia. Department of Agriculture, Fisheries and Forestry – Australia. Report No. 2. 133 pgs.

Marine Invasive Species Act. 2003. State of California Assembly Bill 433. 2003 Regular Session. Passed September 24, 2003.

McEnnulty, F.R., Bax, N.J., Schaffelke, B., Campbell, M.L. 2001. A review of rapid response options for the control of ABWMAC listed introduced marine pest species and related taxa in Australian waters. CRIMP Technical Report No. 23. Hobart Australia. 101 pgs.

Meyerson, L.A., Reaser, J.K. 2002. Biosecurity: moving towards a comprehensive approach. BioScience. 52: 593-600.

Michin, D. and S. Gollasch. 2003. Fouling and ship's hulls: How changing circumstances and spawning events may result in the spread of exotic species. Biofouling. 19: 111-122.

Nehring, S. 2001. After the TBT Era: Alternative anti-fouling paints and their ecological risks. Senckenbergiana maritima. 31(2): 341-351.

New Zealand Ministry of Fisheries. Public consultation paper – proposed biosecurity (hull cleaning) regulations. Accessed February 8, 2006. http://www.fish.govt.nz/sustainability/ballast/hull-cleaning/consultation.htm

Nichols, F.H., J.K. Thompson, and L.E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Pomtamocorbula amurensis.* II. Displacement of a former community. Marine Ecology Progress Series. 66: 95-101.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics. BioScience. 50: 53-65.

Skerman, T.M. 1960. Ship-fouling in New Zealand waters: A survey of marine fouling organisms from vessels of the coastal and overseas trade. New Zealand Journal of Science. 3: 620-648.

Railkin, A.I. 2004. Marine Biofouling: Colonization Processes and Defenses. CRC Press. Washington D.C. 303 pgs.

Ranier, S.F. 1995. Potential for the introduction and translocation of exotic species by hull fouling: A preliminary assessment. Center for Research on Introduced Marine Pests. Technical Report No. 1.

Ruiz, G.M., P.W. Fofonoff, J.T. Carlton, M.J. Wonham and A.H. Hines. 2000. Invasion of coastal marine communities in North America: apparent patterns, processes and biases. Annual Review of Ecology and Systematics. 31: 481-531.

Ruiz, G.M., Miller, A.W., Lion, K., Steves, B. 2001. Status and trends of ballast water management in the United States. First biennial report of the National Ballast Information Clearinghouse. 45 pgs.

Ruiz, G.M., C. Brown, G. Smith, B. Morrison, D. Ockrassa, K. Nekinaken. 2005. Analysis of biofouling organisms associated with the hulls of containerships arriving to the port of Oakland: A Pilot Study. Pp.138-151. *In* Biological Study of Container Vessels at the Port of Oakland.

U.S. Commission on Ocean Policy. 2004. An Ocean Blueprint for the 21st Century. Final Report. Washington, DC. 520 pp.

IX. APPENDICIES

APPENDIX A

Hull-Borne Invasive Species Workshop
List of Attendees
May 11, 2005 ● San Francisco, CA

Marian Ashe
California Department of Fish and Game

John Berge
Pacific Merchant Shipping Association

David Breninger
Recreational Boaters of California

Margot Brown
National Boating Federation

Chris Brown
Smithsonian Environmental Research Center

Brad Chapman
Chevron Shipping Company LLC

Amy Chastain
San Francisco BayKeeper

Ashley Coutts
Cawthron Institute, Marine Biosecurity

Jeff Crooks
Tijuana River National Estuary Research Reserve

Holly Crosson
University of California, Davis, Department Environmental Science and Policy

Ian Davidson
Portland State University

Larry Draper
Recreational Boaters of California

Diane Edwards
California State Water Resources Control Board, Division of Water Quality

Susan Ellis
California Department of Fish and Game, Habitat Conservation Division

Terri Ely
California Department of Boating and Waterways, Aquatic Weed Control Unit

Carl Ernst
Marina Recreation Association

Maurya Falkner
California State Lands Commission

Sylvain Fillion
International Paint Company

Reinhard E.Flick
Scripps Institution of Oceanography, Center for Coastal Studies

Paul Gates
International Paint Company

Suzanne Gilmore
California State Lands Commission

Scott Godwin
Bernice Pauahai Bishop Museum, Hawaii

Jamie Gonzalez
University of California Sea Grant Extension Program

Allison Gordon
Pacific Coast Federation of Fishermen's Associations

Ted Grosholz
University of California, Davis

Brad Gross
California Association of Harbor Masters and Port Captains

Jon Gurish
California Coastal Conservancy

Marla Harrison
Port of Portland

Jeffrey Herod
U.S. Fish and Wildlife Service, Sacramento/San Joaquin Estuary Fishery Resources Office

Andrew Jirik
Port of Los Angeles

Leigh Johnson
University of California Sea Grant Extension Program

Jo-Anne Kushima
State of Hawaii, Dept. of Land & Natural Resources, Division of Aquatic Resources

Tim Leathers
MRA/Cabrillo Isle Marina

Mari Lou Livingood
Association of Marina Industries

Vivian Matuk
California Coastal Commission

Karen McDowell
San Francisco Estuary Project

Sarah Mongano
California State Lands Commission

Paul Murakawa
State of Hawaii, Dept. of Land & Natural Resources, Division of Aquatic Resources

William Needham
Harbor Safety Committee of the SF Bay Region

Peter Ode
California Department of Fish and Game

Deborah Pennell
Shelter Island Marina, Board of Directors MRA

Russ Robinson
Recreational Boaters of California

Greg Ruiz
Smithsonian Environmental Research Center

Dragan Samardzic
Matson Navigation

Jason Savarese
National Sea Grant Law Center

Guy Seabrook
Magellan Companies, Inc

Nan Singhasemanon
California Department of Pesticide Regulation

Lisa Sniderman
California Coastal Commission

Ernie Soeterik
Sherwin Williams

Mike Sowby
California Department of Fish and Game

Cindy Squires
National Marine Manufacturers Association

Jay Stachowicz
University of California, Davis, Section of Evolution and Ecology

Nancy Stein
Contra Costa County Department of Public Works

David Stephens
California State Lands Commission

Sean Svendsens
Svendsen's Boat Yard

Lynn Takata
California State Lands Commission

Drew Talley
San Francisco Bay National Estuary Research Reserve

Mariann Timms
Marina Recreation Association

Raynor Tsuneyoshi
California Department of Boating and Waterways

Valerie Van Way
California State Lands Commission

M K Veloz
Northern California Marine Association

Ted Warburton
California Association of Harbor Masters and Port Captains

Kim Ward
State Water Resources Control Board: Division of Water Quality

Chela Zabin
University of Hawaii, Manoa

Jody Zaitlin
Port of Oakland

APPENDIX B

California State Lands Commission
Technical Advisory Group Participants

** Denotes participants that attended at least one Commission TAG meeting

Cesar Alvarez**
California Sea Grant Extension

Marian Ashe**
California Department of Fish and Game

John Berge**
Pacific Merchant Shipping Association

Chris Brown
Smithsonian Environmental Research Center

Marina Cazorla
California Coastal Conservancy

Brad Chapman**
Chevron Shipping Company LLC

Ashley Coutts**
Cawthron Institute, Marine Biosecurity

Jeff Crooks**
Tijuana River National Estuarine Research Reserve

Holly Crosson**
West Coast Ballast Outreach Project

Ian Davidson**
Portland State University

Nicole Dobroski**
West Coast Ballast Outreach Project

Abe Doherty
California Coastal Conservancy

Diane Edwards
California State Water Resources Control Board

Susan Ellis
California Department of Fish and Game

Richard Everett
United States Coast Guard

Schauadi Falamaki
California Association of Port Authorities

Maurya Falkner**
California State Lands Commission

Sylvain Fillion
International Paint Company

Oliver Floerl
National Centre for Aquatic Biodiversity and Biosecurity, New Zealand

Paul Gates**
International Paint Company

Suzanne Gilmore**
California State Lands Commission

Scott Godwin
Bernice Pauahai Bishop Museum, Hawaii

Jamie Gonzalez**
University of California Sea Grant Extension Program

Ted Grosholz
University of California, Davis

Jon Gurish
California Coastal Conservancy

Jeffrey Herod**
U.S. Fish and Wildlife Service, Sacramento/San Joaquin Estuary Fishery Resources Office

Eric Holm
Naval Surface Warfare Center, Carderock Division

Andrew Jirik
Port of Los Angeles

Leigh Johnson
University of California Sea Grant Extension Program

Giselle Johnston**
California State Lands Commission

Dalia Keroles**
California State Lands Commission

Jo-Anne Kushima**
State of Hawaii, Dept. of Land & Natural Resources, Division of Aquatic Resources

