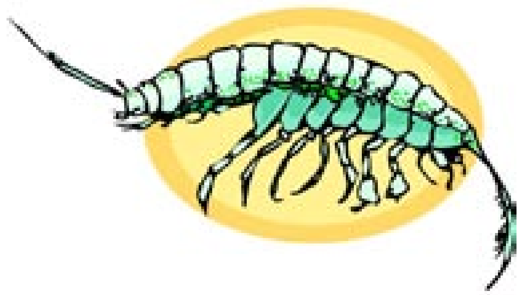
Managing Hull Transport of Aquatic Invasive Species



Proceedings of May 11, 2005 Workshop in San Francisco, California

Sponsored and Conducted by
University of California Sea Grant Extension Program
and
California State Lands Commission

Jamie A. Gonzalez and Leigh T. Johnson, Editors

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Acknowledgments

We wish to thank the broad range of organizations that cooperated to support this workshop.

We gratefully acknowledge the contributions of Maurya Falkner and Lynn Takata of the California State Lands Commission as full collaborators in planning, convening and sponsoring the workshop and in reviewing the proceedings.

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Introduction

University of California Sea Grant Extension Program and California State Lands Commission collaborated to convene the *Workshop on Managing Hull Transport of Aquatic Invasive Species* on May 11, 2005 in San Francisco, California. Sixty-six people representing shipping, boating and coating businesses, vessel owners, and government, environmental and academic organizations attended. They listened to presentations by experts and then deliberated on how best to prevent and control hull transport of aquatic invasive species (AIS). Cost and environmental quality were considered in their deliberations, along with policies, technologies and practices.

Purpose: Lay a foundation for developing solutions to prevent and/or control hull transport of aquatic invasive species.

Problem Statement: Aquatic invasive species attach to all types and sizes of vessels. Measures to prevent and control the hull transport of AIS are necessary as they can have significant ecological and socio-economic impacts.

Workshop Goals:

- Educate stakeholders and facilitate the exchange of perspectives on managing hull-borne invasive species, fouling growth and coastal water quality from the commercial shipping and recreational boating perspectives.
- Develop recommendations on managing the risks associated with the hull transport of invasive species as well as feasible, effective strategies for preventing associated introductions.
- Determine recommendations for action such as research, education, outreach, management measures and policies needed to prevent and control AIS introductions and establishment.

Topics addressed in presentations and/or deliberations:

- Introduction to AIS that may be transported on hulls
- How vessel hulls serve as a vector of AIS
- Ecological, socio-economic, structural, other impacts of AIS
- Status of AIS hull transport and control measures in Hawaii and New Zealand
- Effects of vessel use patterns on attachment and development of fouling organisms
- Existing AIS-related laws and policies
- Potential control measures for AIS hull transport
- Pros and cons of each type of control measure
- Technologies, management measures and policies needed to implement effective prevention and control of AIS hull transport in California

Although it was not discussed during the Workshop, there is a need to establish regional coordination from British Columbia to Baja California to address AIS introductions.

A summary of the Workshop presentations and findings follows. Each presentation includes the speaker's photograph, PowerPoint™ slides, and oral commentary. Workshop findings will also be incorporated in the following:

- White Paper and Policy Analysis to be prepared by the University of California Sea Grant Extension Program on issues related to recreational vessels and
- A report with recommendations for the management of this vector on commercial vessels in California, to be prepared by the California State Lands Commission.

To obtain copies of this and related reports, contact California Sea Grant Communications at (858) 534-4446 or the editors listed in the report.

This report is also available at:
http://seagrant.ucdavis.edu

Click on Publications in the bar at the top of the home page.

For more information on preventing hull transport of AIS, you may contact the Conference Co-Chairs:

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We wish to thank the speakers and participants at the Workshop as well as the following organizations who cooperated to support the Co-Chairs, the workshop and these proceedings. The comments expressed herein do not necessarily reflect the views of any of these organizations.

- California State Lands Commission
- University of California Agriculture and Natural Resources – Cooperative Extension – Sea Grant Extension Program
- California Sea Grant College Program
- National Oceanic and Atmospheric Administration
- U.S. Fish and Wildlife Service
- National Sea Grant Law Center
- California Resources Agency
- California Department of Boating and Waterways
- Pacific States Marine Fisheries Commission
- Western Regional Panel of the Aquatic Nuisance Species Task Force
- County of San Diego

Proceedings Evaluation

May we please have your assistance in evaluating the Proceedings? Your comments will be very important to us in documenting the effectiveness of our educational programs. To do so, please complete the evaluation at the end of the Proceedings. You can return it via email or you can print and mail or FAX it. Thank you!

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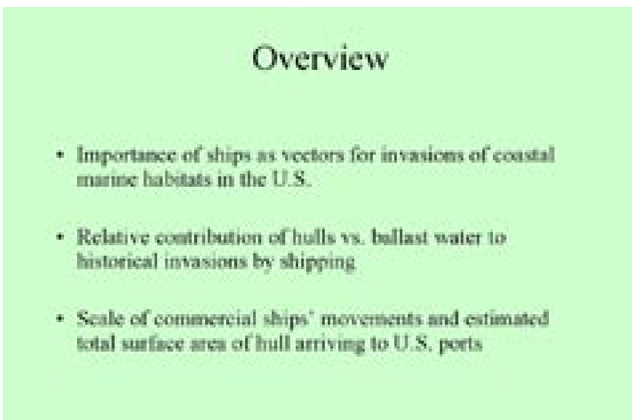
Special note:

As defined in the Marine Invasive Species Act of 2003 (AB433), "vessel" means a vessel of 300 gross registered tons or more.

During the Workshop the word "vessel" was used to identify both ships and boats. In the following Proceedings, unless otherwise noted, "vessel" refers to both ships and boats. ■

Overview of Ships as Vectors for Invasions of Coastal Marine Habitats in the United States

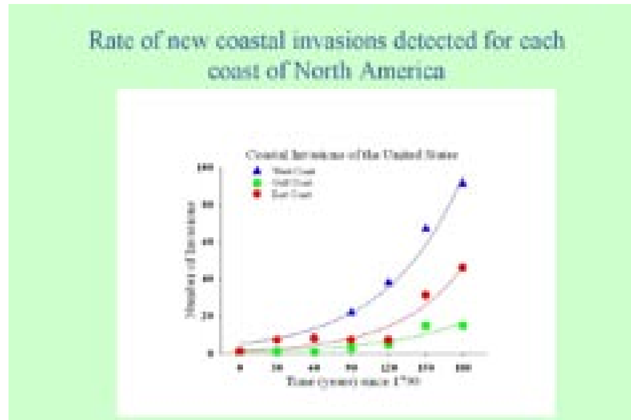
Gregory M. Ruiz: Smithsonian Environmental Research Center



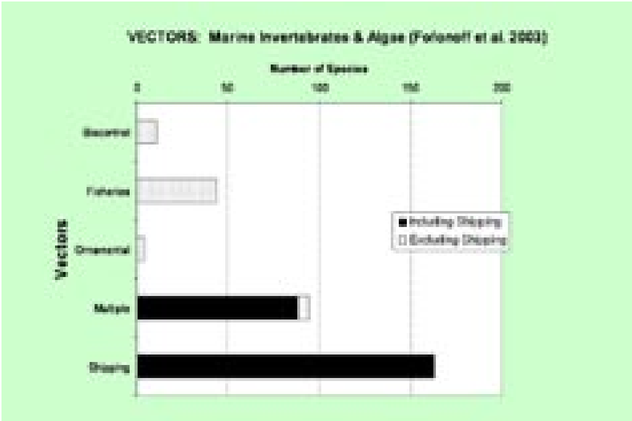
(Slides 1 & 2) I will provide a broad overview of the role of shipping in the transport of non-native species and contrast the roles of ballast water and hulls as major mechanisms. My talk will have three components:

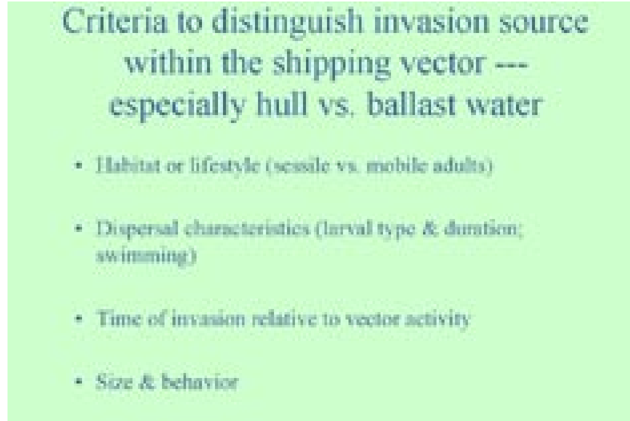
1. The importance of ships as vectors, broadly, for coastal invasions in the United States;
2. The relative contribution of hulls versus ballast water to the historical invasions associated with shipping; and
3. Current research to estimate the scale of commercial ships' hull surfaces moving in and out of different ports within the United States.

I will also comment on the status of our present understanding about hull-mediated transfers of organisms.

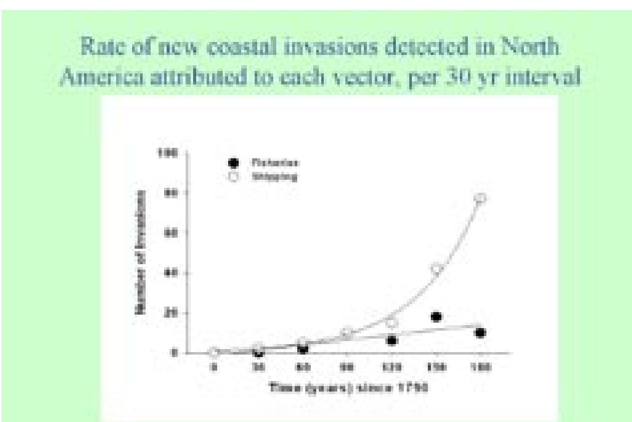


(Slide 3) In 2000, we published an analysis of the number of non-native species of invertebrates and algae that occur in marine waters in North America, including the continental United States and Canada (Ruiz et al. 2000). We evaluated the number of non-native species detected in marine and estuarine habitats at thirty-year intervals since 1790, based on an extensive literature synthesis and a query of the resulting database. What you see is a remarkable increase in the number of newly detected invasions through time and differences among coasts. Overall, the Pacific coast has the largest number of known invasions, followed by the Gulf of Mexico coast and then the Atlantic coast. The rate of invasion increased most rapidly on the Pacific coast, again followed by the Gulf of Mexico and Atlantic coasts. Several other people have done similar analyses in different parts of the world, exhibiting the same general pattern of increase through time.





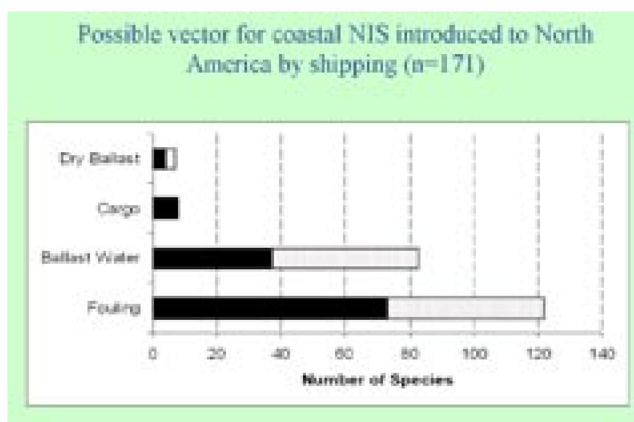
(Slide 4) Both this 2000 analysis and a second analysis by Fofonoff et al. 2003 found that shipping was the dominant transfer mechanism, or vector, for coastal marine invasions in North America. Historically, most of the non-native species invasions are attributed to ships as the largest, single vector. The second most important individual vector is fisheries, followed by species imported for biocontrol and as ornamentals. Importantly, a large number of species could have arrived by one of several mechanisms, shown in Slide 4 as the "Multiple" category, and a majority of species in this category include shipping as a possible mechanism.



(Slide 5) Not only is shipping a dominant signal in coastal invasions in a cumulative sense over the past 200 years, but it is driving the overall increase in the number of newly detected invasions through time. In our 2000 publication, we found that the rate of invasions from shipping increased exponentially (curved line) whereas the rate of invasions from fisheries, the second largest single vector, increased linearly (straight line). In fact the rate of invasions by fisheries declined somewhat in the last thirty-year interval.

(Slide 6) In the 2003 analysis, we further subdivided the shipping vector to examine how many non-native species may have come in ballast water versus hull fouling. In general, we classified non-native marine invertebrates and fish according to their habitat (whether they have sessile versus plankton forms), life history (especially presence and duration of planktonic larval stages), and behavior and size (whether they swim actively and can be entrained in ships' ballast) to evaluate potential for transport by ships' hulls versus ballast water.

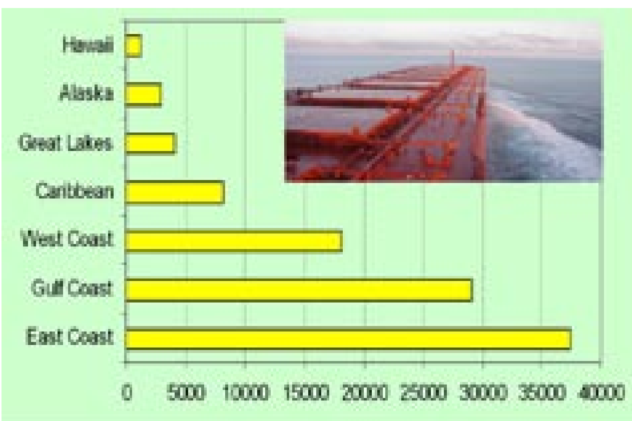
We also examined the time of invasion relative to vector activity. Ballast water did not become very active until the late 1800s, and its use has increased dramatically through time. As a result, ballast water was an unlikely vector for species that arrived prior to the late 1800s. Certainly, dry ballast was a possibility for some early arrivals, and its potential was evaluated based upon species-level characteristics (as mentioned earlier).



(Slide 7) Of the 171 non-native species attributed to shipping as the sole vector, our analysis indicates that both ballast water and hull fouling have contributed

(Slide 7 cont.) strongly overall. Importantly, there remain many species for which either mechanism was a possible vector. Slide 7 shows the number of species attributed solely to each subvector (i.e., ballast water or hull fouling) in black, and those for which that subvector was one of several possible shipping mechanisms in gray. The key point here is that the gray portion of each bar is relatively large for ballast and hull fouling.

A similar pattern emerges when considering the relative importance of ballast water and hull fouling over time. There is an increase in each as a sole mechanism, but a large number of species for which either mechanism was possible. This is true when considering species attributed solely to shipping, and also when considering species for which shipping was one of several other possible vectors (as shown in slide 4; see Fofonoff et al. 2003 for further detail).



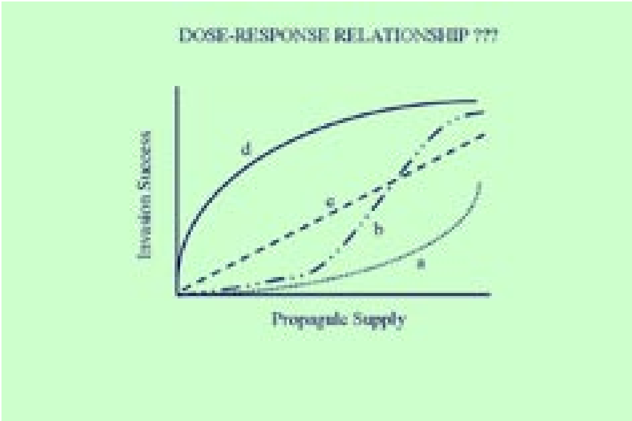
(Slide 8) So far in the United States, much attention has been focused on the relative importance of ballast water. There are several state programs to control ballast water introductions, such as that in California administered by the California State Lands Commission. On the national level my group has been involved with the U.S. Coast Guard's program. Overall, the U.S. has about 50,000 arrivals per year from overseas and another 50,000 arrivals per year from coastwise traffic arriving from a domestic port. The Atlantic coast leads the nation in cumulative arrivals, followed by the Gulf coast and the Pacific coast, with fewer still to other regions. Both the California and national programs are tracking how much ballast water is coming in, where it's coming from, and how it's managed. So we have a pretty good handle on the scale of ballast water that's coming in and how that's changing through time.

(Slide 8 cont.) In sharp contrast to ballast water delivery and management, we don't have much contemporary data for the hull fouling component of ships. Analyses are only just beginning to estimate the magnitude of hull surfaces moving throughout the world and the associated biotic content.

We have a new project to estimate how much hull surface area of commercial ships is crossing among bays and various bio-geographic regions. We are estimating the wetted surface area of commercial vessels coming into selected ports, based on the last port of call. This flux provides one estimate of the potential for hull-mediated transport.

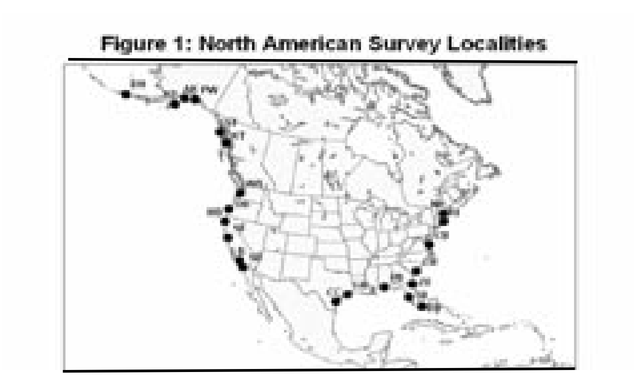
Although we don't yet know much about the biota associated with the hulls of these vessels, research such as that by Ashley Coutts and Scott Godwin in New Zealand and Hawaii (respectively) is starting to develop a picture. Along the western U.S. coast, I have recently initiated research to estimate the extent and diversity of species associated with ships' hulls with colleagues at Portland State University in Oregon.

For hull fouling in general, we need to know what organisms are moving across the world on hulls of ships and how that varies by vessel type, hull husbandry, and route. From both a management and basic science perspective, we wish to know how extent of hull fouling and species richness vary with the ship type, hull husbandry practices, residence time in port, and route (such as whether ships visit freshwater ports or move across tropic to temperate to cold climates). This is the next major challenge: to get a good handle on how many organisms are actually being transported by hull fouling and under what circumstances.



(Slide 9) More broadly, for both ballast water and hull fouling, we can and should estimate the number of organisms that are coming in on different types of vessels, but there is also still uncertainty about what that means for the risk of invasion. In other words, we don't have a good quantitative understanding of the Dose-Response relationship between delivery of propagules, whether by ships' hulls or ballast, and the risk of invasion. We know that in general the more organisms that come in the higher the risk or likelihood that colonization will occur. We don't know whether this is a linear or an asymptotic relationship (see Ruiz and Carlton 2003 for further discussion.).

Thus, there is a strong premium on being able to track how invasions are changing in space and time. As we witness the ramping up of ballast water management and perhaps a change in hull husbandry practices, we need to track number of established invasions as an important response variable to these changes. In the end, the goal is to reduce invasions and not just propagule delivery, so we need to track changes in both aspects of invasion dynamics and better understand the relationships between them.



(Slide 10) Toward this goal, we have been doing systematic surveys of sessile invertebrate (fouling)

(Slide 10 cont.) communities throughout many different bays in North America. We want to get a snapshot or baseline of how many non-native species occur in each of these locations. Several other research groups and state agencies, such as California Department of Fish and Game, have implemented additional surveys with a similar purpose, and I hope to work closely together in the future, allowing us to learn how communities are changing in concert with advancing management strategies.

Acknowledgements. I wish to thank Lynn Takata, Maurya Falkner, Jamie Gonzalez, and Leigh Johnson for organizing the workshop and inviting me to participate. This research was sponsored by Department of Defense Legacy Program, National Sea Grant College Program, NOAA Fisheries, Prince William Sound Regional Citizens Advisory Council, Smithsonian Institution, and U.S. Fish and Wildlife Service.

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Ruiz GM, P Fofonoff, JT Carlton, MJ Wonham, & AH Hines. 2000. Invasions of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases. Ann. Rev. Ecol. Syst. 31: 481-531.

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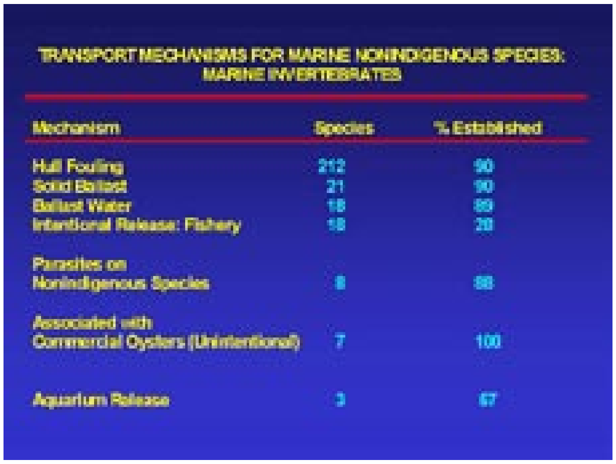
Marine Invasive Species Transported by Vessel Hull Fouling: Potential Management Approaches

Scott Godwin: B.P. Bishop Museum, Department of Natural Science

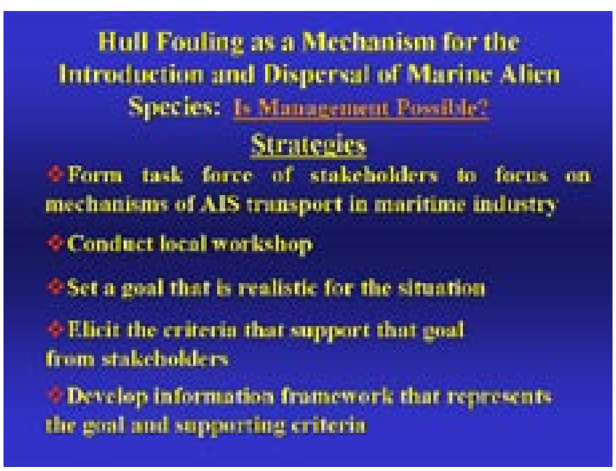
(Slide 1) The talk that I will be presenting today is based on a research project I conducted in 2003 with funding from the NOAA Coastal Ocean Program that's funded through the Hawaii Coral Reef Initiative and a partnership with the State of Hawaii Department of Land and Natural Resources: Division of Aquatic Resources. This project focused on the survey of hull fouling communities on a variety of vessel types that were part of the overseas arrival component and the inter-island component that we have in Hawaii. Another component of the project was initial steps in determining management strategies for vessel hull fouling. This project is a culmination of the things I've been doing in Hawaii since 1998 concerning hull fouling. It coincided with my involvement in the development of the Hawaii Aquatic Invasive Species Management Plan in 2003.

(Slide 2) Hawaii is the most isolated inhabited area in the United States and the world. This isolation in the Pacific provides a barrier that limits the frequency of natural species invasions to the Hawaiian archipelago. This barrier is overcome by expansion of transportation networks that are associated with our growing global economy. Hawaii's dependency on the maritime industry and commodities shipping is only going to increase in the coming years. This will serve to further expose Hawaii to marine invasive species connected to the maritime industry.

(Slide 3) I'd like to do a quick summary of the marine invasive species issue in Hawaii. At present we have documented 343 marine invasive species in Hawaii. Those are broken down into 287 marine invertebrates, 24 macroalgae, 12 flowering plants such as mangroves, and 20 fish species. This information is from surveys of historical literature and present day species inventories that are all conducted under the auspices of the Hawaii Biological Survey at Bishop Museum. Also under the auspices of the Hawaii Biological Survey, we determined some of the transportation mechanisms associated with the marine invasive species that are established in Hawaii.



(Slide 4) This slide shows just the marine invertebrates. This information is based on review of historical surveys and historical documentation of introductions, present day species inventories, and things that have been documented by myself and other researchers to have been brought in on hull fouling and other vectors and are now established in Hawaii. If you notice from this slide, hull fouling accounts for roughly 70% of the established marine invertebrates in Hawaii. If you look down on the list, ballast water accounts for roughly 6% of the marine invasives. Therefore from the work for the Hawaii Biological Survey, we determined that hull fouling is quite an important vector to Hawaii. We can't speak for other regions but for Hawaii we can consider hull fouling a very important mechanism of transport.



(Slide 5) Since 1998, the work I've been doing in Hawaii has shown that hull fouling is a mechanism for transporting non-native marine species to Hawaii, but it's also acting as a dispersal mechanism for marine invasives that are established in Hawaii. After doing all these field surveys the next logical step for me was

(Slide 5 cont.) to determine if management is possible. The strategies that I used are based on the fact that hull fouling is a very new management issue. Everything I would be doing would be laying the initial groundwork for future efforts by people who deal with management issues and write administrative policy.

The first step with my partnership with the state of Hawaii was to form a task force of stakeholders to identify mechanisms of AIS transport in the maritime industry and to conduct a local workshop (starting to sound familiar?). I conducted the local workshop with two colleagues from New Zealand, Ashley Coutts, who will be presenting after me today, and Oliver Floerl who is at the National Institute of Water and Atmospheric Research. We have been studying hull fouling in the Pacific for quite awhile. We had a two-day workshop where we presented issues concerning commercial and private vessels and their impact as hull fouling vectors. We started the early work that I was going to continue in the remaining eight months of the collaborative process in determining management strategies. Also during the workshop we solicited information from the stakeholders there to determine what a realistic goal was for the situation. Next, over the following eight months we had monthly meetings with my partnership with the state of Hawaii. I elicited criteria from the stakeholders concerning this goal. After this I developed it into an information framework that represents the goal and the supporting criteria.

(Slide 6) As I mentioned before, this whole process coincided with my involvement in the development of the Hawaii Aquatic Invasive Species Management Plan. This is a very simple schematic showing all the

(Slide 6 cont.) players that participated in the development of this plan. On the far right you'll see "AAOTF," which is the task force that was formed jointly with myself and the state of Hawaii for looking at maritime vectors including ballast water, sediments and hull fouling. I did the hull fouling aspect and the state did the administrative roles for the other vectors. The people that were involved were maritime industry representatives from commercial and private sectors, the Coast Guard, the scientific community, and aquatic resource managers from the state and the federal sectors.

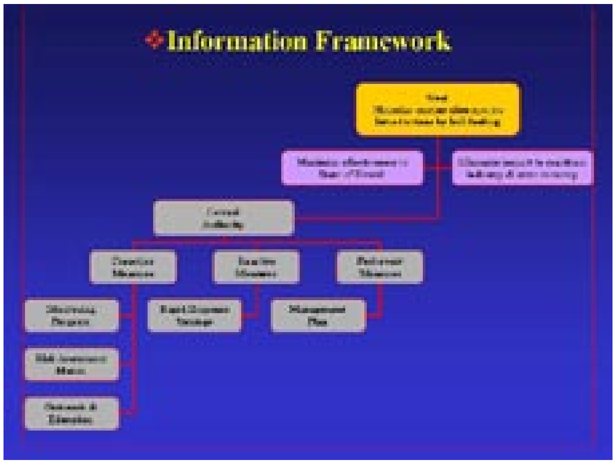
(Slide 7) When talking about potential management strategies, the early steps that I took involved looking at what I refer to as the "dynamics of port arrivals." We're focusing just on Hawaii at this point but some of these things can carry across to other ports. So when I'm talking about the "dynamics of port arrivals," we're talking about teasing out trends of vessel types that are arriving from the years and years of vessel arrivals data that I have compiled from my various projects and determining what high risk components exist within these arrivals and their source regions. The information from this collaborative effort will be pulled together into a framework that can be used as a guide for a course of action for formal management efforts.

(Slide 8) From the work I've done in Hawaii and other parts of the United States, it's become clear to me that you can look at arrivals at a port in two components: A predictable component and a stochastic component (random). Basically all port systems have a predictable set of vessels that arrive at certain frequencies and a smaller, stochastic component.

Within the task force we did a lot of ruminating over what we considered to be high-risk vessel platforms for hull fouling transport, and this is what we have come up with. We based these vessels on the traffic that we receive in Hawaii. These vessels were chosen because of their port residency times, their slow speeds (as most of these are towed platforms), and also the variability in their vessel husbandry scheduling (basically a lot of variability in how well the hulls are maintained).

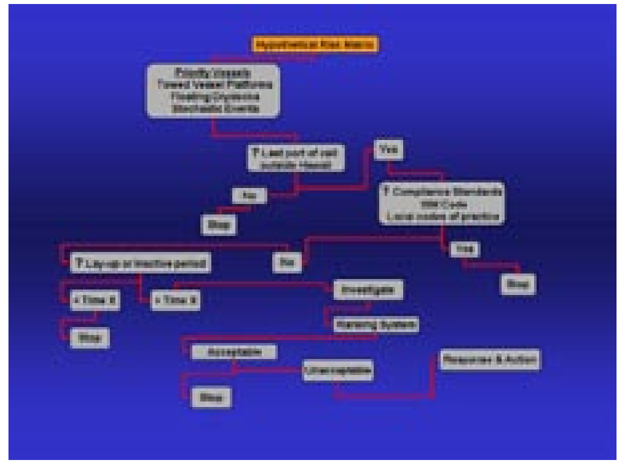
I'll cover these briefly: Towed vessel platforms are referring to things like cargo barges, salvage barges, and other sort of construction barges that Hawaii receives quite a bit. You can see that it's in both the predictable and the stochastic component because we receive predictable numbers of towed cargo barges from the West Coast and the central Pacific every month. We're also receiving these "odd ball" vessels that come at weird periods. Derelict vessels are referring to vessels that have either been salvaged in the open sea or have mechanical problems that require getting towed into Hawaii. We receive a lot of these since we are in the central part of the Pacific. We receive stuff from everywhere from southeast Asia to Chile. Decommissioned military are inactive, retired military vessels that are either purchased by foreign countries and towed to their country for scrapping and sometimes end up making their way through Hawaii when their towboat breaks down, or they are

(Slide 8 cont.) brought to Hawaii by the military directly as targets for all the war games that they have out there after they have been sitting in another location for years without any hull cleaning. They are also vessels brought out to areas for setting up memorials much like the Missouri Memorial in Pearl Harbor.