Jackie Mackay**
California State Lands Commission

Vivian Matuk
California Coastal Commission

Karen McDowell**
San Francisco Estuary Project

Whitman Miller**
Smithsonian Environmental Research Center

Steve Moore
San Francisco Bay Regional Water Quality Control Board

Paul Murakawa
State of Hawaii, Dept. of Land & Natural Resources, Division of Aquatic Resources

Sarah Newkirk
The Ocean Conservancy

Peter Ode
California Department of Fish and Game

Henry Olsen
Matson Navigation

Stephen Philips
Pacific States Marine Fisheries Commission

Deborah Ruddock
California Coastal Conservancy

Greg Ruiz**
Smithsonian Environmental Research Center

Dragan Samardzic**
Matson Navigation

Tim Schott
California Association of Port Authorities

Linda Sheehan
California CoastKeeper

Lisa Sniderman
California Coastal Commission

Mike Sowby
California Department of Fish and Game

Jay Stachowicz
University of California, Davis

Lisa Swanson**
Matson Navigation

Mark Sytsma**
Portland State University

Lynn Takata**
California State Lands Commission

Drew Talley**
San Francisco National Estuarine Research Reserve

Kim Ward**
California State Water Resources Control Board

Steve Weisberg
Southern California Coastal Research Project

Rodney Young**
Hawaii Dept. of Land and Natural Resources

Chela Zabin
University of Hawaii, Manoa

Jody Zaitlin
Port of Oakland

APPENDIX C

Summary of the Hull-Borne Invasive Species Workshop
May 11, 2005
San Francisco, CA

Though the full workshop presentations and discussions examined the issue of introductions through fouling on both recreational and commercial vessels, the summary here focuses on topics that apply to the commercial industry. This text was prepared by staff of the California State Lands Commission so the agency may move forward with additional discussions regarding management recommendations for commercial vessels, as mandated by state legislation. A more complete proceedings document will be produced, to be collaboratively developed with the California Sea Grant Extension Program.

Morning Presentations

Greg Ruiz, Smithsonian Environmental Research Center:
Hull-Borne Aquatic Invasive Species Overview:

Dr. Greg Ruiz provided an overview on aquatic/marine/estuarine invasions, and specifically provided information on the relative importance of hull fouling and ballast water as vehicles for the introduction of alien species.   Commercial shipping is the largest means by which species are introduced to North America.   The rate of invasion due to this "vector" has increased exponentially in North America since 1790. These increases have been largest on the Pacific Coast. Ballast water and fouling are, in turn, the dominant shipping sub-vectors responsible for the largest number of invasions. The number of invasions likely due to fouling is growing in North America, and the rate of invasions through this vector may be increasing as well.

The Smithsonian has been conducting additional studies on the importance of the commercial vessel fouling vector. A preliminary estimate was conducted on the amount of vessel surface area arriving to the United States that may be colonized by fouling organisms. The estimate, based on vessel arrival data and vessel particulars from Lloyd's Registry, suggested that some 130-150 million m^2 of colonizable surface arrived to U.S. ports annually between 1999 and 2001. The Smithsonian is also conducting fouling plate surveys at sites throughout the coastal United States, British Columbia, and Alaska. Plates made of PVC, plastic and wood are deployed at sites to collect fouling organisms, later retrieved, and attached organisms are identified. Such studies will allow researchers to better understand the relationship between the number of organisms transported to North America via shipping (propagule supply), and the number of organisms that successfully establish reproductive populations (invasion success).

Scott Godwin, P.B. Bishop Museum:
Marine Invasive Species Transported by Vessel Hull Fouling: Potential Management Approaches

Hawaii has been highly impacted by invasive species, with approximately 343 introduced through human mechanisms, and approximately 212 are believed to have been introduced via vessel fouling. In 2003, the state began formulating an information framework to minimize introductions through the fouling vector. Prior to stakeholder discussions, studies were conducted on the dynamics of Hawaii port arrivals, and field surveys of fouling communities to inform the stakeholder meetings. High risk vessels fell into those with regular, predictable arrivals, and those that do not behave regularly (stochastic):

Stochastic, High Risk:

- Towed Vessel Platforms (i.e. floating dry docks, barges, drilling platforms)
- Derelict vessels
- Decommissioned Military
- Personal Craft

Predictable, High Risk:

- Towed Vessel Platforms

The stakeholder input effort began with a 2-day workshop in February 2003, and continued during meetings held through July 2003. The overarching goal adopted was, “Minimize marine alien species introductions by hull fouling,” since absolute prevention (no introductions) was deemed less realistic. The management strategies ultimately recommended by the task force to achieve this goal fell into three categories: proactive, reactive, and post-event.

- Proactive Measures:
    - Vessel traffic monitoring – to identify and respond to high risk situations
    - Strong inter-agency communication, particularly to assist with the monitoring effort of recreational vessel arrivals
    - Creation of a risk matrix (see notes below) to identify high risk situations that may warrant investigation
    - Education and outreach component to increase awareness of the issue with the maritime public
- Reactive Measure:
    - Rapid response investigation of high risk events/vessels identified during the proactive stage
- Post-event Measures:
    - Quarantine
    - Cleaning requirement & procedures for proper cleaning

A very preliminary risk matrix was drafted to prioritize high risk events that may warrant investigation. Factors that lead to a high risk determination were:

- Priority (high risk) vessels
- Last port of call was outside of Hawaii
- Vessel does not observe compliance standards, such as local codes of practice, or IMO International Safety Management codes
- Length of time vessel was inactive or laid up (long time = higher risk)

Ashley Coutts, Cawthron Institute (New Zealand):
An Overview of the Management of Biofouling on Vessels in New Zealand.

Vessel fouling is considered to be a very important vector for New Zealand invasives. Known invasives have originated from all over the world, with the top 3 source regions being the Europe/U.K./Mediterranean (48%), the United States (13%), and Asia/Japan (11%).

Management of the vector was initiated due to a Russian fishing vessel that arrived in 1993, remaining in New Zealand for 18 months with 90 tones of fouling. Pre-border management controls that have been put in place since then are:

Fishing Industry Codes of Practice:

- All chartered foreign owned or sourced fishing vessels must be substantially free from plant or animal growth prior to entering New Zealand's Exclusive Economic Zone (EEZ).
- If it is not free of fouling, the vessel must be inspected and cleaned prior to departure.
- If it arrives to New Zealand and inspections reveal the vessel to be significantly fouled, the vessel is cleaned in a manner that doesn't release organisms to the environment.

Outreach (primarily geared towards recreational boaters)

- Distribute information packs in the Pacific Islands (where personal vessels often originate), and at popular ports of entry to New Zealand.
- Distribute materials in yachting magazines.

Hull fouling questionnaire on ballast water reporting form (commercial vessels)

- When and where was the vessel last dry-docked and cleaned?
- Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If yes, state when and where?
- Do you intend to clean the hull of the vessel in New Zealand? If yes, state when and where?

Current Knowledge of Fouling:

- Merchant vessels have been observed to carry a substantial diversity of fouling exotics.
- Fouling extent is related to the age of paint, vessel speed, and voyage duration.
- Fouling is higher in sheltered areas or those lacking good antifouling paint coverage (i.e. recesses, dry dock support strips, sea chest gratings).

Current Research

- En route survival of fouling organisms
- Evaluation of organism viability after various cleaning methods are used
- Fouling type and extent across various vessel types arriving to New Zealand
- Efficacy of hull cleaning methods.

Dragan Samardzic, Matson Navigation:
Commercial Vessel Fouling Control

Dragan Samardzic provided an overview of Matson's corporate history, and characteristics of their regular trade routes to Hawaii and Guam from California. Fouling control is important to commercial shippers in order to protect the environment, reduce drag and save fuel, deliver goods more swiftly, and to protect the hull. Factors that affect fouling appear to be the type and condition of antifouling paint, locations where a vessel travels, the seabed type at ports and anchorages, and the speed of the vessel. U.S. flagged vessels typically go into dry dock approximately every 5 years for repairs, hull cleaning, and re-application of antifouling paint. As with Matson, hulls may be inspected more frequently by divers, and in-water cleaning occurs as needed.

Sylvain Fillion, International Paint Company:
Antifouling and Foul-Release Technologies

Sylvain Fillion provided an overview of the major antifouling (biocidal) and fouling-release (non-biocidal) coatings and their ability to reduce fouling on commercial vessels.

Biocidal coatings involve a "soluble binder" which is slowly released into the water and prevents organisms from attaching. The three main biocidal coatings are rosin-based, self polishing co-polymer (SPC), and a hybrid type (rosin/SPC combination). The best performing but most expensive are the SPC types, followed by the hybrid which is less expensive but less effective. The least expensive, but least effective biocidal coating is the rosin type, with an effective life of approximately 36 months on exposed portions of the hull.