(Slide 9) This is the information framework. It was developed from the collaborative effort with the task force. As I said before, we set a realistic goal: to minimize marine invasive species introductions by hull fouling. We're talking about the word "minimize" instead of "prevent." The philosophy is that the task force decided that there is no way that we can prevent marine invasive species introductions by hull fouling with the existing measures and management tools that they have as their resources at this point. So therefore we decided that it is more realistic that we minimize through a set of proactive, reactive and post-event measures that maximize their effectiveness to Hawaii but also minimize impact to the maritime industry and the state economy. This would be managed through a hypothetical central authority, which we were keeping as neutral as possible, not naming any particular public agencies that would be tasked with this.

Basically the correct measures would involve a monitoring program, meaning monitoring of vessel arrivals, employing a risk assessment matrix that can be acted on very quickly, and an outreach and education component. This component involves spreading the information concerning hull fouling to commercial and private sectors focusing on the local community and regionally, including California and countries that these vessels are coming from. Other measures include reactive measures, or rapid response strategy, and a post-event measure management plan focusing on mitigation.

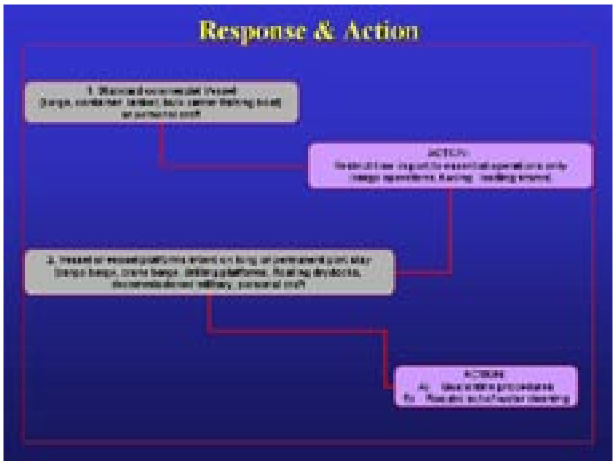


(Slide 10) I'd like to close out my talk by focusing on the risk assessment matrix and the rapid response strategy. This is a very simplistic risk assessment matrix that we developed within the task force that's based on these high-risk vessel components that we have been talking about. This is a binary risk assessment matrix that I came up with based on the comments from the people in the task force. There are many things that still need to be developed but this is a first step framework.

Basically, we have a priority vessel that we've identified and the first step is to determine whether its last port of call is from outside of Hawaii. If no, the process stops. If yes, we move onto a phase we call compliance standards. The task force decided that the ISM code, which is an international code for safe operation and maintenance of commercial vessels, would be a good first cut because you can determine from Coast Guard records whether these vessels are ISM code compliant. It was decided by the task force members that if they are not compliant with this code, more than likely the vessel husbandry standards are very low. The task force wanted to be able to set their own local codes of practice that would be disseminated through the public outreach and education component that the vessels would also have to follow. So if they are compliant to this you stop. If not, we determine whether the vessels have a lay-up or inactive period. If it's less than time X, no problem. If it's greater than time X, where we haven't developed the X yet, we move on to the investigation phase where we use a ranking system.

A colleague of ours, Oliver Floerl in New Zealand, has used a ranking system like this for sailboats, standing dockside looking down at the boat and using a 1 to 5 scale ranking, which you can see at the

(Slide 10 cont.) waterline. He used public officials within some investigative agencies to show that this is actually a pretty good tool. We could also do in-water or some sort of remotely operated vehicle system. If the vessel is acceptable, stop. If it's unacceptable, move on to what we refer to as a response and action phase.



(Slide 11) These are response and action scenarios that we developed; one being for standard commercial vessel activity concerning cargo barges, container vessels and the like even considering personal craft. The action would be, if these are considered high-risk events, to restrict their time in ports to their essential operations only. So basically let them do any of their cargo operations, their fueling, their loading stores and send them on their way. This would allow less time for the environment to be exposed to their vessel hull fouling community. Not great, but the best action we could come up with.

The second scenario considers the vessel's, such as cargo barges, decommissioned military vessels, and personal craft, or vessel platform's likely long or permanent port stay. This would require more drastic action where we require quarantine procedures and out-of-water cleaning. This seems very drastic, but this is more the public outreach component. If vessels know that this sort of action might be taken against them, even the military, if they know that they are going to be towing a vessel out for target practice and it has 10 years of fouling growth from San Diego Bay, they are going to know that Hawaii will be proactive about this and we can force them to take steps to deal with this issue before they leave the port.

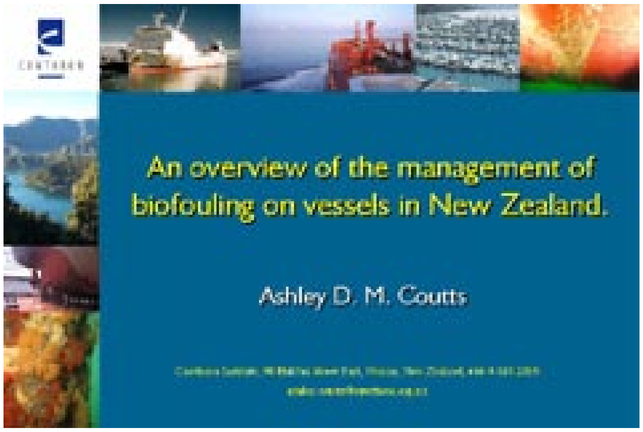
(Slide 12) To review what I've learned since 1998, hull fouling is an important marine invasive species vector. The philosophy that we use for management is to minimize at this point instead of trying to worry about preventing. This is being done through the monitoring of high-risk components, as I've shown you, applying simple risk assessment matrices that are based on these high-risk vessels, and developing with partners like Sea Grant, a good outreach and education program that focuses on local and regional issues concerning vessel movements. We've had what I consider many successes in Hawaii with these informal networks that we've set up so far. We don't have anything formal set up with the state and the feds right now but we do work in this informal group and we've managed to have a few victories in preventing big hull fouling events that could have happened.

This photo is a perfect example. This is a floating dry dock that was coming from Chile that was purchased by a company in China. The large boat that you see in front of it is the towboat that was taking it across the Pacific. The towboat had a mechanical problem and was just going to pull the dry dock into Honolulu harbor while it was being fixed. We determined that the dry dock had not been cleaned or had any sort of vessel husbandry in well over 10 years. The crew said there was not much fouling, but there was in fact fouling 5 inches thick. So working with the state, Coast Guard and maritime industry we basically said this can't come into the harbor. The towboat can come in but the dry dock can't. So we contacted the people that were buying it, and they decided that instead of getting into it with the Hawaiians they would hire a smaller tugboat from one of our local companies to keep this boat about 2 miles offshore. They towed it back and forth for a week until the larger towboat was repaired in port and then it went back

(Slide 12 cont.) out and took off. So we prevented this heavily fouled dry dock from coming in. This could have been another one of our issues because we had an issue just like this with the military that introduced about 10 species to Pearl Harbor in 1992 with a floating dry dock from the Philippines. These are the informal networks that I'm talking about. There's nothing set in stone right now. Everyone knows about the issue from all of the outreach and all the technical reports that we have published and workshops that we've had. Now people think about it and they know who to contact and what steps they might be able to take. Thank you. ■

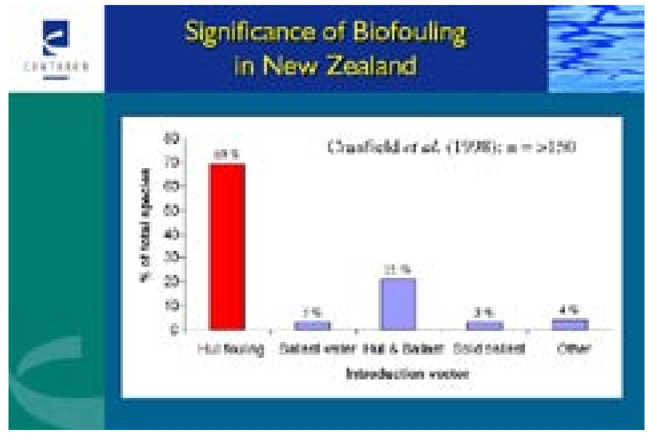
An Overview of the Management of Biofouling on Vessels in New Zealand

Ashley Coutts: Cawthron Institute

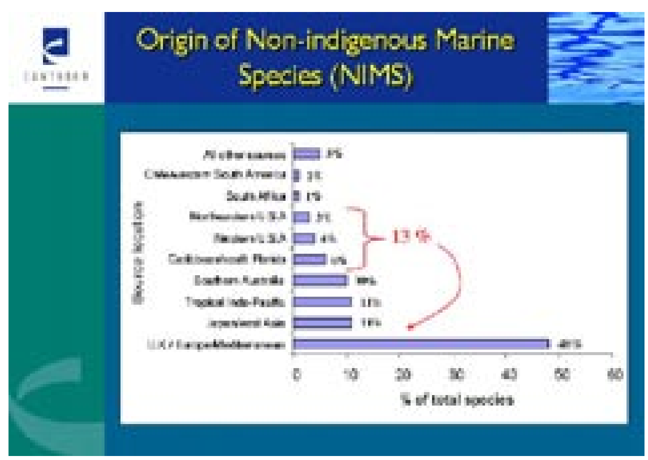


(Slide 1) I am going to present to you a short overview of the management of biofouling on vessels in New Zealand.

(Slide 2) New Zealand is situated approximately 2000 kilometers east of Australia in the South Pacific Ocean. Like Hawaii, we are isolated and that isolation has essentially evolved many endemic species. 80% of our indigenous biodiversity occurs in the sea such as 95% of sponges, 90% of molluscs, 60% of bryozoans and crabs, 35% of microalgae and 20% of fish. We even have a few Hobbits and Warlocks as well. This isolation provides us with a unique opportunity to protect our borders. Having so many endemic species in New Zealand also makes us very vulnerable to invasive species. So we are also very vulnerable given that we very reliant on shipping for trade.

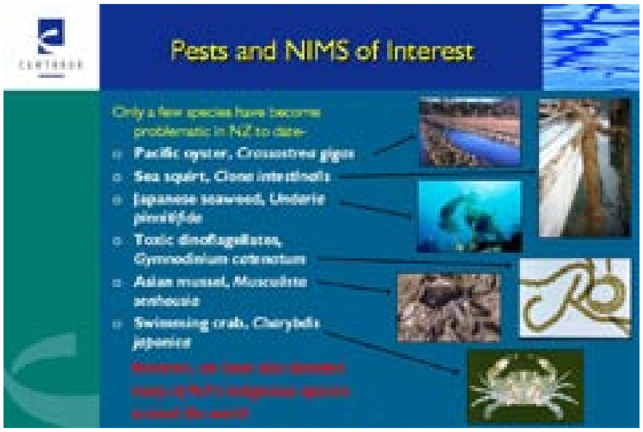


(Slide 3) In 1998, Cranfield and others discovered that approximately 150 non-indigenous marine species (NIMS) already exist in New Zealand. Interestingly, it looks as if hull fouling has been a major contributor both historically and in modern times. Notice ballast water is approximately 3% but the 21% could be of hull or ballast. Historically, solid ballast and the intentional introduction of various species for aquaculture have also been responsible for introducing various NIMS.

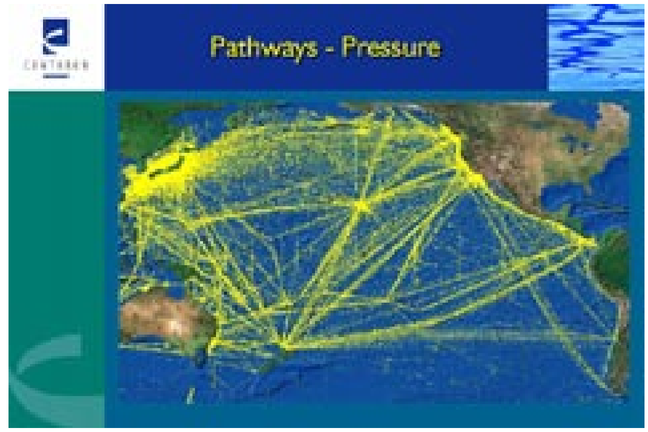


(Slide 4) So where have all our NIMS originated from? Approximately 48% of those 150 NIMS have arrived from the UK, Europe and Mediterranean. Japan and East Asia and the Indo-Pacific have donated 11% of NIMS each. If you look at North America, West America, Caribbean, and Florida, those regions combined have donated up to 13%. So the United

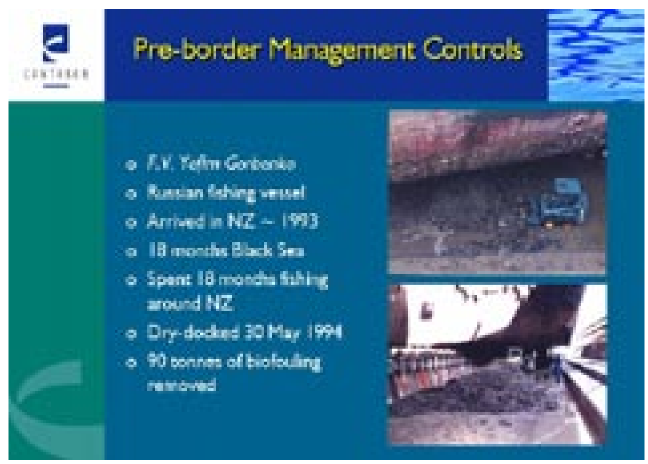
(Slide 4 cont.) States has donated a large percentage of NIMS to New Zealand. In summary we have a number of different pathways that have been responsible for introducing species to New Zealand.



(Slide 5) Interestingly, out of these 150 NIMS, only a few are problematic in New Zealand. For example, the Pacific oyster, *Crassostrea gigas* was accidentally introduced to New Zealand. On the one hand it's a problem, but on the other it's being aquacultured and is quite a highly valued species. The sea squirt, *Ciona intestinalis*, is considered cosmopolitan around the world. However, this has posed some headaches amongst mussel aquaculture operations in New Zealand, Chile and South Africa. For example, species cost our greenshell mussel industry $NZD10 million in lost production in 2000. The Japanese seaweed, *Undaria pinnatifida* is scattered through most New Zealand's coastal waters. It poses a problem to some aquaculture operations and is known to reduce biodiversity in some coastal areas. Considering the species grows so well in New Zealand's pristine water, some believe it should be harvested and sold to fund its control and eradication. But this is very controversial in New Zealand at the moment. Toxic dinoflagellate blooms such as *Gymnodinium catenatum* have caused some serious problems in New Zealand with the closure of bivalve aquaculture operations. The Asian mussel, *Musculista senhousia* and the swimming crab, *Charybdis japonica* at this point haven't really posed a great problem. An interesting point to make is many of these species are from Asia. Why is this so?

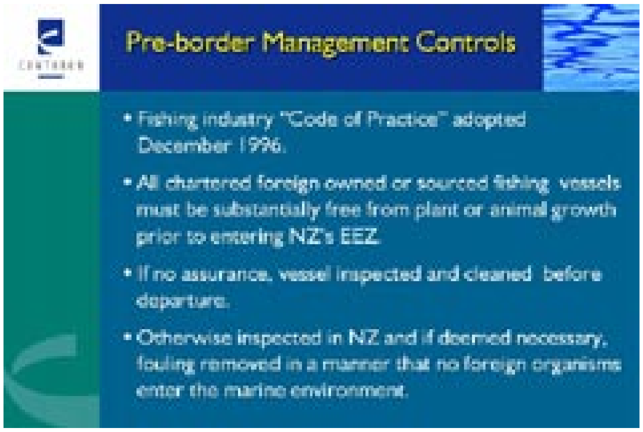


(Slide 6) This slide illustrates all ship and recreational vessel movements with tracking beacons. I think this picture clearly illustrates why we're seeing so many species from Asia and Japan being introduced to Australia, New Zealand and the United States. However, it is important to keep in mind that it's a two-way street. While we are receiving species we are also donating them. So that's something we need to consider when managing hull fouling.

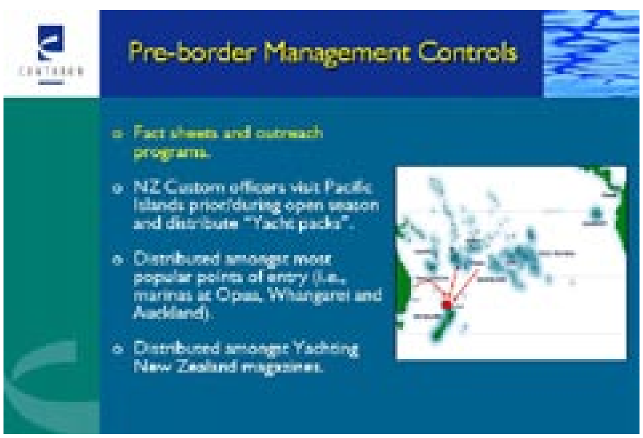


(Slide 7) Pre-border management controls in New Zealand probably started around the mid-1990s as a consequence of a vessel known as the F.V. Yefim Gorbenko. This was a Russian fishing vessel which spend 18 months decommissioned in the Black Sea, hence accumulating extensive amounts of biofouling prior to its arrival in New Zealand in1993. The vessel spent approximately18 months fishing around New Zealand. The master of the vessel complained about excessive fuel use and overheating, hence the vessel was dry docked on 30 May 1994. A total of 90 tons of biofouling was retrieved. Unfortunately, all the defouled material was landfilled before scientists were aware of the situation. However, given the origin and history of the vessel, it is assumed that the

(Slide 7 cont.) majority of the 90 tons of biofouling would have been foreign to New Zealand. Hence, this situation prompted biofouling management in New Zealand in the mid-1990s.

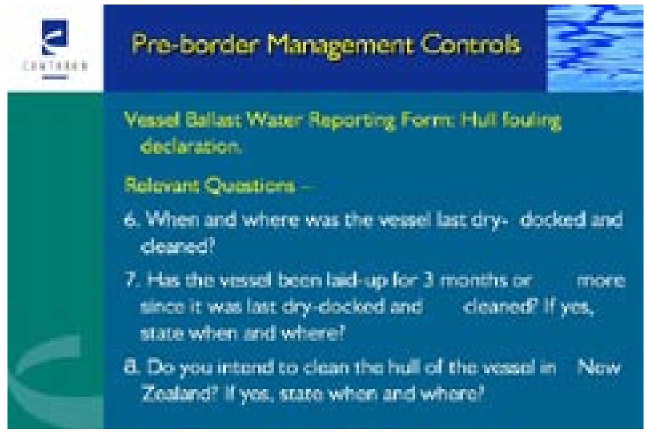


(Slide 8) The fishing industry adopted a "Code of Practice" in December of 1996 which included: All chartered foreign owned or sourced fishing vessels must be substantially free from plant or animal growth prior to entering New Zealand's EEZ. If no assurance, the vessel is inspected and cleaned before departure. Otherwise it's inspected in New Zealand and if deemed necessary, fouling is removed in a manner such that no foreign organisms enter the marine environment.



(Slide 9) Some other pre-border controls include "Fact Sheets" or "Outreach Programs". These essentially request yacht and pleasure craft owners to maintain active antifouling paints and maintain a low level of biofouling. That is, keep levels of biofouling to slime, nothing more, hence the biosecurity risk is reduced significantly. I've brought along some examples of the "Yachting Package" designed for vessel owners on why and how they should maintain their hulls to prevent the movement of unwanted

(Slide 9 cont.) organisms on their hulls. The New Zealand Custom Officers distribute these amongst vessel owners during their visit to the Pacific Islands given that's our main source of where the vessels come from during the open season. They also distribute these amongst the main entry points (i.e., marinas at Opua, Whangarei and Auckland). They also distribute them through *Yachting New Zealand* magazine.



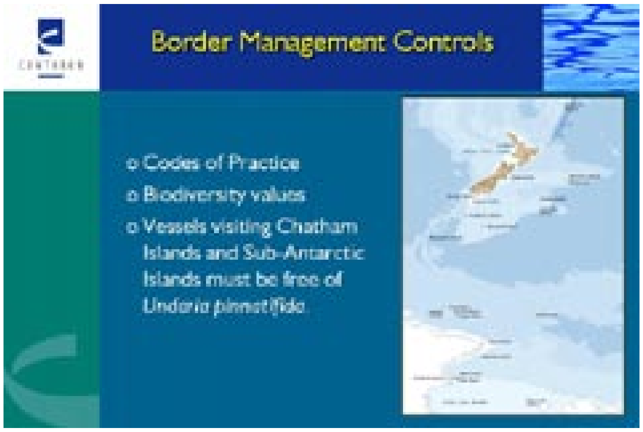
(Slide 10) Another pre-border management control requires all international vessels to complete a vessel ballast water reporting form which includes a declaration or questions pertaining to hull fouling and the relevant questions that they must answer are:

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

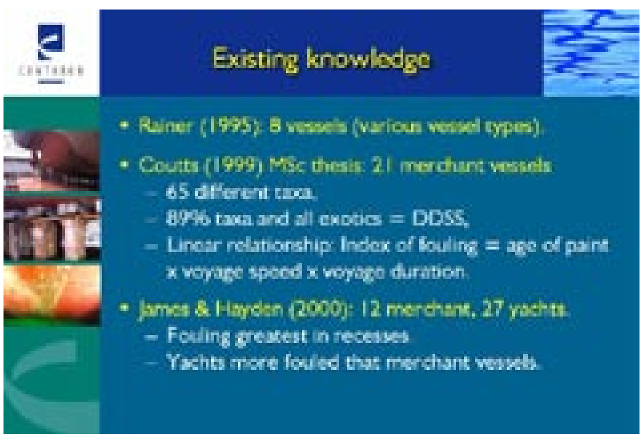
•Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If yes, state when and where?

•Do you intend to clean the hull of the vessel in New Zealand? If yes, state when and where?

This is essentially building up a knowledge base for us to get a feel for the vector or the problem with biofouling.

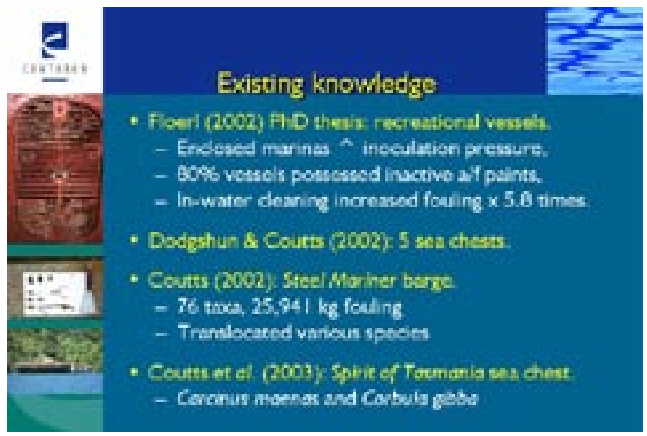


(Slide 11) As far as border management controls, we have a "Code of Practice" amongst the sub-Antarctic Islands and Chatham Islands which aims to prevent the introduction of *Undaria pinnatifida* to these highly valued areas mainly from the biodiversity point of view. And that's been going for a number of years now. It appears that all stakeholders are complying with this and it's working very, very well given that these islands are pristine untouched areas and we want to keep it that way.



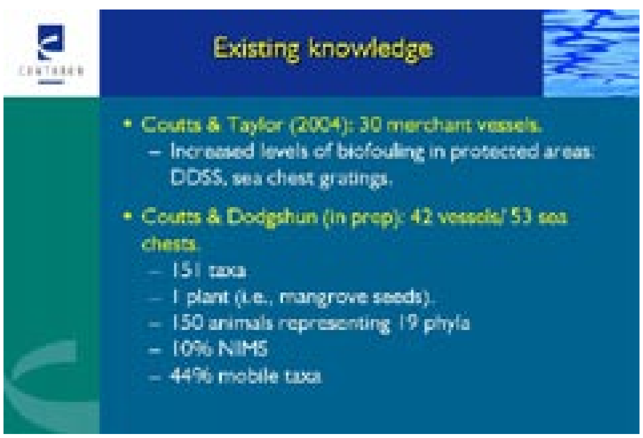
(Slide 12) Moving on to existing knowledge of biofouling research and management around New Zealand and Australia. In 1995 Rainer released his findings on biofouling on eight vessels in Western Australia. This study used SCUBA to inspect the biofouling present on various vessel types such as commercial, fishing, tugboats, etc. They generally found quite high levels of biofouling, particularly in protected areas of the vessel. In 1999 I undertook my Master's degree where I used SCUBA to inspect 21 merchant vessels entering northern Tasmania. I found 65 different taxa that existed on these hulls, but I was mainly inspecting the biofouling in the uniform areas of the hull. I found 89% of taxa including all the

(Slide 12 cont.) exotics were found in what I call Dry Docking Support Strips (DDSS). The photos on the left side of the screen are examples of DDSS there and they refer to the regions where vessels sit during dry docking where they are unable to re-apply the antifouling paint so when the vessel goes to sea those areas are essentially nontoxic. We found that some of these areas can add up to 20% of the total submerged area of the hull. Some vessels, such as military vessels actually re-float, re-dry dock and re-apply anti-fouling paint to these areas. But generally commercial vessels do not have the time or money to do this. In 2000, James and Hayden published their research on biofouling on 12 merchant vessels and 27 yachts in New Zealand. Generally the protected areas of the vessels were most fouled and yachts were generally more fouled than merchant vessels. Quite a significant finding.

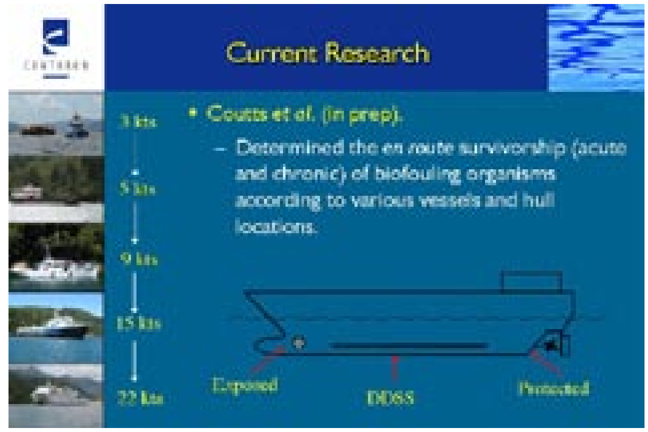


(Slide 13) In 2002, Oliver Floerl's PhD thesis looked at recreational vessels in Cairns and Townsville. This made a significant contribution to our understanding of biofouling on these vessels. He found that enclosed marinas reduce flushing rates leading to an increase in inoculation pressure. That is most of our marinas have rock walls to protect them and if a vessel visits with a species which spawns, generally all other vessels present are also inoculated which in turn are capable of migrating to other enclosed marinas and doing the same. Furthermore, 80% of the vessels he surveyed possessed inactive antifouling paints which is rather scary, and in-water cleaning increased fouling rates thereafter by up to 5.8 times. So if you scrub your hull, the antifouling paint is probably spent by that point anyway. You are also leaving traces of organisms on your hull which provide a) a non-toxic surface, and b) settlement cues for organisms to settle upon. In 2002 a colleague at Cawthron and I looked

(Slide 13 cont.) at the contents of sea chests. Very briefly, sea chests are where the ballast water enters a vessel and it's a cavity inside the hull covered by a grate or a grill. We found a whole host of organisms that prompted further research which I will expand on later. In 2002 I released a report on my discovery of a large steel barge in New Zealand with 76 taxa and the hull had close to 26,000 tons of fouling on it. It successfully translocated a number of species from the north to the south island of New Zealand. The lesson I learnt from this was the potential for slow-moving towed vessels to translocate large volumes of biofouling given they are not interested in hydrodynamic performance like other vessel types. In 2003 some colleagues and I published a note on our inspection of a sea chest of a ferry traveling between mainland Australia and Tasmania. To our amazement we found the European green crab *Carcinus maenas* and bivalve *Corbula gibba* in those sea chests. Once again that prompted some further attention on sea chests because at the moment everyone had been focusing on ballast water and hull fouling.

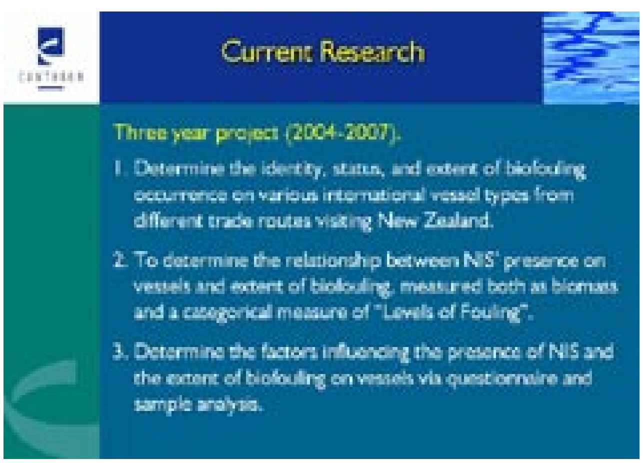


(Slide 14) In 2004 a colleague and I published a paper on the biofouling present on 30 merchant vessels using video footage of in-water surveys. We viewed a library of videos held by various commercial diving companies in New Zealand and generally found that increased levels of fouling were in protected areas such as dry dock support strips and on sea chest gratings. At the moment I'm writing a paper which I hope to release at the New Zealand Marine BioInvasions Conference in August 2005 where we surveyed 42 vessels and 53 sea chests. We found 151 taxa, 1 plant, and 150 animals representing 19 phyla. 10% were non-indigenous marine species. The most significant finding for me was that 44% of those were mobile taxa. With biofouling you generally wouldn't expect a crab to hang on to a hull but in sea chests decapods were so prominent and frequently occurring, it was staggering. This is definitely an overlooked mechanism for species transfers.