Fouling-release coatings (non-biocidal) do not contain soluble binders, and are ultra smooth coatings that offer lower frictional resistance, and require less coatings on a vessel when compared to their biocidal counterparts. With such coatings, organisms may attach, but are easily knocked off with vessel movement or gentle removal. Vessels show little fouling after 25 months (primarily slime). After 25 months, vessels exhibit low amounts of fouling.

Jason Savarese, National Sea Grant Law Center:
Legal Overview

Jason provided an overview of local, national and international regulations related to vessel fouling control, antifouling paints, and government bodies involved with invasive species policy development. Though regulations related to both commercial and recreational vessels were covered, the summary here highlights those policies that relate to commercial vessels.

Regulations for Vessel Fouling:

- **Victoria, Australia**: Vessels of less than 200 tons must discard fouled organisms on land.

- **New Zealand**: Fishing industry has adopted codes of practice to clean vessels before leaving port, and require vessel maintenance and movement information from vessels in conjunction with ballast water reporting form (also see summary of presentation by Ashley Coutts).

- **Australian and New Zealand Environment and Conservation Council (ANZECC):** Adopted codes of practice for commercial vessels that discourage in-water hull cleaning wherever possible (also see talk by Ashley Coutts).

- **United States**: U.S. Code of Federal Regulation 33, and California law AB 433 requires rinsing of anchor chains of organisms at their place of origin, and regular cleaning of hulls, piping and tanks. Hawaii has formulated a management framework for the issue that may be lead to the implementation of policies in the future (see presentation by Scott Godwin).

Antifouling Coating Policies

- **The International Maritime Organization**: The convention on the Control of Harmful Antifouling Systems on Ships bans the use of organotins on vessels, or requires vessels to cover such coatings so they do not leach after January 1, 2008. However, ratification had not been achieved by the 2003 implementation date, and the convention is not yet in force.

- **Other Countries** have adopted regulations banning or restricting biocidal antifoulant use. **Australia** banned Tributyl tin (TBT) in 2006. The **Netherlands** banned TBT for recreational vessels in 1999, but allowed its use on commercial vessels. After 2000, antifoulants many be used in the **European Union** only after evaluation and approval.

- **In the United States**, the EPA has adopted recommended TBT discharge values for application with the Clean Water Act and other EPA regulations. California, Washington and Alaska restrict the use of TBT on commercial vessels.

Alternative Fouling Control and Water Quality Considerations:
Jamie Gonzalez, UC Sea Grant Extension Program

Though there is an international convention for the eventual phase out of TBT, biocidal copper-based paints will remain legal in many areas, and will likely be used quite commonly to prevent fouling. Due to the low circulation of enclosed basins and harbors, the leached metals build up in the water and sediments, causing various problems for organisms residing in them. A non-toxic bottom paint demonstration project was conducted by Sea Grant in San Diego on a small number of (recreational) boats, to test the efficacy of non-biocidal coatings. The results indicate that epoxy and ceramic-epoxy coatings may potentially last longer than copper paints, but require more frequent cleaning. In the long term they may be more cost effective under certain use conditions, though they are more expensive initially.

Speaker Question and Answer Session

A brief question and answer session was held for participants to pose questions to speakers.

In response to a question on their opinion with regard to the balance between water quality (especially with relation to biocidal paints) and the prevention of fouling, speakers suggested that; 1) the goals of the society should drive the management priorities, and 2) In the case of Hawaii, the management recommendations aimed towards minimizing fouling introductions did not conflict with the water quality regulations in place, but tended to compliment each other. The water quality issues were entrusted to the regulatory agencies that had more expertise and experience dealing with them.

In response to a question about the typical hull husbandry practices of the whole commercial fleet, it was noted that international standards for the cleaning of vessels exist depending on vessel class. The U.S. fleet follows these standards. In the case of Hawaii, it was not the U.S. flagged vessels that typically posed the most risk. The “flags of convenience” vessels and foreign fishing vessels typically pose the most severe risk, though these comprise a small percentage of the entire fleet that arrive to Hawaii.

Afternoon: Breakout Discussion Session

During the afternoon, participants were separated into three discussion groups, each consisting of a mix of scientists, regulators, recreational vessel stakeholders, and commercial shipping stakeholders. Groups were asked to address five questions:

1. Does vessel/boat fouling pose an invasive species risk that needs to be addressed?
2. What needs to be considered in solving the problem of hull transport of invasive species by recreational and commercial vessels?
3. Where, how, and when should vessels be maintained to prevent fouling ANS introductions?
4. What information gaps need to be closed?
5. What are the outreach and educational needs for AIS prevention in California for recreational and commercial boats?

Following the breakout discussions, all participants were reconvened, and representatives from each presented a synopsis of their respective discussions. Points of general (but not necessarily unanimous) agreement or discussion are included in this summary.

Question 1. Does vessel/boat fouling pose an invasive species risk that needs to be addressed?

The majority of members in 2 of the 3 groups believed that fouling posed a risk that should be addressed. One group felt that fouling posed a risk, but the severity of that risk, and where the majority of the risk fell with respect to recreational or commercial vessels was unclear.

Question 2. What needs to be considered in solving the problem of hull transport of invasive species by recreational and commercial vessels?

- Because it is not possible to predict what the next problematic invader might be, because control is generally much more costly than prevention, and because eradication is not typically successful, consider a vector-based management approach that minimizes introductions via the fouling vector as a whole.

- Consider incorporating a risk-based system that prioritizes high risk vessels or situations. Factors that may be used to evaluate the risk of a vessel or situation to consider are:
    - Vessel behavior (speed, sitting time)
    - Vessel type
    - Hull husbandry practices
    - Season
    - Age of antifouling paint
    - Vessel voyage route
    - Port region/location

- Consider a management framework based on the hull husbandry practices of vessels and boats (see question 3 below).

- Examine existing program models (i.e. Australia, New Zealand, Hawaii) to observe lessons learned and to avoid pitfalls.

- Consider water quality issues and regulations with respect to biocidal coatings.

- Any management measures proposed should incorporate a level of simplicity.

Question 3. Where, how, and when should vessels be maintained to prevent fouling ANS introductions?

Though there was no general consensus on what type of hull maintenance procedures should be adopted, discussions generated several potential practices that could be adopted, and the advantages and disadvantages of each. The points summarized below were topics that were raised by at least 2 groups.

- Periodically maintain antifouling coatings, with a preference for foul-release coatings (non-biocidal). One group suggested that coating application or cleaning periodicity could be certified to verify that a vessel has been maintained properly. At this time, however, it is recognized that non-toxic coatings are initially very costly, and are still currently undergoing testing and further development.

- Remove fouling organisms regularly from hulls as well as from other areas such as sea chests, anchors, etc. Ideally for ANS prevention, this would be done out of the water, however, this process is expensive and time consuming. In-water cleaning is more common and less costly, but current methods generally result in the release of fouling organisms into harbors or ports.

- One group suggested that a code for “Best Management Practices” could be adopted for fouling maintenance.

- Another group suggested that vessels could be cleaned upon departure from California and inspected upon return.

Question 4. What information gaps need to be closed?

- The relative risk posed by vessels based on vessel type, vessel behavior, and port conditions that increase potential risk (i.e. location, temperature).

- Current maintenance practices of vessels. One group suggested that this could be advanced through a survey that asks vessel operators or owners:
    - How long was the vessel at the last port of call?
    - When was paint last applied to the vessel hull?
    - When was the vessel last in dry dock for hull cleaning?

- Extent of biofouling as it is affected by factors such as:
    - Vessel type
    - Hull maintenance practices
    - Vessel activity

Question 5. What are the outreach and educational needs for AIS prevention in California for recreational and commercial boats?

- In general, outreach and education was deemed to be very important, and was particularly advocated for and by the recreational boating community. Potential vehicles for outreach discussed, therefore, applied largely to the recreational community. Suggestions that could be applied to the commercial industry included:
    - Advertisements/articles in industry publications (magazines)
    - Distribution of posters and brochures to commercial community
    - Internet/email distribution of information

- Communication between agencies involved with the shipping industry should be facilitated. In Hawaii, this is the major vehicle by which many high risk vessel movements are tracked (i.e. fishing vessels, barges, etc…).

- Increased communication between scientists and commercial/recreational stakeholders regarding magnitude of the invasive species problem.

APPENDIX D

Summary of the California State Lands Commission Technical Advisory Group Meeting

August 3, 2005
Sacramento, CA

Overview: Advisory Group Goals and Process

Following the welcome and participant introductions, a presentation was given of the technical advisory group goals (TAG), anticipated advisory group meeting process, and the information that will likely be considered for the final legislative report.