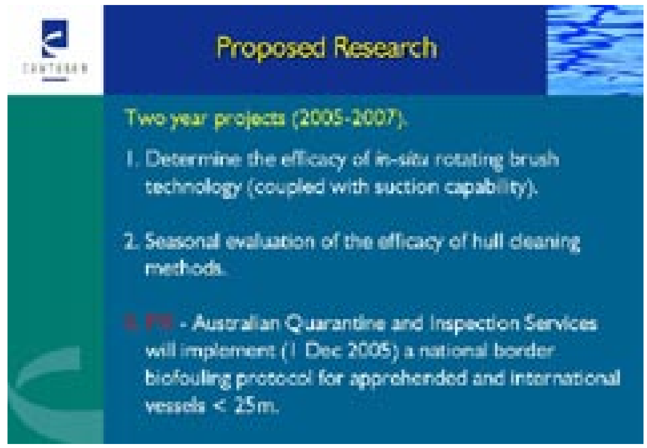
(Slide 15) Other research I'm undertaking is determining the en route survivorship, both acute and chronic, of biofouling organisms according to various vessels and hull locations. I've come up with a mechanism of attaching plates to vessels. What I've been able to do is target various vessel types that travel between 3 and 22 knots and attach these pre-fouled plates to the hulls of the vessels at 3 different locations, that is the bow, middle and stern. As you will appreciate, survivorship might vary according to hull location so this is important. Furthermore, when it comes to managing biofouling on vessels, we don't have a biosecurity risk if no organisms are capable of surviving from Point A to Point B. To me this is a very central question. I photographed the levels of fouling on the plates before the vessel departed and immediately upon its arrival at its next location. Then I removed those plates, because that's the acute assessment, and took them back to the origin where they accumulated fouling to assess the chronic survivorship a week later. So they might survive the voyage but do they survive after? I'm currently analyzing this data and this is going to be very useful for us to actually build into a risk assessment model as you'll appreciate.

(Slide 16) Hull cleaning and hull husbandry: Biosecurity New Zealand contracted McClary in 2001 to undertake a desktop study. He found that generally any effluent from hull cleaning facilities or in water cleaning operations should be filtered to 60 microns. The government was going to implement some regulations and guidelines surrounding this recommendation, however *Yachting New Zealand* kicked up a fuss and said they need further evidence that defouled organisms are capable of survival. So in 2003 they contracted Oliver Floerl and others to evaluate the viability of de-fouled organisms according to various treatment methods. He found that generally 16% of organisms were viable on haulout facilities after treatment, 43% were viable after dry docking and cleaning, and 72% of organisms were viable after in-water cleaning. At this point the government is proposing to undertake even more study because it's not quite clear what to do in managing that threat.



(Slide 17) Other current research: Biosecurity New Zealand has commissioned various contractors in New Zealand to determine the identity, status, and extent of biofouling occurring on various international vessel types from different trade routes visiting New

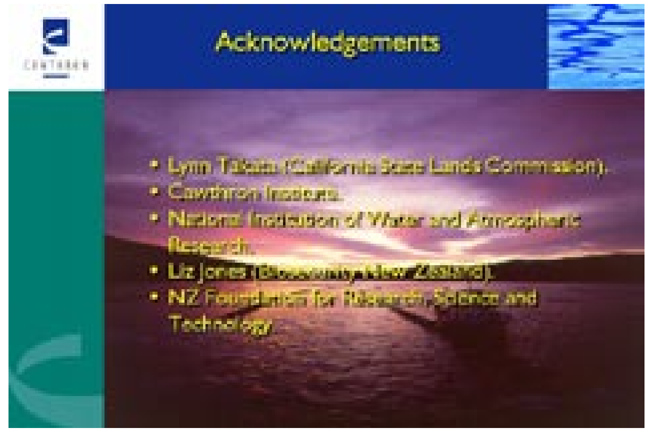
(Slide 17 cont.) Zealand. This is a huge project over the next three years. A representative sample of all vessel types from different pathways at different times of the year will be surveyed to determine the relationship between the presence of non-indigenous species on vessels and the extent of biofouling, measured both as biomass and a categorical measure of five "Levels of Fouling". We will also determine the factors influencing the presence of non-indigenous species and the extent of biofouling on vessels via questionnaire and sample analysis.



(Slide 18) Biosecurity New Zealand has just offered a series of tenders [biosecurity research projects] so there's going to be a flurry of activity in this area in the next 5 years. For example, they want to determine the efficacy of *in situ* rotating brush technology. It might be a little short sighted to ban in-water cleaning completely given that TBT is now being banned, hence if the alternative coatings are not as effective, increased levels of biofouling may enter your port on each vessel. So to prevent in-water cleaning could actually make the problem worse. So we're very serious in assessing this and are hopeful that we can develop an *in situ* cleaning mechanism that can remove and collect biofouling in a biosecure manner. Also the seasonal evaluation of hull cleaning methods needs to be addressed. For your information, the Australian Quarantine and Inspection Services will implement a national border biofouling protocol for apprehended and international vessels smaller than 25m as of December 1st, 2005. They consider such vessels as posing a significant biosecurity risk. I have that document with me if anyone's interested.

(Slide 19) We're also about to undertake an evaluation of domestic vessel pathways. It's not just international vessels that pose a biosecurity risk as obviously NIMS arrive by international vessels but it's the domestic vessels that spread them thereafter. While we may not be able to stop every organism arriving, there might be highly valued areas like the sub-Antarctic Islands that we can protect and this is why we're undertaking this evaluation. We're going to survey commercial, merchant vessels, recreational, passenger, fishing boats, barges, and oil platforms between New Zealand's major ports and marinas. We'll also determine and mitigate the risks posed by vessel biofouling to the marine biosecurity protection of the sub-Antarctic and Chatham Islands and Fiordland.

(Slide 20) The evaluation of risks posed by international slow-moving barges and oil platforms will also be undertaken. These are very infrequent visitors to our country, but I think they deserve special attention.



(Slide 21) Finally, I'd like to thank the following people and organizations for assisting me to be here to share this information with you. ■

Current and Emerging Hull Husbandry Practices of Commercial Vessels

Dragan Samardzic: Matson Navigation

(Slide 1) Good morning. Matson is a container shipping company with a long tradition.

(Slide 2) As you can see it started in 1882 and made it all the way to the passenger era of World War II. Containerization started in 1950 and now we have a modern fleet of 13 container vessels. A new one is coming May 21st from a Philadelphia shipyard. We have 4 barges in Hawaii trade and we have one carrier which is mainly used for transporting sugar from Hawaii to Richmond.

(Slide 3) This is a summary of our fleet. Most of our ships are engaged in trade with Hawaii. They regularly travel from Long Beach and Oakland to Honolulu and some ships travel to the smaller ports of the islands. Four barges are engaged in inter-island transportation.

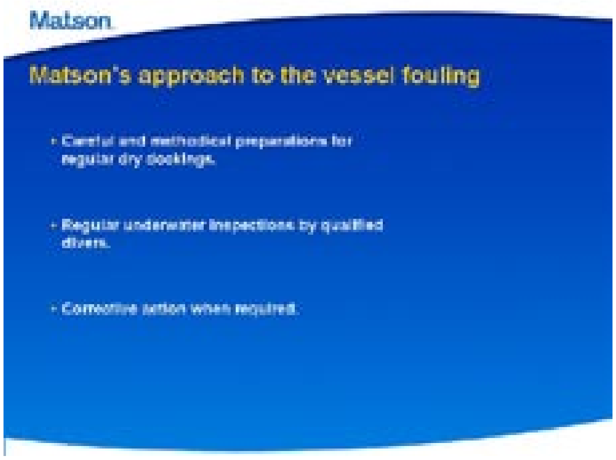
(Slide 4) This is the barge service which is serving the islands. We have two barges with self-discharging cranes and two plain barges.

(Slide 5) We also have shipping delivery services from Guam. They have shadow service between Hawaii and Guam.

(Slide 6) This is about the background from the ship owner perspective on the husbandry practices of commercial vessels. The importance of maintaining clean hulls is not only because of environmental issues. It also has to do with commercial issues as well. It is historically important for the reasons listed here: The first was to save lives. As you know the environment was not as friendly years ago. There were a lot of enemies, pirates or others that were attacking everyone and each other. It was very important to have a fast ship and the speed of the ship is directly related to the condition of the hull. The more grass or barnacles on the bottom lowers the speed. The second one was to protect ship and cargo for the same reasons: to deliver goods as fast as possible, a typical commercial interest. The third reason was to avoid bad weather: the ships in the old days were not so fast and they had to run away from storms and unfriendly shores.

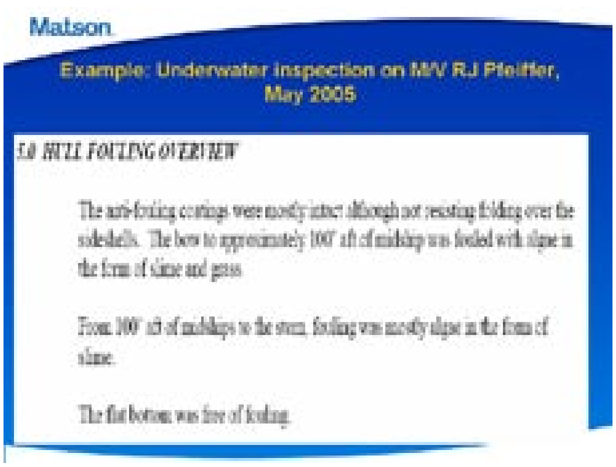
(Slide 6 cont.) Today the reasons are: to protect the environment and prevent excessive accumulation of algae, grass and barnacles, to save fuel and maintain speed and performance with the rising cost of fuel and demand for trade, and to maintain the schedule. It is of utmost importance to keep the ship's underwater area clean as often as possible, deliver goods as fast as possible, and to evaluate and protect the underwater hull not only to prevent collection of growth but also to protect the hull against corrosion.

(Slide 7) Factors affecting hull fouling: type and condition of antifouling paint. This is probably the most important factor. Sylvain will give you the presentation of the current trends and the future trends in this area. Trading zones: the worst trading zones that are affecting ships are the tropical areas where the seawater temperature is high. This is affecting the growth of algae and barnacles. The configuration of the seabeds in the ports and anchorages: if you are in areas with a sandy bottom and hot water, there is much more possibility that the algae will collect and the barnacles will stick. I was engaged in trade in the Caribbean and people who were experienced always said you have to be very careful where you drop the anchor because within days it can make a big difference. So they were always trying to avoid the areas with sandy bottoms. Speed of the ship: the faster the ship, the less the growth. That is typical. The ships with low speeds are much more exposed to the effects of fouling.



(Slide 8) Matson's approach to vessel fouling: Careful and methodical preparations for regular dry dockings. Dry docking is a regulatory requirement. Every ship has to go once every 5 years to the dry dock and must be inspected by the class by the American Bureau of Shipping. Intermediate inspection is done approximately every 36 months from the last dry docking. This is the way we look at what kind of a coating we will prepare and how we will apply the coating. Regular underwater inspections by qualified divers happen every 5 to 6 months. Every ship is inspected by the divers not only for the condition of the paint and underwater area but also for structure failures, condition of the rudder and propeller and all the other underwater areas.

We get pictures and video and based on the findings we decide if it's necessary to take action and we look at long term planning when we take the ship out of the water if necessary or do some other corrective action when required. This is to follow up with the diver's inspection or to follow up on the regular class inspection which is in between the 5 year period.



5.0 HULL FOULING OVERVIEW

The anti-fouling coatings were mostly intact although not resisting fouling over the sideshells. The bow to approximately 100' aft of midship was fouled with algae in the form of slime and grass.

From 100' aft of midships to the stern, fouling was mostly algae in the form of slime.

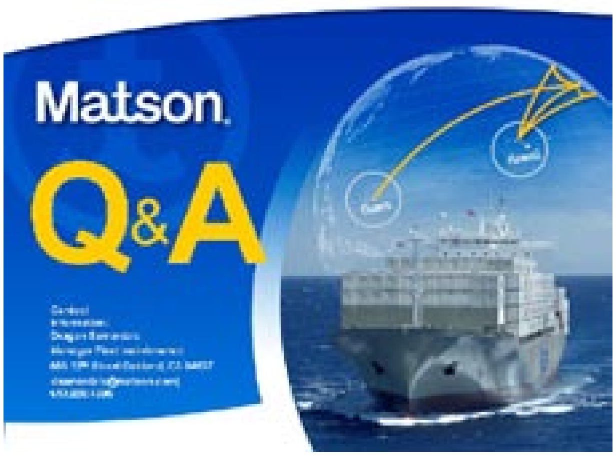
The flat bottom was free of fouling.

(Slide 9) This is an underwater inspection on one of our ships, RJ Pfeiffer, which was done in May 2005 by divers in Long Beach. This is an abstract from their report which addresses the fouling. You can see it's very light and there aren't any recommendations for a clean-up. This ship was in a dry dock in 2001. I have a couple of photos following that will show you the typical condition. The ship is due for a dry dock next year in April. This is part of our action to make sure that we constantly know the exact condition of the ship in terms of slime and growth as well as from the structure point of view.

(Slide 10) This is the typical condition on the bow.

(Slide 11) This is the top of the bilge keel with light algae in the form of slime. Bilge keels are two long steel bars running on each side of the ship to keep the ship on balance to prevent excessive rolling.

(Slide 12) This is again one of the pictures on the bow.

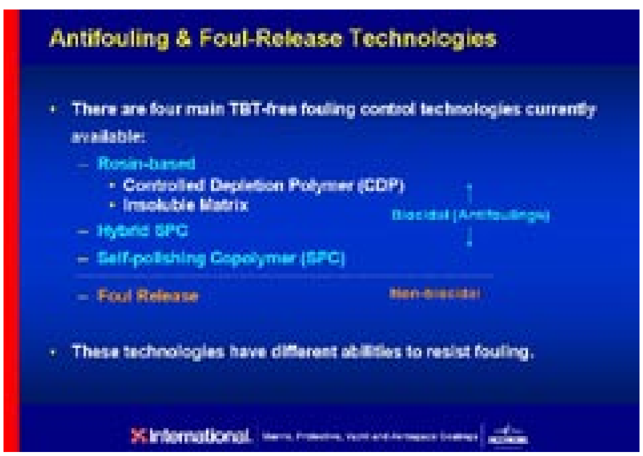


(Slide 13) Thank you. I will now hand it over to Sylvain who will explain the chemistry and current trends in antifouling paints. ■

Antifouling and Foul-Release Technologies

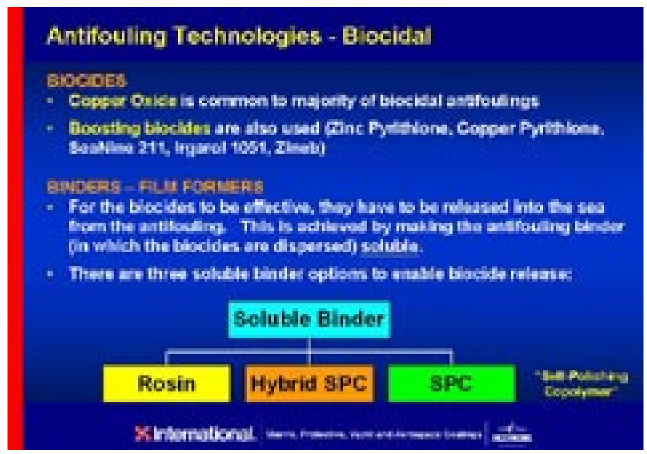
Sylvain Fillion: International Paint

(Slide 1) It's a pleasure to be here. The topic of my presentation is about the various antifouling and foul-release technologies that are currently available in the marketplace. This is not a sales pitch, it's all generic. I'm not going to go too much into technical detail. I will try to give you a brief overview of those technologies currently available. During the course of the day I will be available to answer any of your questions.