TAG Function: As outlined in Assembly Bill 433 passed in 2003 (AKA "The Marine Invasive Species Act"), the function of this TAG is to serve as consultant to the CSLC in its analysis of the relative risk of non-ballast, commercial vessel based vectors for the release of nonindigenous species to California waters. Further consultation with the U.S. Coast Guard and the State Water Quality Control Board is also mandated by the legislation. The CSLC will then submit a report summarizing an analysis and recommendations to the state Legislature by March 1, 2006.

Source of Report Input: The CSLC anticipates several sources of input for the final legislative report. In addition to TAG discussions, these will include:

- Review of scientific and grey literature on vessel fouling.
- Marine Bioinvasions Conference Discussions: The U.S. Coast Guard and Biosecurity New Zealand organized an informal discussion on the risk and management of vessel fouling for species introductions at the 4th Biennial Marine Bioinvasions Conference in New Zealand. The CSLC will participate, share information with the TAG, and incorporate applicable information into the report.
- Analyses of existing California vessel arrivals data. Additional analyses may also be completed and/or considered, but will be dependent on data availability, information needs uncovered, and time constraints.

Anticipated Framework for TAG Meetings

Though this framework is subject to modification, it is anticipated that a total of 4-5 TAG meetings will be held through December 2005 or January 2006. The first few meetings are or were intended to mutually inform all TAG participants, so discussions may proceed from a base knowledge of the issue. The current meeting continues the information sharing process begun during the joint workshop held on May 11, 2005 (see attached summary). The 3rd meeting will be scheduled for late September or early October, during which discussions will begin on recommendation frameworks. The 4th meeting is anticipated for November or December 2005, and will likely continue discussions around potential recommendations. If consensus or majority recommendations are not reached, a final 5th meeting will be held in early January.

Review of May 11th Workshop

An overview was given of speaker presentations and break-out group discussions from the May 11th workshop. Major points presented by speakers that applied to the commercial vessel side of the issue were reviewed (see attached workshop summary, and power point presentation from the August 3rd meeting).

<u>"Non-Ballast, Vessel-Based Vectors": What should this include? Can the list be prioritized?</u>

AB 433 lists several explicit areas on a vessel that shall be considered during the risk analysis of fouling introductions. These, "…include, but [will] not be limited to, hulls, sea chests, sea suction grids, other hull apertures, in-water propellers, chains, anchors, piping and tanks." The group was asked to discuss the list, if any area of importance should be added to the list, and if the items could be prioritized.

"Non-Ballast, Vessel-Based Vectors"

Two additional vessel areas/categories were suggested as a component to consider with the AB 433 list: **rudders**, and "**non-hull protected areas**". Non-hull protected areas would include regions of a vessel that are sheltered from water shear forces when a vessel is underway, such as bow thruster tunnels, rope guards, intakes or grills. Ashley Coutts noted that he has observed organisms in these anomaly areas during the course of his research. It was suggested that an alternative method for organizing vessel regions according to risk could be to split items into "laminar areas" (lower risk, i.e. exposed hulls) and "protected areas" (areas protected from shear forces – higher risk).

It was asked if the mandate was intended to include NIS transport connected to the transfer of goods, for example, those that may be moved with pallets or in packing material.

It was also noted that organisms which do not attach to the vessel surface and are thus not technically "fouling" organisms, may also pose a risk for introductions (Miller). These may be located on interstitial areas of the vessel or within sea chests, and are associated more frequently with slow moving vessels. For example, Ashley Coutts found large mature organisms, including decapod crustaceans (i.e. crabs) in sea chests.

Prioritizing Parts of a Vessel:

In many cases, the categorization of parts of a vessel into higher or lower risk categories was complex, as several factors interact with each other. A risk determination, therefore, will often depend on a number of variables acting in concert (i.e. location on a vessel, maintenance practices, vessel behavior, vessel location, etc.). In general, highest priority vessel parts could be considered a higher risk on all vessels, regardless of other factors. Lower priority areas on are likely low for many vessels, but could be considered a high risk on some depending on other factors. For example, the laminar hull of a fast moving vessel (low risk factors) that hasn't been repainted in some time and has spent substantial time in its last port of call could pose a significant risk.

Given these complications, areas that are likely of **higher risk** would include:

- **Hulls:** Laminar areas where antifouling paint coating is thin or old (i.e. dry dock support strips). Portions sheltered from shear forces.
- **Sea Chests:** Extensive fouling communities including large mobile organisms have been observed to inhabit sea chests.
- **Sea Suction Grids**: Intake grids have been observed to accumulate fouling.
- **Non-Hull Protected Areas:** described above.
- **Rudders:** Areas sheltered from shear forces, such as the stem, can accumulate fouling.

Though the designation of risk could depend on other interacting variables, **lower risk** areas may include:

- **Laminar Hull** areas that are well maintained (cleaned and painted).
- **Rudder** areas that are well maintained (cleaned and painted) and subject to the shear forces of the propeller.

Several of the items listed in AB 433 required clarification, and more information will be obtained prior to the next meeting in October.

- **Tanks:** It was unclear what type of tank this refers to (i.e. ballast, grey water?)
- **Piping:** It was unclear if this referred to the areas around intakes and outtakes or all piping.

For some vessel regions, the relative risk for fouling accumulation was unclear due to lack of knowledge or research:

- **In-Water Propellers:** Could be a lower priority due to the movement of the propeller, and safety issues associated with a fouled propeller. Chevron noted that they coat propellers with self-polishing antifouling paints (Chapman).
- **Anchors:** Some companies, such as Chevron, equip vessels with automatic mechanisms that rinse anchors with ambient port water as they are brought aboard (Chapman).
- **Rudders:** It is suspected that main portions exposed to shear forces may pose a lower risk, while protected areas may accumulate fouling (Coutts).

Environmental Characteristics That Influence Fouling

A pre-prepared list of characteristics was created based on the May 11th workshop, and the TAG was asked if there were environmental factors that would result in more or less fouling on a vessel, and if these could be prioritized. As with the prioritization of locations on a vessel, the relationship between level of fouling and environmental factors can be complex. Numerous variables likely interact and result in varying amounts of fouling, and varying rates of species survival.

Osmotic (salinity) and temperature stresses may be an important driver for the survival of organisms associated with vessels, and should be considered. It was noted that the relationship between survival and these variables is very complex, and more research needs to be conducted to better understand them. Several points for consideration were discussed.

- **Rapid and dramatic changes in salinity or temperature** are stressful for many organisms. In a management context, vessels arriving to the Great Lakes from high salinity ports, for example, may be a lower concern than those from other freshwater ports. Conversely, it was noted that voyages within the same latitude (similar temperatures) have been found to be especially problematic in New Zealand (Coutts).
- **Some organisms are adapted to tolerate wide fluctuations in temperature and salinity**. The issue was raised that, in theory, transits to and from high and low salinity organisms may serve to select for the hardiest NIS. Widely fluctuating conditions could possibly result in vessels arriving to port with organisms that are the most tolerant and thus more likely to invade.
- **The frequency and duration of freshwater exposure** is important for seagoing vessels (and organisms). Vessels that arrive to Portland, then sail to freshwater portions of the Columbia River, and thereafter return to Portland, are observed to be less fouled than when they initially arrived (Davidson). Also, observations from international voyages to and from Alaska, suggest that trips shorter than 12 hours are related to better survival (Coutts).

In addition to the physical tolerances of potential NIS, the variability of environmental salinity and temperature can be complex, and can be influenced by a number of factors that are not as straightforward as season or latitude. Several considerations were discussed.

- **Salinity will generally decrease in port areas during periods of high rain or snowmelt**. This occurs, for example, in Alaskan harbors. Conversely, periods of little freshwater input will generally result in higher salinities.

- **Depth of vessel keel**: A deeper keel would expose an organism to higher salinities, relative to shallower portions. Even if a vessel enters an estuary with a fresh surface salinity, deeper portions of the estuary and the vessel may experience higher salinities. Temperature, likewise, will vary with depth.
- **The sea chest environment may experience wide temperature and salinity fluctuations**, as ambient water is taken into a vessel through it for vessel operations. Nonetheless, they have been observed to have significant fouling communities.

Bottom Type
During the May 11th workshop, invited speaker Dragan Samardzic of Matson Navigation indicated that the harbor seafloor type is a factor that influences fouling, but the TAG was unfamiliar with this relationship. Lisa Swanson will touch base with Dragan and clarify.