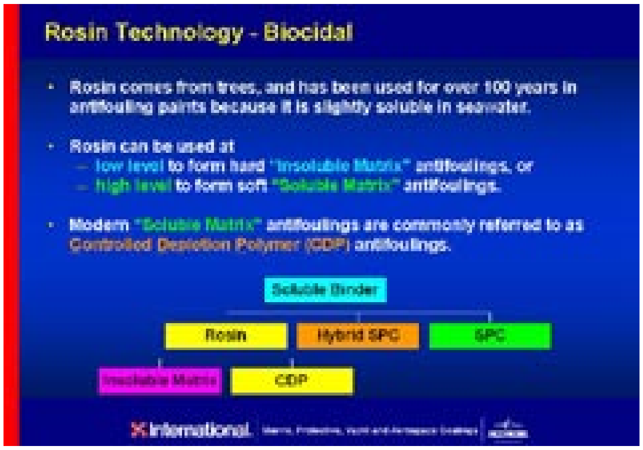


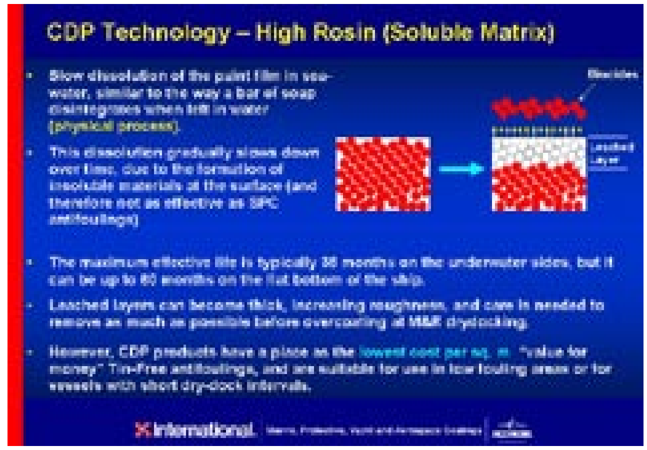
(Slide 2) My presentation is also about tin-free technologies. Most paint companies, as you are probably aware, have phased out tin-based antifoulings. Basically there are four main TBT-free fouling control technologies currently available. The first three are all based on biocides. The fourth one is a foul-release technology. A little bit of semantics here: When we say antifouling, we always refer to something that contains biocides. When we say foul-release technology, we refer to something that does not contain biocides. We're going to spend a couple minutes on the first three technologies. Again, they all contain

(Slide 2 cont.) biocides. The first one is based on rosin. Rosin is a natural product that comes from trees. It's been used for over 100 years. The last one, the SPC technology, is what we call self-polishing copolymer. The one in the middle is basically a blend, a mixture of those two technologies. All these technologies have different abilities to resist fouling. Sometimes you're going to use the best antifouling that you can find in the world and it's still going to foul. You're dealing with Mother Nature and it's not always easy or predictable.

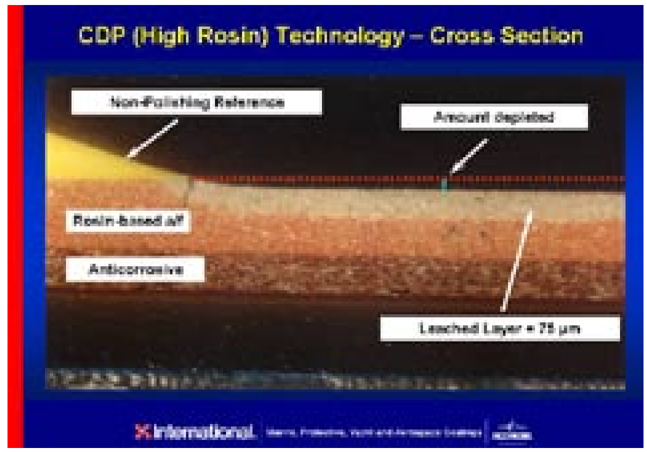


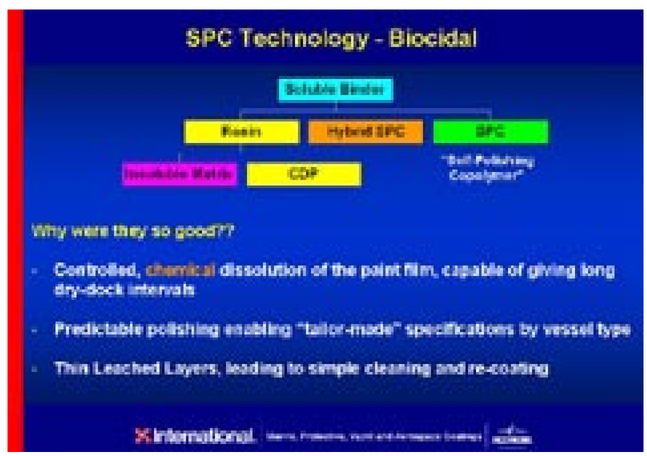
(Slide 3) When you want to formulate an antifouling paint you have to have a biocide package and an effective release mechanism. By release mechanism we mean you have to have a binder system and I'll get to that in a minute. First, the biocide package: nowadays cuprous oxide is the main biocide that is used in those antifouling paints. This is for all antifouling companies. Paint companies also use some boosting biocides. Keep in mind that the common one is cuprous oxide nowadays. Moving onto the release mechanism: to release the biocides you have to have a binder system that is slightly soluble. Basically there are three different kinds in the market place. The first one is rosin based, or rosin, the one in the middle is the hybrid SPC, and the one on the right is SPC or self-polishing copolymer. The way you release the biocides in the seawater is based on a physical dissolution process. Think of it as a bar of soap in a bathtub.





(Slide 4) Rosin has been used for 100 years but it has some limitations in terms of performance. However, it's still the main technology sold in the U.S. When you buy an antifouling paint it is probably based on rosin technology. The one on the right, the SPC technology, the way the release mechanism works is based on a chemical dissolution process. Basically when it comes in contact with seawater you have a chemical reaction that goes on and that's the way the biocide package is released. As I said, I'm not going to go into those technical details on how and why one is better than the other. I can answer your questions throughout the day if you want to know more. Just keep in mind that the SPC technology is the high end of these technologies. It's the better performing technology. Again it's based on a chemical dissolution process. It's also more expensive. Rosin is much more economical. It doesn't perform as well but it's more economical and rosin-based is the bulk of the technology sold in the U.S. In between is the blend of the two. It's not as expensive as SPC but it's more expensive than the rosin technology and the performance is pretty much in the middle as well.





I'm going to skip the technical slides.
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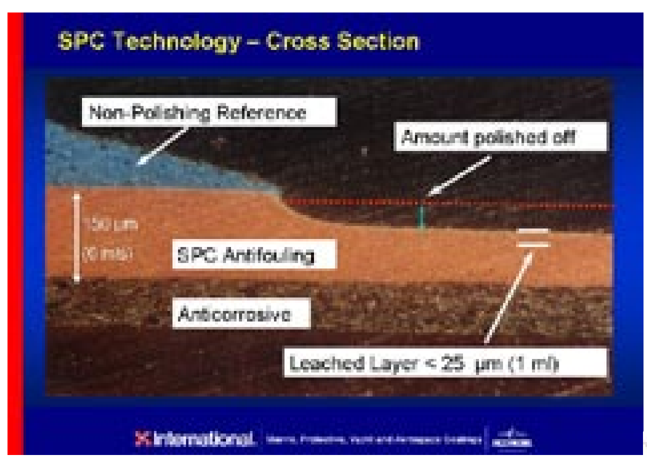
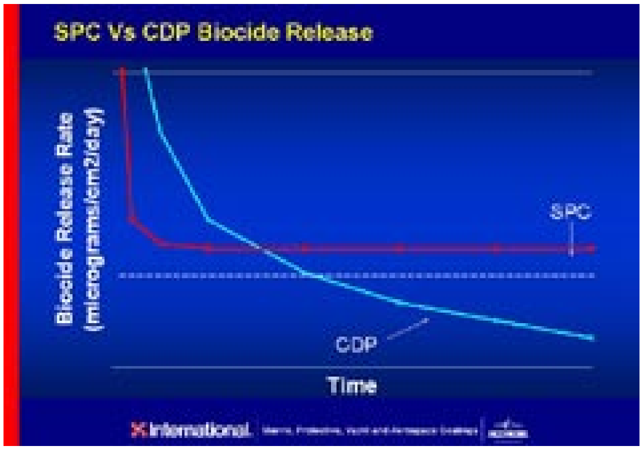
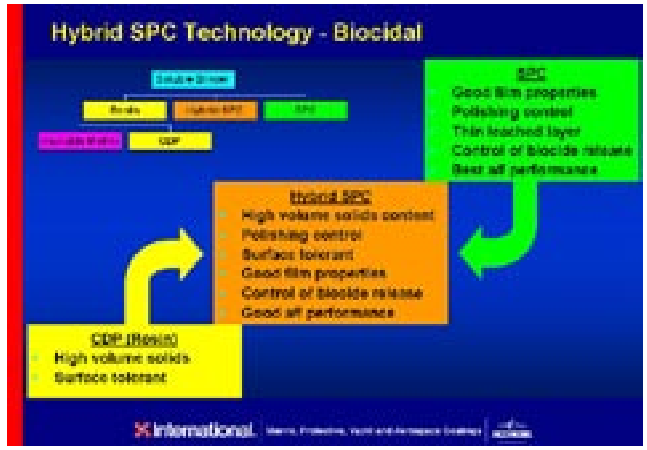




(Slide 10) This is what you can see on a big tanker at times. We applied SPC antifouling technology on these two ships. The one on the left is after 24 months and the one on the right is after 51 months. The picture of the one on the right, from 51 months, was taken after the vessel was pressure washed. There was probably a bit of slime on the vessel.

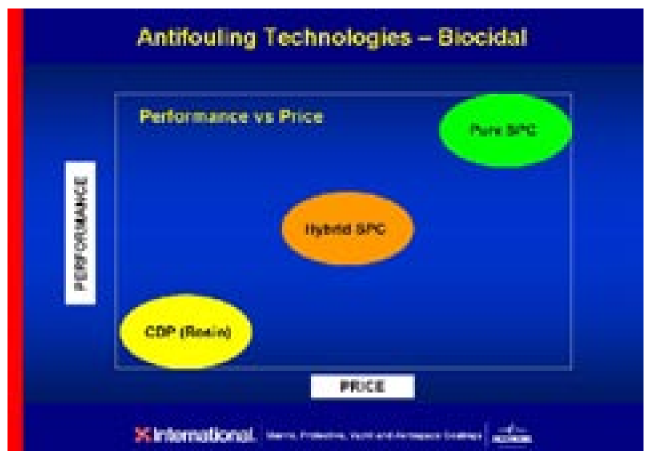
(Slide 11) This one is going into dry docking after 60 months. Of course you don't see what's underneath on the underwater hull but normally when you have

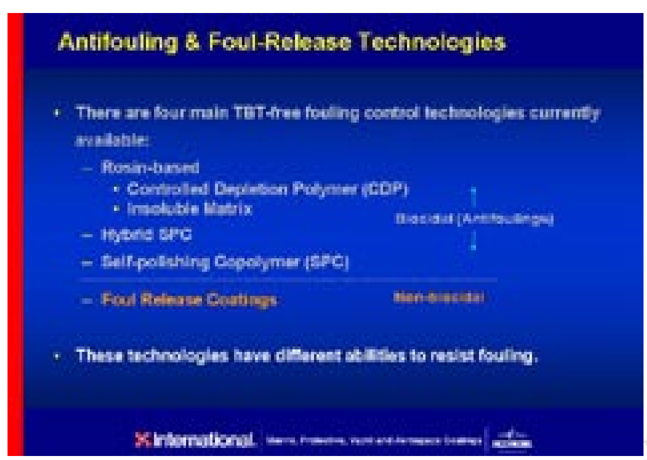
(Slide 11 cont.) a fouling problem you see something at the waterline. And you don't see anything on those pictures. This is just to show you how SPC technology can perform.

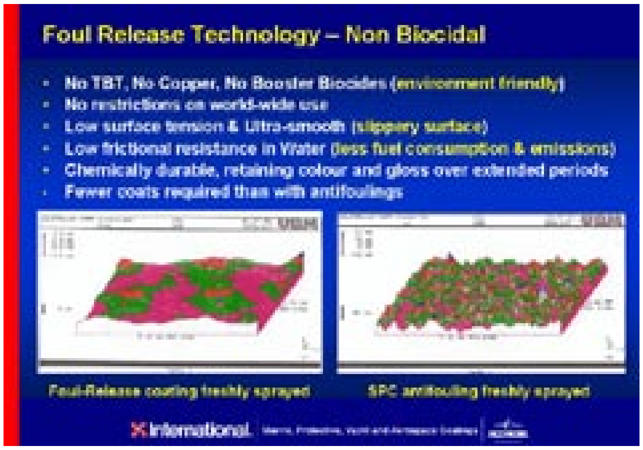


(Slide 12) The hybrid technology is basically a blend of the rosin technology and the SPC technology. So I'm going to skip that.

(The following 2 slides were not dicussed)







(Slide 15) The fourth technology is what we call a foul-release technology. It does not contain any biocides. No tin, no copper, no boosting biocides, so it's friendly to the environment. There are no restrictions worldwide. You probably don't know but if you want to formulate your own antifouling paint it takes a long time to get it approved by the EPA. It's not an easy process. Because this technology does not contain biocides, there are no restrictions. You don't have to go through that EPA approval process. Our foul-release technology is based on silicone. The way it works is there is very low surface tension, very smooth, very slippery. Because of this the barnacles and other organisms have a very tough time sticking to that surface. So it's purely physical. There is no dissolution of the paint film. As time goes by you deplete antifouling paint so two or three years later you have to apply more paint. This is a different deal. The film itself does not dissolve in the water. It's a durable finish. Again you don't release any biocides in the seawater. On the left you have a pictogram of the surface of a foul-release coating freshly applied; on the right is the profile of a SPC product freshly applied. You can tell on the left that the silicone technology is much smoother than the SPC and that has an impact on fuel consumption for big tankers and that sort of thing.

The next few slides are pictures of how this technology works.

(Slide 16) On this picture a few barnacles were able to attach themselves but they are very loosely attached. You can pick them up with your fingers. When you have a fouling problem on regular antifouling paint with barnacles, it takes a hammer and a chisel to take them off. In this case we can pick them up ourselves and they were loosely attached.

(Slide 17) This is one ship that was coated with a foul-release product. That's after 25 months. On the left that's the way she came up with slime. She looks dirty but it was just slime. All we did was high pressure wash the vessel with freshwater. That's just to show you that it is a durable finish after you wash off the slime. You go back to the original state of the film which is a glossy finish.

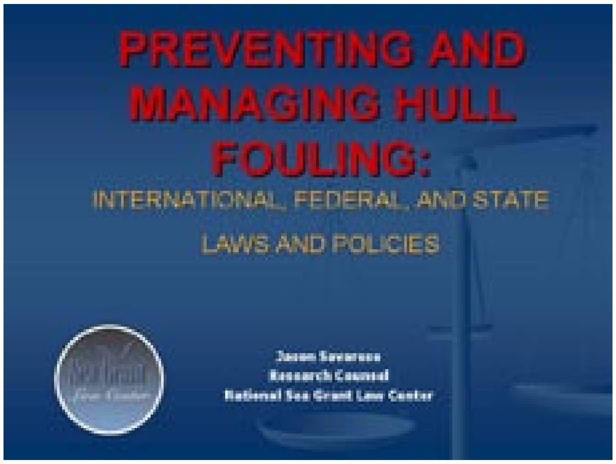
(Slide 18) This is the same ship 61 months later. Again, slime is on the vessel, we washed it and it goes back to the original state of the coating. Again it's a silicone based paint. It's a durable finish.

(Slide 19) That's another picture to show you that it picked up slime but it's still fairly easy to clean up. No animal fouling on the ship.

(Slide 20) We covered four different technologies. As a company we are looking at future technologies: we're looking into a low copper antifouling technology. We're also looking into making antifoulings with no copper, but obviously we would still need boosting biocides. We're also looking into trying to come up with better antifouling technologies. Thank you. ■

Preventing and Managing Hull Fouling: International, Federal, and State Laws and Policies

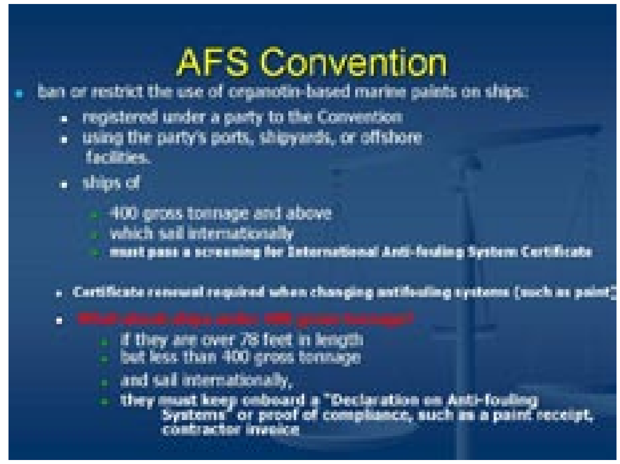
Jason Savarese: National Sea Grant Law Center



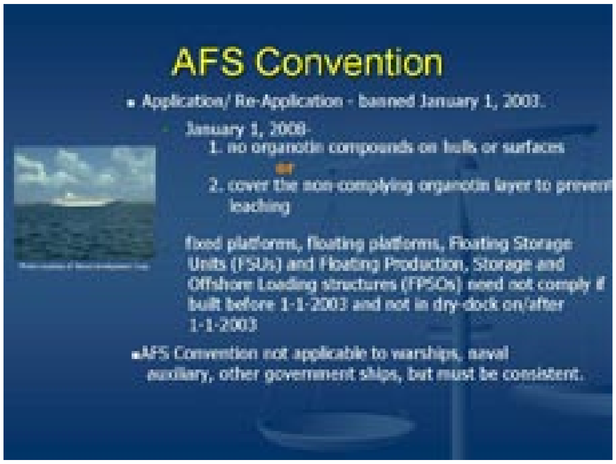
Jason has updated his presentation from May 2005. The updated version, from August 10, 2005, is included here.

(Slide 1) Good morning. I'm going to be moving through my presentation quickly as I have a lot of slides to cover but I'll be here for questions at the end if there's anything that you missed.

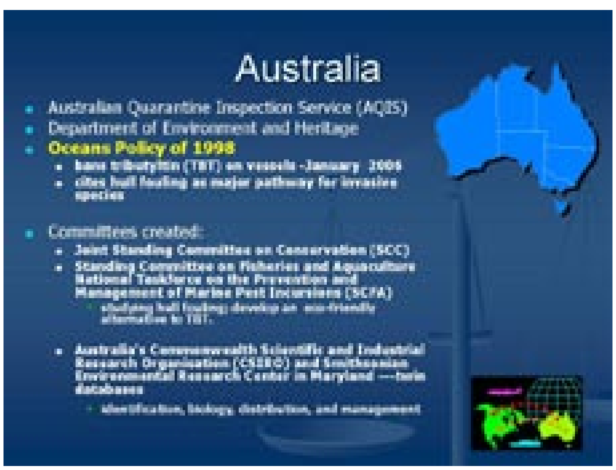
(Slide 2) I'm going to begin on the global level with the International Maritime Organization's Convention on the Control of Harmful Antifouling Systems on Ships, also known as the AFS Convention. This was signed in 2001 but has not yet entered into force due to the fact that it requires 25 nations, representing 25% of the world's merchant shipping fleet tonnage, to agree to the Convention. Currently there are about 11 nations, or 9.28% of the world's shipping tonnage, that have agreed to that Convention. The U.S. has signed the AFS Convention but has not ratified it yet.



(Slide 3) The AFS Convention restricts the use of organotin-based marine paints on ships that are registered in nations that have agreed to the Convention. Ships using any of the parties' ports, shipyards or offshore facilities must also comply with the Convention. Vessels of 400 gross tons or above that sail internationally must pass a compliance screening before receiving a required International Antifouling Systems Certificate. The Certificate must be renewed whenever the antifouling system is changed, such as when a vessel is repainted. Ships under 400 gross tons and over 78 feet in length that sail internationally must keep onboard a "Declaration on Anti-fouling Systems," such as a paint receipt or contractor invoice. The Declaration shows that the ship has met the requirements of the Convention.



(Slide 4) Under the Convention, the application or re-application of organotin-based systems is banned as of January 1, 2003. As of January 1, 2008 no organotin compounds can be used on hulls or surfaces. Alternatively, the AFS Convention allows parties to the Convention to cover the non-complying paint layers with a sealing layer to prevent any leakage. Fixed platforms, floating platforms, (such as barges) and oil platforms need not comply with the Convention if they were built before January 1, 2003 and haven't been in drydock since then. The AFS Convention does not apply to warships, naval auxiliary, or other government ships, but these ships must act in a manner consistent as far as reasonable and practicable with the Convention.



(Slide 5) In Australia, the Australian Quarantine Inspection Service, in partnership with the Department of Environment and Heritage, works to prevent and manage aquatic invasive species. Australia's Ocean Policy of 1998 bans the use of TBT on vessels as of January 2006. It also cites hull fouling as a major transport for invasive species in Australian waters. The Ocean Policy created several committees

(Slide 5 cont.) including the Joint Standing Committee on Conservation and the Standing Committee on Fisheries and Aquaculture National Taskforce on the Prevention and Management of Marine Pest Incursions. Both of these are studying hull fouling and trying to develop a safe and eco-friendly alternative to TBT.

In addition, Australia's Commonwealth Scientific and Industrial Research Organisation and our own Smithsonian Environmental Research Center in Maryland have set up twin databases to share information between the countries on identification, biology, distribution, and management of these invasive species.

(Slide 6) In 2001, Australia formed the National Marine Pests Coordination Group to design a national management system for invasive species. In addition, some Australian states have adopted their own local policies to deal with invasive species. Victoria's state EPA requires vessels of less than 200 tons to discard on land any fouled organisms that are removed from vessels. South Australia requires slip owners to use bunding, a non-permeable concrete or earthen "tub," to contain the fouling organisms once they are removed from the vessels. It is illegal to discharge fouling materials in South Australia's waters.

(Slide 7) In New Zealand, the lead agency for invasive species prevention and management is the Ministry of Fisheries. This agency partners with the Biosecurity Division of the Ministry of Agriculture and Forestry. I believe someone mentioned earlier that there are about 150 invasive species found in New Zealand waters and about 70% of those may have come from hull fouling. New Zealand has instituted a public awareness campaign to enlist the help of citizens in sighting invasive species in the marinas. They have also instituted a "Marine Invaders" telephone hotline so the public can phone-in any sightings. Government inspections and harbor monitoring are also used. They have implemented Action Plans to deal with aquatic invasive species once they're sighted - they know exactly what to do and can get the response going as quickly as possible. They have also listed seven marine species as unwanted and have provided information to the public, including pictures, to help with the identification of those species.

(Slide 8) New Zealand's Biosecurity Act of 2003 regulates the holding, disposal and treatment of "risk goods." The phrase "risk goods" is defined as "any organism, organic material or other thing, that may cause unwanted harm to natural and physical resources or human health in New Zealand." In effect, hull fouling equals risk goods under the Biosecurity Act.

(Slide 9) Hull cleaning regulations were proposed a few years ago in New Zealand. The regulations would have required containment and cleaning facilities to collect discharged fouling materials and filter discharged water to retain anything having a volume over 60 microns. The proposed regulations were opened for public comment and later deferred until more information could be gathered. Voluntary measures are currently being used in New Zealand. They encourage boat owners coming into New Zealand waters from a foreign port to clean their hulls before leaving that port.

(Slide 10) In 1997, Australia and New Zealand set up a joint Environment and Conservation Council to develop a code of practice for commercial vessels. The code restricts the removal of fouling in waters

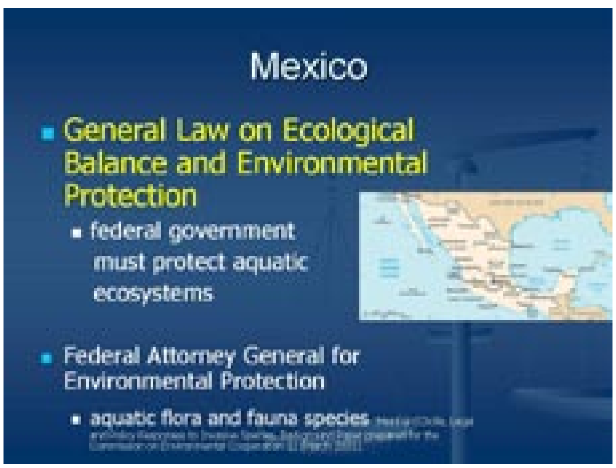
(Slide 10 cont.) unless there is an emergency, and even then it requires 5 days notice before cleaning propellers or sea chests in those waters. The code also requires the government to be given a containment and disposal list to document what was removed.

(Slide 11) In the Netherlands, the Pesticide Authorisation Board regulates the use of antifouling vessel paints. Following a risk assessment, copper-based antifouling paints were banned in the Netherlands as of March 1, 1999 for use on personal water craft but were still allowed to be used by the shipping, offshore industry, and the Netherlands Navy. As of 2001, the sale, purchase, and possession of copper paint was still legal. The Netherlands government found that this situation probably resulted in owners of personal watercraft continuing to use the copper-based paint despite the ban. A Netherlands court decision in early 2005 questioned whether the copper paint risk assessment was complete. The court lifted the ban on copper paint until a new assessment, which is presently being conducted, is completed. There are currently no restrictions on the use of copper-containing antifouling paints in Dutch waters. The Netherlands has banned the cleaning or scrubbing of copper-bearing antifouling paints in its waters.

(Slide 12) The Netherlands is a member of the European Union, and as such it must follow the European Union's Biocidal Products Directive. The Directive regulates and requires the registration of all chemical biocides. The Directive also says that antifoulants made before May of 2000 are allowed continued use. After May of 2000, the Directive will require full European Union evaluation and approval of such paints.

(Slide 13) Canada has no legal regime set up specifically for hull fouling. However, it does regulate ballast water through a management program. Environment Canada is the lead organization for invasive species, in addition to the Canadian Department of Fisheries and Oceans and Transport Canada. These agencies monitor ballast water using voluntary guidelines at the moment. Regulations are being drafted for mandatory ballast water management in Canada.

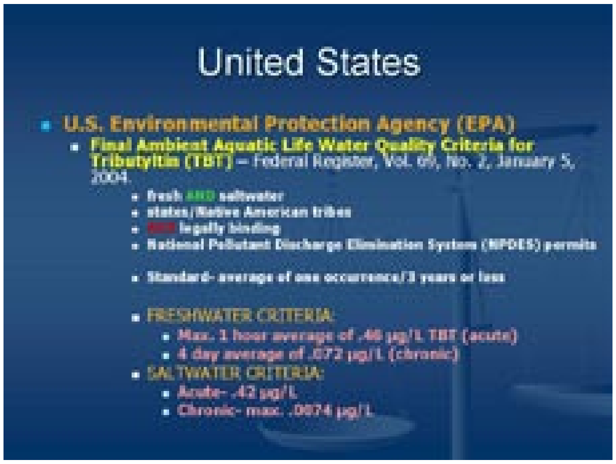
(Slide 14) Mexico also has no specific legal regime for hull fouling. Two agencies have authority to manage invasive species in Mexico, including the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food and the Secretariat of Environment and Natural Resources.



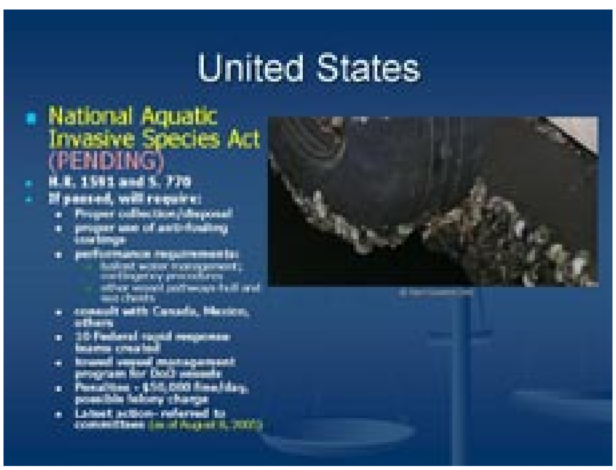
(Slide 15) Mexico has a general law on ecological balance and environmental protection which requires the federal government to protect Mexico's aquatic ecosystems. In addition, the federal Attorney General for Environmental Protection is specifically authorized to conduct enforcement activities and prevent the unauthorized introduction of aquatic flora and fauna.

(Slide 16) In 1993, Canada and the United States signed a side agreement to NAFTA called the North American Agreement on Environmental Cooperation. This agreement established the Convention on Environmental Cooperation (CEC), the goal of which is to protect North American aquatic and marine ecosystems by closing the pathways used by invasive species. They are currently assessing the pathways.