<u>Vessel Behavior and Maintenance Practices That Influence Fouling</u>
As with environmental characteristics, the TAG was asked to discuss and prioritize vessel behaviors and maintenance practices that influence fouling. Research by Ashley Coutts revealed a striking relationship between the age of antifouling paint, voyage speed and voyage duration. Again, fouling levels can be influenced by several factors acting together, and consideration of any one alone would not be adequate to evaluate risk. In general the priority factors were considered to be:

- **Vessel Inactive/Layover Time**: The more frequently a vessel is sedentary, the more fouling it accumulates.
- **Vessel Speed**:
  - **"Fast" vessels** traveling approximately 15 KTS or faster may be considered a lower risk. Vessels traveling at 22 KTS or above for at least 3 hours has very little fouling (Coutts).
  - **"Slow" vessels** traveling approximately 10 KTS or slower are a high risk. Vessels that typically travel at 3 knots or less will have extensive fouling.
- **Age of Paint:** The older the antifouling paint, the higher the fouling. Studies in Tasmania indicate that copper based antifouling coatings less than 663 days old had the lowest levels of fouling (Coutts). Thereafter, fouling increased dramatically.
- **Voyage Duration:** Shorter voyages pose a higher risk.
- **Age of Vessel/Vessel Flag:** This factor is often correlated with the maintenance practices of the vessel owners. Companies that can afford new vessels, are also more able to keep them well maintained, and less fouled. These are also often correlated with the vessel's country of registry (Coutts). The maintenance of vessels are very dependent on operators, and poorly managed vessels/companies (i.e. irregularly scheduled, irregularly routed tramp vessels) should be a priority (Chapman).
- **Last Port of Call:** In New Zealand, a last port of call with a similar latitude is considered a higher risk.

<u>Hull Maintenance and Vessel Classification Societies</u>
John Berge of PMSA provided the TAG with information on classification societies, and their relationship to vessel hull maintenance. Classification societies are private (non-governmental) organizations that establish and apply vessel design and maintenance standards for vessels. Societies certify vessels that are maintained according to rules established by that society for a particular vessel type. The vast majority of the world fleet belongs to one of the 10 major societies, as current certification is important for insurance purposes.

Classification society rules include requirements for periodic hull maintenance. Though these are directed towards ensuring safety and structural integrity rather than NIS prevention, the frequency with which most vessels routinely clean hulls are dependent on the requirements of their classification. Prior to this meeting, John Berge conducted an informal survey of PMSA members on their hull cleaning practices, and those that responded (5) indicated that they typically follow the requirements of their classification society. In general these are:

- Dry dock every 5 years with extensions possible with favorable interim in-water inspections.
- Interim in-water inspections and cleanings (diver):
  - Self polishing coatings: 24-36 months after dry dock
  - Other Coatings: Every 6 months.

Dry docking occurs more frequently under certain circumstances:

- As a vessel ages, societies generally require more frequent out-of-water inspections
- In the event of an emergency, or an incident that raises concerns for hull integrity (i.e. significant scraping or bumping)

Due to the scarcity of dry docks available scheduling is very difficult, so vessels are generally not dry docked more frequently than needed or required. Dry docking is also expensive. Brad Chapman indicated that for Chevron, each day in dry dock costs approximately one million dollars for the docking, cleaning, and vessel repairs.

There is generally not a requirement to recoat antifouling paint during required dry docking intervals, however, most operators take advantage of the opportunity to clean, and paint or touch up their hulls. Cleaning and repainting during these periods is also in the best interest of the operators, due to safety concerns and costs associated with reduced fuel efficiency from fouled laminar hull areas. Many vessels conduct frequent performance tests to evaluate fuel efficiency, and conduct in-water (diver) cleaning accordingly (Berge). In-water cleaning takes approximately 1 day (Chapman).

Special Area Requirements: Vessels operating in certain areas or routes may also be required to maintain vessels more frequently. For example, all vessels operating in Alaska's Prince William Sound are inspected annually, and are taken out of the water every two years (Chapman).

Sea Chest Maintenance: Sea chests are coated and/or cleaned less frequently than laminar areas, as they are generally of less concern for fuel efficiency, and can only be accessed during dry dock. Cleaning may occur once every 10-15 years as needed, and the sea chest of a vessel nearing the end of its operational life may not be cleaned or painted.

Action Items

- Clarify definition of items from AB 433 list of parts of a vessel that should be considered: "tanks" and "piping"
- Determine if AB 433 applies to NIS introductions related to vessel cargo.
- Locate upcoming paper by J. Crooks that observed that NIS had a survival advantage over natives in harbor environments with relatively high contaminant concentrations. (Tally)
- Locate paper by Michin on the temperature and salinity conditions that trigger fouling community spawning events.
- Lisa Swanson will clarify with Dragan Samardzic regarding the relationship between sea bottom type and fouling.
- Contact Keith Hayes who has been studying risk assessment models for NIS based on environmental factors.

APPENDIX E

Summary of the California State Lands Commission Technical Advisory Group Meeting

October 13, 2005
Sacramento, CA

West Coast Ballast Outreach Project Update

Following welcome and introductions, Holly Crosson, Project Coordinator for the West Coast Ballast Outreach Project (Sea Grant Extension) provided a program update. The project has received funding for 3 additional years, during which Holly and Program Representative Nicole Dobroski will continue the outreach mission of the project. Planned activities include:

- Updated reprint of the "Stop Ballast Water Invasions" poster and associated brochure
- Re-initiation of the Ballast Exchange newsletter with expanded distribution
- Coordination with the California Maritime Academy on the development of a ballast related seminar series
- Creation of a new project website

Though the program's grant directs that the Project's efforts be focused on ballast water, there is the potential for other NIS issues, such as vessel fouling, to be addressed to a lesser extent.

TAG Input Framework – Meeting Goals

The overall framework for the TAG input process was reviewed. The goals of this third meeting were to examine existing management frameworks in other countries/states for vessel fouling and to discuss options for the California to consider. Staff intends to utilize discussions from today's meeting to construct "straw-men" management scenarios for discussion, criticism, deconstruction and/or revision at the next (4^{th}) meeting, planned for November or early December.

The TAG's final input to the CSLC is not required to be in any specific format. Considerations put forward may be explicit or general (i.e. guideline-like), and the final format will be up to the TAG. It does not necessarily need to be presented in a written document. AB 433 states only that the CSLC must consult with an advisory group (the TAG), and consider this input during the formulation of recommendations for the report to the state Legislature.

Action Items from Prior Meeting (August 3, 2005)

Non-Ballast Vessel Based Vectors List: Linda Sheehan (California Coast Keeper) was contacted for clarification on intent of AB 433 with regard to the type(s) of piping and tanks that were meant for consideration by this TAG, and if cargo-related NIS (such as those associated with packing material) were intended for consideration. She indicated that the terms were meant to have broad application towards anything that may involve NIS.

The Animal and Plant Health Inspection Service (USDA) announced that as of September 16, 2005 wood packing material (i.e. wooden pallets, boxes, crates, etc.) must be heat treated or fumigated prior to entering the United States to reduce the risk of pest introductions. The APHIS regulation would presumably address the issue of introductions via packing materials.

A question was raised weather recreational boats carried on commercial vessels might be subject to consideration by the TAG, for example, if they were fouled and later placed in a California harbor. Dragan Samardzic noted that during his years working on commercial vessels, he had never witnessed such a situation.

Fouling NIS Survival and Copper Contamination: Jeff Crooks summarized the findings of his recent study that compared the diversity of nonindigenous, and native fouling organisms in the San Francisco Bay Area (Tiburon) when exposed to varying concentrations of copper contamination. The results indicated that the diversity of natives declined with increasing contamination, while the diversity of NIS did not. These results suggest that contamination may have some bearing on the vulnerability of a system to invasion, in addition to traditional factors such as propagule pressure (number of organisms). The results are currently being drafted into a manuscript for publication.

NIS Transfer from Vessel to Port (Michin and Gollasch 2003): Ian Davidson provided a copy of a paper suggested during the last meeting, which described the effects of temperature on fouling introductions. Four mechanisms by which organisms attached to vessels can be transferred to a recipient port were also described:

1. A rise in sea temperature less than 3.6 ºF can trigger a wide range of species to spawn
2. Mobile species associated with fouling communities, such as crabs, can simply drop off
3. In-water cleaning releases viable organisms from a vessel to the water column or sea floor
4. The waste disposal practices of dry dock facilities may result in NIS discharge with effluent to a port.

The waste disposal practices of commercial dry docks in California are governed by National Pollutant Discharge Elimination System (NPDES) permits issued by the Regional Water Quality Control Boards under the authority of the Clean Water Act. The San Francisco dry dock is prohibited from discharging effluent directly into the waters of the state. Following repair operations, wash-down water is collected in holding tanks and discharged into the City of San Francisco's Treatment plant. Since the Regional Boards may have varying requirements for such discharges, Staff will investigate disposal practices of commercial dry docks located in Southern California.

Sandy Sea Bottoms and Fouling Accumulation
Dragan Samardzic clarified that the information shared during the May 11th workshop (vessels moored in sandy bottom areas tend to accumulate fouling faster than in other areas) was based on personal observation from his years working in the merchant shipping industry.

<u>Styela Clava (a Sea Squirt) Invasion in New Zealand</u>
Ashley Coutts shared news on a recently discovered invasion of a sea squirt to New Zealand. In August, the presence of *Styela clava* in Auckland (North Island) was confirmed by a scientist visiting from the United Kingdom for the Marine Bioinvasions Conference. Since then, it has also been observed in Lyttleton Harbor (South Island).

The species devastated the Canadian mussel aquaculture industry by smothering mussel lines and competing for food, resulting in a ~40% loss of production. There are concerns that it may cause similar impacts to New Zealand's mussel farming industry. Originally from Korea and introduced to Australia in the 1970's, the New Zealand invasion likely originated from Australia via vessel fouling. Larvae are only viable for 24 hours, and are thus not likely to have been transported via ballast water. A survey is currently underway to ascertain the geographic extent of the invasion, and to decide what management measures might be taken.

<u>Existing Vessel Fouling Management Practices (See appended Table, pg. 8)</u>
A table of management practices considered or adopted in other states/nations was distributed to the group prior to the meeting, and quickly reviewed. Strategies included:

- Codes of practice (antifouling paint application, cleaning periodicity, in-water cleaning restrictions/bans)
- Survey (New Zealand): vessel behavior/maintenance
- Risk-Assessment
- Regulations (Australia, vessels <25 m): Requirements for hull condition prior to entering Australian waters

Clarification of Merchant Classification Society Requirements: (See amended table, pg. 8). (Samardzic) The periodicity of interim in-water cleanings are not mandated, but are generally completed as noted in the table (every 2-3 years for self-polishing coatings), and are typically dictated by fuel consumption performance. Frequency of diver inspections is typically dependent on company requirements (Matson performs these quarterly).

Companies strive to control levels of fouling, as heavy fouling can only be removed through scraping, often down to exposed metal. Hard scraping removes antifouling coatings, eliminating protection from future attachment, and vessel operators prefer to avoid it. For example, Dragan Samardzic once observed vessels that had been stationary for 3-9 months in the tropics that had accumulated incredibly large and thick fouling organisms (esp. barnacles). Such fouling can only be remedied via scraping. It is uncommon to observe operators that continue running vessels without regard to fouling control. (Samardzic)

Effectiveness Codes of Practice and Surveys (Coutts, New Zealand): It was asked whether there was some sense for how widely applied and how effective non-mandatory codes of practice where. Initially, compliance was limited; however, compliance appears to have increased even without government enforcement for several reasons:

- Growing public awareness and support for biosecurity – education and outreach are very important
- Industry/company desire to avoid the hassle and embarrassment of being responsible for a new introduction (i.e. 1993 Russian trawler)
- The point above appears to have resulted in some level of industry self-policing

The vast majority of commercial vessels are clean, with the exception of the difficult to reach nooks and crannies on any individual vessel. The majority of ocean-going recreational boats (i.e. yachts) are also clean, as most owners have the incentive and financial ability to maintain them. It is the exceptional, stochastic vessel types/events that pose the most risk, such as vessels that travel at slow speeds, military vessels that are sold or moved after being laid up, the small minority of vessels/owners uninterested in maintenance, etc. It was this logic that led to the development of the Hawaii risk matrix.

The survey included on the ballast water declaration appears to serve mainly as an information gathering tool, rather than for targeted investigation or enforcement. By the time a form is received and processed, the vessel has typically departed.

Can it be assumed that risk factors observed in New Zealand apply to California?
(Ruiz) With the caveat that direct studies are lacking the Northern Hemisphere, it is likely that, in general the characteristics of highest risk vessels for California will be very similar to those in New Zealand (slow movers, long lay-up). Also as in the Southern Hemisphere, the expectation is that fouling on any given vessel will be generally low with small “hot-spots” of heavier fouling (the “nooks and crannies”). However, the specific magnitude of risk for North America is not clear. Even for the Southern Hemisphere where the majority of recent research has been conducted, studies are limited, covering small sample sizes, a limited number of vessel types, vessel behaviors, cleaning practices, and routes. How the diversity of fouling organisms on vessels in North America will stack up is unknown.

Priority Research Questions and Information Needs

Given the lack of research/information on vessel fouling as a NIS vector in North America and California, CSLC anticipates that further data gathering will likely be included as a recommendation. The TAG was asked which questions might be the most important for directing future management options and for furthering the basic science of the field.

Surveys on the species and extent of biota arriving to California ports via commercial vessel fouling were considered one of the highest priorities. Discussion indicated that such studies should be coupled with information on several vessel variables to elucidate relationships with NIS introduction risk:

- *Vessel type* – include a broad cross section of vessel types
- *Vessel behavior* - voyage speed, lay over time, etc.
- *Maintenance practices* - frequency of in-water cleaning and out of water cleaning
- *Transit route(s)* – prior ports of call. Supplemental information could be obtained from the USCG for the last 3 ports of call.
- *Antifouling coating age and type* - (Coutts) As the phase out of TBT-based coatings proceeds, invasion patterns may shift in response to increased use of Copper-based coatings. (Samardzic) Many companies have already moved away from TBT coatings. (Gates) As of 2005, TBT paints could not be sold in the U.S., and all vessels must have sealed (covered) or removed such paints by 2008.

Aquatic Bioinvasion Research and Policy Institute (ABRPI), a partnership between the Smithsonian Environmental Research Center and Portland State University, are currently initiating a study with funding from CSLC, which intends to address many of the above priority research. Current research aims to:

- Estimate "wetted surface area", or vessel surface area that may be colonized by fouling organisms, that moves into and out of U.S. West Coast ports.
- Investigate pilot methods for biological surveys of fouling organisms across vessel types coming into and out of these same ports.

Future components of the research would include a characterization of fouling communities across vessel types, source ports (transit route), and vessel behaviors (maintenance, residence time, etc). Together, these data sets would then enable an analysis of the overall magnitude of NIS moving through West Coast Ports.

Information on vessel operations and maintenance factors tied to fouling: Information on vessel activities that might influence fouling extent and accumulation was considered a high priority, and would be extremely useful if combined with biotic surveys of fouling (described above). Such information could be collected via a vessel survey, with questions related to dry docking, cleaning, painting, and/or laid-up periods, etc.

Potential survey in conjunction with CA SB 771: California Senate Bill 771 passed in September (2005) requires the CSLC to conduct a 1 year survey of arriving vessels for greywater/blackwater discharge issues. The CLSC could devise 2-4 targeted fouling related questions in consultation with the scientific community, and add them to this survey. This approach would minimize the number of forms required of arriving vessels, and would collect information that could compliment the biotic surveys.

Information could also be gathered through shipping agents, CSLC inspectors, and coordinated communication with USCG.

Fouling on military vessels: Virtually nothing is known about the fouling levels on military vessels, though some likely exhibit high risk behaviors. For example, vessels in the "Mothball" fleet (out-of-service military vessels) have been moored in Suisun Bay (San Francisco Bay Region) for extended periods, and likely contain substantial fouling communities. Transport of such vessels would constitute a high risk event. Unfortunately, research access to military vessels is extremely difficult to obtain. In addition, AB 433 specifically exempts military vessels from its authority, and they are instead subject to the Uniform National Discharge Standards for Vessels of the Armed Forces.

Cruise/passenger vessels have been observed to have substantial communities in sea chests, and their voyage patterns may be of particular importance. Such vessels tend to visit pristine areas (marine parks, wilderness areas) that may require higher levels of protection. They make frequent trips on regular routes to international locations (i.e. California to Mexico, California to Canada), increasing NIS exposure from specific regions (repetitious inoculations).

Stochastic, theoretically high risk vessels, such as slow moving towed structures, foreign fishing vessels, derelict vessels, should be examined or monitored in California, due to the disproportionately high risk they present in Hawaii and New Zealand. For California, towed drilling platforms may be of particular interest as these may occasionally be moved to other regions in the U.S. and Canada.

Role of route and freshwater exposure: There is evidence that freshwater exposure dislodges/inactivates many organisms attached to vessels, suggesting that seagoing vessels that spend some period in freshwater may pose a lower risk in some situations. This effect, and its implications for NIS introduction potential, should be investigated.

Colonization from vessel to port: The mechanisms by which organisms may transfer from a visiting vessel to a recipient port, through spawning or in-water cleaning for example (Michin and Gollasch 2003), are important research areas, however, may be of less immediacy given information gaps in more critical areas. In the meantime, it would be good to assume that high levels of fouling on a vessel equate to high risk for introduction to a port.

Long term monitoring of NIS, such as the CDFG coordinated monitoring, should clearly be continued. Long term monitoring will be key to evaluate how invasion patterns change with ballast water management, ballast water treatment, and the phase out of TBT. This will also be the primary information needed to attempt to evaluate the effectiveness of management activities.

<u>Potential Management Strategies for California</u>

The TAG was asked to discuss the following question, "Considering what's known/not known about fouling and other non-ballast water vessel vectors, what management strategies should or could California consider?"

Further research and vessel operational/maintenance information collection via surveys (as discussed in the prior section):

- Clear priority
- Some members felt that more information and/or research was needed before regulations or restrictions should be implemented.

Codes of Practice:

- At a minimum, these should be developed rather than postponing action until more information is gathered. These could be particularly important if it is decided that it is premature to implement restrictions or regulations.
- Could expand upon the maintenance requirements of merchant classification societies.

Requirements for regular sea chest painting and cleaning

- It was noted that most vessels currently paint sea chests every 5 years.
- Water used to cool a vessel's engine is brought in through sea chest openings. Chlorination systems typically operate to keep cooling system components unobstructed by growth, and sea chests are exposed at some level to the de-fouling action of these systems.
- However, researchers have observed that some sea chests are very clean while others are not. Since many vessels have multiple sea chests, it may be that the operational condition of chlorination/cleaning systems varies in each one, or that the exposure of sea chests to these systems varies.

Support or incentives for the development of in-water cleaning technologies that eliminate or reduce organism release into the water. There are a small number of technologies in developmental stages that reduce particle release during in-water cleaning; however, none are known to be ready for commercial distribution:

- U.S. Navy (Jerry Bohlander) – First presented the development of a technology some years back, but current status is unknown.
- 2 companies in NZ claim they have a technology developed that contains organisms as small as 60 microns. System testing will begin in November (2005), and the results may be available in approximately a year.

A major disadvantage of these prototype systems is that they have difficulty reaching the recesses & crevices where fouling is commonly highest. They perform best on exposed laminar surfaces, where fouling is generally the lowest.

Though the ANZECC and some Australian ports promote codes of practice that prohibit in-water cleaning, it's not clear that such prohibitions are beneficial in all situations (i.e. on heavily fouled vessels). In-water cleaning bans also do not a create win-win situation for environmental protection and commercial shippers. Support or incentives for the development of in-water cleaning technologies have the potential to create a mutually beneficial solution for all parties

Define parameters for a risk matrix, and implement action on high risk vessels. Since the vast majority of the arriving fleet will likely present a low risk, it was suggested to focus attention on infrequent, high risk occasions (poorly maintained, slow movers, extended sitters). Some suggestions for action that could be taken were:

- Inspection
- Cleaning requirements/case-by-case permits for cleaning
- Quarantine
- Restrictions on port activities

Outreach and Education: An outreach and education component to the merchant shipping industry should be included as part of any recommendations.

APPENDIX F

Summary of the California State Lands Commission Technical Advisory Group Meeting

December 19, 2005
Sacramento, CA

Proposed Vessel Dismantling Operation in Oregon & Suisun Bay Mothball Fleet
Ian Davidson provided a brief overview on the developments related to a proposal by Bay Bridge Enterprises to establish a ship dismantling operation in the Port of Newport, Oregon. Should the proposal move forward, the deactivated vessels from Suisun Bay (AKA the “Mothball Fleet”) may be moved to Oregon for deconstruction. Originally, relocation was planned for February, but has been postponed due to vocal opposition over the potential for contamination and NIS introductions. It is likely that an EIS will be prepared, and the TAG was asked monitor the federal register notice for the EIS and send comments.

It is unclear which federal or state environmental regulations will have to be followed prior to relocation efforts since most, if not all of the fleet is composed of military vessels. Kim Ward indicated that if California state water quality issues come into play, jurisdiction and oversight would fall to the Regional Water Quality Control Board. Karen McDowell volunteered to find out if anyone from the RWQCB has been monitoring the issue.

Several related newspaper articles from the Oregonian, Portland’s main newspaper, were distributed to the group. A December 18th article focused specifically on the issue of potential fouling NIS introductions through the relocation activities. Quoted representatives from the Maritime Administration (MarAd), and from the Texas Parks and Wildlife Department (where some vessels have already been moved) were unaware of the hull fouling issue.

Hull Husbandry Survey for 2006
As discussed during the last TAG meeting (October 13th), 4 questions related to the hull fouling husbandry/fouling control practices were formulated with input from members of the TAG from the scientific community. The questions are designed to supplement biological studies, and were distributed in conjunction with the 2006 California Clean Coast Act survey (see attached document).

The distribution of the survey was targeted at vessels arriving to California, however, it was noted that it would be advantageous if the hull husbandry survey could be distributed more widely. The CSLC welcomes other states to utilize the survey if they are interested. It was noted that vessel identification was missing from form, and the IMO number and vessel name will be added to an amended form. It was also noted the specificity of the question about the type of antifouling treatment applied was unclear (Chapman). If the form is revised, the question and/or the instructions for this question may also be revised.

Overview of TAG Discussions Thus Far
Throughout the TAG discussions since May, several considerations have been identified that frame the development of recommendations

- Vessel fouling poses an NIS risk that needs to be addressed
- Specific knowledge on the nature of fouling risk factors for N. America and California is very limited
- There is generalized knowledge on fouling risk factors, based on studies conducted in New Zealand and Hawaii

- Dry docks are in high demand and booked well in advance. There is little flexibility for unplanned scheduling.
- Biocidal antifouling paints pose water quality problems
- Much of the merchant fleet is well maintained, and likely pose lower NIS risk
- Occasional/stochastic vessels likely pose significant NIS risk

During the last TAG meeting (October 13th) several potential management frameworks were discussed and prioritized in very broad terms. These were: Information gathering/research, codes of practice, sea chest maintenance requirements, incentives/support for in-water cleaning technology development, and regulatory action on stochastic high risk vessels.

Straw-Person Management Options

Based on discussions from the October TAG meeting, Staff formulated a set of straw-person management scenarios to generate discussion and constructive criticism during this meeting. TAG members were asked to provide feedback on why options were favorable or not, if or how an option might be improved, and to consider which management ideas might be appropriate both for now and for the future. Scenarios ranged from education and outreach to regulatory action, and were distributed on a handout (see attached document). These were then discussed systematically by the group.

Discussion: Straw-Person Management Options – Outreach

It was noted that a lack of knowledge on fouling and associated NIS risk was underscored by the Oregon ship dismantling operation controversy. It will therefore be important to increase awareness amongst agencies or companies that may be involved in activities that pose a high fouling risk, and with state and federal entities involved in policy development and decision making (Ruiz).

Discussed entities that may warrant targeted outreach, and avenues for reaching them were:

Commercial Shipping Industry

- **Target Companies**: salvage operations, dry dock facilities, oil platforms, vessel towing companies
- **Articles for industry publications** such as Pacific Maritime, and maritime listservs
- **Commercial dive companies** that clean and inspect vessels

UC Sea Grant Extension/West Coast Ballast Outreach Project has several initiatives planned that may be potential avenues for outreach:

- Seminar series in conjunction with the California Maritime Academy - the fouling issue could be a topic area covered.
- Advisory Committee meeting January 17th for input on NIS issues and outreach recommendations
- Regular mailings and/or distribution of pamphlets could include fouling education materials, for example, an insert in the ballast water brochure
- Special workshop organization and coordination.
- Inclusion of fouling information on their website
- Articles in their newsletter

State Resource Agency Networks:

- **California Association of Professional Scientists** (state scientist union)

- **Western Regional Panel of the ANS Task Force** meetings are organized by Susan Ellis (California Department of Fish and Game) however, this group meets somewhat irregularly and informally

Federal Agency Priorities and Information Networks

- **Maritime Administration**: has an environmental officer for the western region. Dragan Samardzic will locate his contact information.
- **ANS Task Force** is composed of a network of federal agencies for the purposes of coordination and communication. Scott Newsham (executive secretary, ANS Task Force) may be a good contact.
- **Additional agencies that should be priority outreach targets**: U.S. Army Corps of Engineers, Military, Fish and Wildlife Service, Minerals Management Service
- **Outreach to legislators, such as Sununu and Boxer** through letters or other avenues.
- **Washington DC meetings/briefings** geared towards informing Congressional staffers on relevant current issues and may be good networking/outreach opportunity. These occur throughout the year, and an option could be to sponsor an event through a program such as the Oceans Caucus, or participate/organize events that receive media attention such as the National Invasive Weeds Awareness Week held in DC.

Discussion: Straw-Person Management Options – Vessel Surveys

The TAG was asked if a mandatory vessel survey would be beneficial. It was noted that a survey similar to New Zealand's could be very useful, however, without an associated penalty for non-reporting, submission rates will be less effective (Davidson, Miller). It was suggested that fouling questions could also be asked by CSCL inspectors during boarding (Ruiz). If a mandatory survey is implemented, it was suggested that the industry be involved with the formulation of questions to ensure that they are clear and reasonable (Chapman).

Discussion: Straw-Person Management Options – Hull Maintenance: Codes of Practice & Requirements

Straw person scenarios outlining specific hull cleaning and coating practices for codes of practice (COP) and maintenance requirements were identical, however, the COP version would be optional whereas requirements would be mandatory. These options are summarized together here, because discussions generally applied to both.

It was noted that promotion/distribution of any COP should be accompanied with information on their rationale and purpose, and with a contact for more information (Ruiz).

Time periods specified in the cleaning requirements (clean within 6 months; coat within 3 years of arrival, 2 week lay-up) generated notable discussion. It was noted that these place holder periods were somewhat arbitrary (Sytsma) and it was unclear if vessels that meet these criteria would constitute a high risk. The TAG was unable to suggest more appropriate time frames. A complicating factor is the variability of fouling rates due to environmental factors. In particular, fouling accumulates faster in warmer waters depending on geographic location. In addition, some antifouling paints are designed to last up to 10 years, and are more effective if not scraped. Frequent cleaning on these coatings may not improve hull cleanliness, and could exacerbate fouling (Gates, Samardzic)

Idea - Dive inspection rather than cleaning or coating: A suggestion was put forward to request (in the case of COP's) or require (for regulations) dive inspections, rather than cleaning or coating, if certain criteria are not met by vessels prior to arriving in California (e.g. not cleaned within 6 months, not coated within 3 years, laid-up more than 2 weeks) (Falkner, Chapman). This could be coupled with a requirement to provide the inspection documentation to the CSLC.

If an inspection requirement was implemented, standardized protocols for the survey and collection of specific types of data would need to be developed to ascertain relative fouling risk. Criteria would also need to be developed to discern acceptable versus unacceptable fouling condition (Samardzic). Currently, inspection procedures are performed according to the requirements of classification societies or owners, and focus on mechanical and structural aspects rather than on biological issues (Gates, Samardzic). Inspection reports are unstandardized and narrative in format, typically noting only problems. They are also not conducted in low visibility conditions (~30 ft or less), and are thus not often conducted on the U.S. west coast. (Chapman)

Inspection videos are typically taken during diver inspections. If these or photographic images could be collected in a standardized manner, they could provide information for inspection purposes and also biological data for research. Images and video reduce error and are less subjective for data collection and evaluation. Vessel masters also seem to be extremely interested in this type of information, so they may monitor operational aspects of their vessel. (Ruiz)

Fuel Consumption as an indicator for fouling: It was asked if fuel consumption is related to fouling accumulation (Berge). There is a relationship between higher levels of fouling and lowered fuel economy, though engine or mechanical problems can also cause increased fuel consumption (Chapman, Samardzic). Chevron has been investigating the relationship, and Brad Chapman will provide information that is available.

Discussion: Straw-Person Management Options – Regulatory Action on High Risk Arrivals

Identification of a high risk vessel will be critical for determining which will be subject to regulatory action (Berge). The TAG was thus asked to consider what criteria might be used. Some extraordinary cases, such as the Suisun Bay Mothball fleet movement, are very likely high risk situations (Davidson). However, though it is known which general factors constitute higher risk (slow speed, long lay-up, high temperature, etc.), in less extreme cases it is not clear where an acceptable delineation between high and low risk might lie for California. The concept of locating potential high risk vessels for closer investigation is good, but it is not clear if it would be most appropriately implemented as a data gathering activity, or as a regulatory action (Ruiz). At this point in time, it may be best to flush out the characteristics of a high risk vessel, and develop options for what may be done with high risk arrivals, both today and in a few years as new technologies are developed (Ruiz).

Responsibility and resources: If inspections or investigations were implemented, it was asked which agency would be responsible for conducting them (Crosson). It will be important to make this determination, and to identify funding that would be needed for such personnel intensive efforts (Falkner).

Actions on high risk arrivals: If a vessel was determined to be a high risk arrival, the TAG was asked to consider what actions might be taken.

> **A requirement for out-of-water-cleaning** would be difficult to implement due to dry dock demand and scheduling issues, particularly since vessels in this situation would likely be irregular and unplanned (McDowell). An in-water cleaning would not be protective (Chapman).
>
> **Fine or fee:** To be effective, any fine or fee should be higher than the cost of cleaning the vessel, however this would not be protective once a vessel has already arrived in port (Ashe). A fine could also be subjective, unless specific criteria were used to evaluate fouling accumulation (Berge).
>
> **Quarantine:** It was suggested that an area outside of a port, possibly a low current area offshore, could be dedicated towards inspections and in-water cleaning (Samardzic). Identification of such a site would be difficult, however (Ashe), as NIS spread to other areas would still be a potential problem. The state of Hawaii has been investigating potential quarantine sites which would be sacrificial in nature, but have not yet been successful (Kushima).

Require vessel remedy problem or deny return: An idea suggested was that if a high risk vessel arrives, require that they remedy the problem before their next visit, and provide documentation that they have done so (e.g. diver cleaning and inspection). If they do not comply, deny entry on the next visit to California (Chapman). A similar type of procedure is used by the Coast Guard. It was noted that though the CSLC's has authority to deny entry, it has never been used and could be challenged (Berge, Falkner).

Action on extreme risk arrivals: Though there is not enough knowledge at this point in time to discern between high and low risk vessels for California, it was noted that the state could attempt to define an extreme risk criteria. For example, a vessel laid up for 30-50 years such as those in the Suisun Bay Mothball Fleet would fall into an extreme risk category. Such vessels could be subject to meet certain criteria before entering California waters, or face penalties.

Discussion: Straw-Person Management Options – In-Water Cleaning Restrictions

In-water cleaning using a technology or technique where fouling material is contained and collected (not allowed to enter the water column or seafloor) was discussed both as an action that could be implemented on high risk arrivals, and as the only in-water cleaning method allowed in California on any vessel. Though vacuum type-technologies are under development by the Navy, and by companies in New Zealand and Hawaii, none are currently available for commercial application (Kushima, Samardzic). Biological evaluation will occur during 2006 on the New Zealand technology. Other technologies may warrant investigation, such as the limno-curtain used to contain biocides applied to freshwater plant pests.

It was asked what size class fouling organisms typically fall under (Berge). Most research has been focused on larger organisms. There may still be an issue with smaller organisms such as algae spores and microbes, but little research has been done on organisms in these size classes (Ruiz). It was also asked what size filter might be appropriate, say, if a contained in-water cleaning technology utilized one to eliminate organisms prior to discharge in the water column (Falkner). It was suggested that a 50-80 micron mesh might be appropriate, according to unevaluated, best scientific judgment (Ruiz). This would not, however, address microorganisms or algal spores (Ruiz).

Points of General Agreement:

- Outreach on vessel fouling as a vector for NIS introductions is a clear priority. Companies engaged in potentially high risk operations, resource agencies, and policy-making entities should be priority outreach targets.
- Biological research on levels and type of fouling on vessels that arrive to California is important.
- Vessel surveys on behavior and maintenance factors that influence fouling will be important to compliment biological research and for the development of risk evaluation.
- The identification of conditions and criteria that constitute a high risk arrival to California/West Coast is needed for the development of regulatory management frameworks.
- For vessels identified as high risk, the development of response measures that prevent NIS release is needed.
- The development of technologies that contain and collect fouling effluent during in-water cleaning is needed.
- If a requirement for diver inspections is implemented, standardized survey methods, data collection protocols, and video/image collection procedures will also need to be developed.

X. ACKNOWLEDGEMENTS

Special thanks to Ian Davidson for providing preliminary data and text in Section V on the wetted surface area of commercial vessels arriving to California ports.

Staff would also like to extend its sincere appreciation to the following people for contributing a substantial amount of their valuable time and expertise to the development of this report:

Marian Ashe

John Berge

Brad Chapman

Ashley Coutts

Jeff Crooks

Holly Crosson

Nicole Dobroski

Richard Everett

Oliver Floerl

Paul Gates

Scott Godwin

Jeffrey Herod

Jo-Anne Kushima

Karen McDowell

Whitman Miller

Greg Ruiz

Dragan Samardzic

Lisa Swanson

Mark Sytsma

Drew Talley

Kim Ward