(Slide 17) In 1998, the Organotin Antifouling Paint Control Act (Organotin Act) was passed in the United States. The Act defines organotin as "any compound of tin used as a biocide in an antifouling paint." It banned organotin paints on boats smaller than 25 meters in length with two exceptions: organotin paint could be used on aluminum hulls shorter than 25 meters and also on outboard motors/ lower drive units on vessels less than 25 meters. EPA approval was required for organotin-based antifouling paints to be used including the sale, delivery, purchase and receipt of such paints. An interim standard was adopted in the Organotin Act of 4.0 micrograms per square centimeter per day.

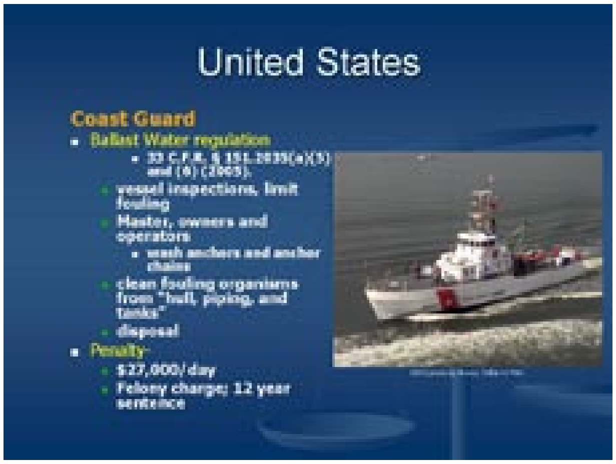


(Slide 18) In addition, the EPA has developed Final Ambient Aquatic Life Water Quality Criteria for TBT. This covers fresh and salt water and was designed for use by states and Native American tribes so that they can set up their own regulations. The EPA standard is not legally binding. It is enforceable through National Pollutant Discharge Elimination System (NPDES) permits. Setting a standard of one occurrence every 3 years or less, the freshwater criteria is as follows: Max. 1 hour average of .46 µg/L TBT (acute) and 4 day average of .072 µg/L (chronic). The saltwater criteria is a little different.



(Slide 19) The proposed National Aquatic Invasive Species Act of 2005 is currently before Congress. If the legislation passes it would require the maximum possible collection and proper disposal of fouling debris removed from ship hulls and the correct usage of antifouling coatings on ships. It would also implement performance requirements to reduce or eliminate invasive species in ballast water, vessel hulls, sea chests, and other such pathways. The Act suggests, not requires, that the U.S. consult with Canada, Mexico and other foreign nations to ensure a coherent international scheme. The Invasive Species Act would create 10 federal rapid response teams to eradicate or control invasive species once they're identified on federal or tribal land. They would also carry out or assist in the removal and management of invasive species detected on state lands. The Act also sets up a towed vessel management program for Department of Defense vessels to minimize the risk of introduction of aquatic species through hull transfers. Violators of the proposed legislation would incur penalties of a $50,000 fine per day and possible felony charges.

(Slide 20) The EPA negotiated with TBT-bearing coating vendors for the voluntary cancellation of their registrations under FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) which regulates the sale and use of pesticides in the U.S. The cancellation is now complete. After the AFS Convention enters into force, which has not yet occurred, vessels bearing TBT paints may be refused port entry into the U.S. The EPA and U.S. Naval Sea Systems Command are currently working on a set of uniform National Discharge Standards which will govern discharges by the military and the Coast Guard. They are also exploring marine pollution control devices to manage and avoid vessel discharges like antifouling leachate.



(Slide 21) U.S. Coast Guard ballast water regulations help limit hull fouling as a pathway for aquatic invasive species. This is done through vessel inspections. Coast Guard regulations direct masters, owners, and operators on ships containing ballast tanks to wash their anchors and anchor chains on-site to lessen the chance for hull fouling invasives. In addition, they are to clean their hull, piping, and tanks. They must also dispose of their organisms in accordance with all state, federal, and local laws. Penalties for non-compliance include a fine of $27,000 per day and a possible 12 year felony sentence.

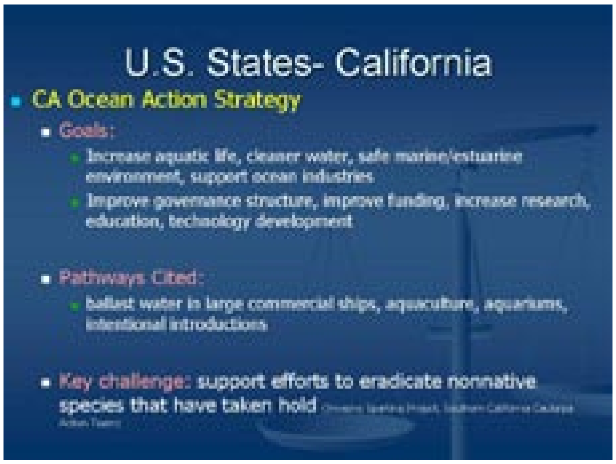
(Slide 22) California has restricted the use of TBT, including any organotin or tri-organotin compounds used in antifouling paints. The use of TBT is restricted to vessels over 84 feet in length and with aluminum hulls and outboard motors and lower drive units, which mirrors the federal standard. The use of TBT on docks, piers, nets and other fishing equipment is also restricted. To purchase TBT, a buyer would need to produce his or her vessel registration to show compliance with the state's use restrictions. In the alternative, a sworn statement can be given, stating that the vessel meets state requirements.

(Slide 23) TBT oxide pesticides (paint additives) cannot be applied to any surfaces that will come into contact with California's waters. The state allows a maximum average organotin release rate of 4 micrograms (µg), which is also the federal standard.

(Slide 24) California Assembly Bill 433 passed in 2003 and regulates ballast water. It's also known as the Marine Invasive Species Act and expires in 2010. It directs the California State Lands Commission, Coast Guard and a Technical Advisory Group (made up of shipping, port and related industry representatives) to evaluate the risk of commercial vessel hull fouling as a vector for invasive species. Under 433, this risk should be reduced by requiring ship owners to rinse their anchor chains, clean hull fouling and pipes, and ensure there is proper disposal. The Assembly Bill does not apply to military vessels or foreign vessels traversing U.S. waters that are not using

(Slide 24 cont.) U.S. ports if they are not discharging ballast water in or near state waters.

The Aquatic Bioinvasion Research and Policy Institute will study the potential of hull fouling as a vector for invasives. The study will be conducted in fresh and salt water and is scheduled to begin in July of 2005. The study will last two years.



(Slide 25) California's Ocean Action strategy seeks to increase aquatic life in California, making the water cleaner, ensuring a safe marine and estuarine environment, and supporting oceanic industries. This can be accomplished through the improvement of California's ocean and coastal governance structure, funding of programs and projects from various sources, increasing related research and educational opportunities, and aiding in the development of new technology. California waters have been affected by many invasive species, such as the European green crab and the Chinese mitten crab.

The Action Strategy will support efforts to eradicate species that have taken hold, including the Invasive Spartina Project and Southern California Caulerpa Action Team.

(Slide 26) Additional information from updated and added slide as of August 10, 2005: This slide was not presented in the Workshop presentation.

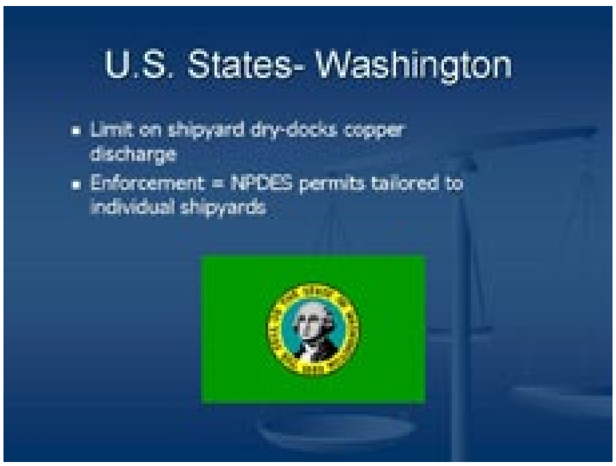
California Assembly Bill 433 (2003) requires the California State Lands Commission to develop a report on the "vectors, other than ballast water, and relative risks of those vectors, for release of nonindigenous species from vessels" (hull fouling). The report should also make recommendations regarding the minimization of hull fouling's role in invasive species introductions and other topics relating to ballast water. The California Ocean Council will oversee the report and the implementation of recommended actions.

(Slide 27) Additional information from updated and added slide as of August 10, 2005:
This slide was not presented in the Workshop presentation.

The California Ocean Protection Council was created in 2004 by Governor Schwarzenegger's signing of the California Ocean Protection Act. At its June 10, 2005

(Slide 27 cont.) meeting, the Council proposed the California Ocean and Coastal Information, Research, and Outreach Draft Strategy. The draft was open to public comment until July 25, 2005.

The strategy identifies California's information and research needs: Fisheries and Aquaculture, Ecosystems and Habitats, Coastal Hazards and Shoreline Processes, Water and Sediment Quality, and Invasive Species. With regard to invasive species, the Council expressed a need to expand prevention controls, create a statewide detection program, develop science-based eradication methods, and support research and development aimed at controlling the spread of invasive species.

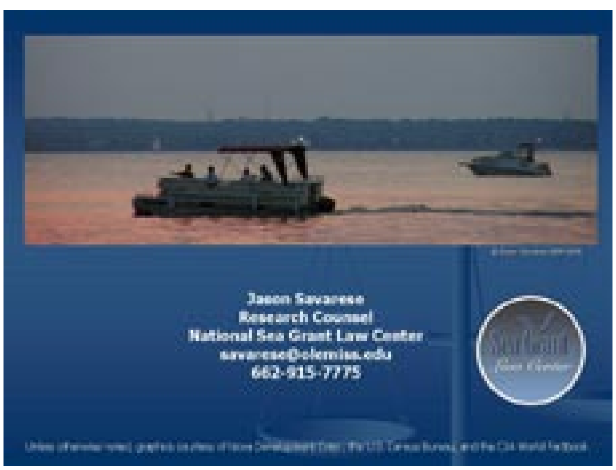


(Slide 28) In Washington state's Puget Sound, the discharge of copper by shipyard drydocks is limited through the use of NPDES permits tailored to the conditions, facilities and individual characteristics of the shipyards.

Slide 29) In Alaska, the sale and use of TBT paints are restricted. Most TBT paints cannot be sold or used. Vessels, fishing gear, and other items that have been sprayed with TBT cannot be used, sold, rented, leased or imported. There's no need to remove TBT-based paint on fishing gear, vessels, and other items, but these items may not be re-painted. Fish culture or capture nets painted before December 1, 1987, cannot be used after December 1, 1992. Slow-leaching TBT-based paint may be imported and sold for use on aluminum hulls and lower outboard drive units. (It may be imported and sold, rented, leased, or used).

(Slide 30) Some vessels are not required to remove their TBT antifouling coatings in order to use Alaskan waters. These include vessels from the U.S. government, foreign vessels in state water fewer than 90 consecutive days, and vessels of 4,000 gross tons or more. In Alaska, a vessel is defined as "watercraft used or capable of being used as a means of transportation on water," including aircraft and barges.

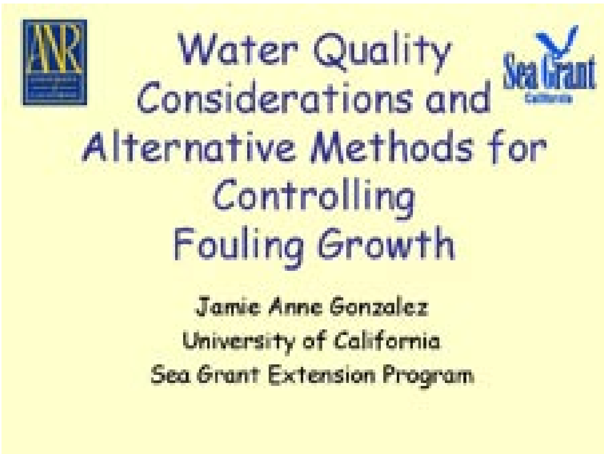
(Slide 31) Hawaii has a statewide hull fouling and ballast water prevention program, which is managed by the Department of Land and Natural Resources. The program's goal is to prevent invasive species "through the regulation of ballast water discharges and hull fouling organisms." It's a two-phase project. Phase 1 will focus on ballast water management. Those proposed rules have been drafted. Phase 2 will encompass hull fouling management and has not yet begun. It could be finished by 2007 or 2008, depending on funding and research availability. Currently, the Hawaii Alien Aquatic Organism Task Force is working with stakeholders to develop risk assessment strategies for hull fouling.



(Slide 32) Thank you for your time. ■

Water Quality Considerations and Alternative Methods for Controlling Fouling Growth

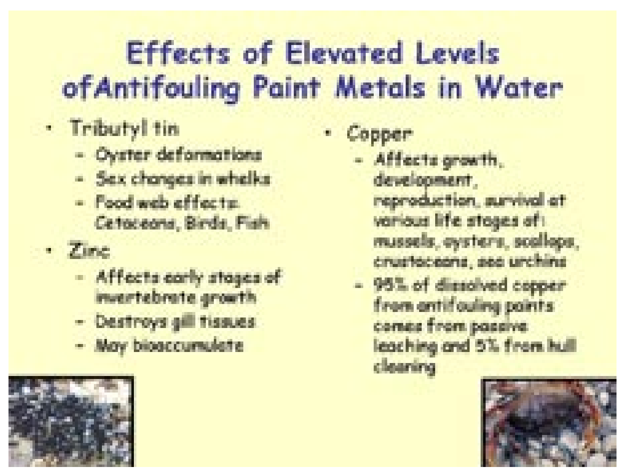
Jamie Gonzalez: University of California Sea Grant Extension Program



(Slide 1) Thank you. I'm going to be covering water quality considerations and alternative methods for controlling fouling growth.

(Slide 2) As was mentioned before, TBT has been banned in the U.S. and is currently being phased out for vessels making international voyages. Since the TBT ban and the upcoming phase out, copper-based antifouling paints have become the most common method to control fouling growth on recreational boats and commercial ships. However there are currently water quality concerns due to elevated copper levels in Southern California, Florida, Chesapeake Bay and Europe.

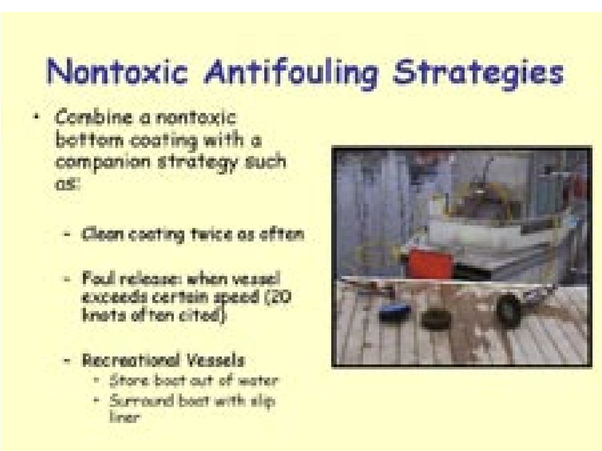
(Slide 3) Antifouling paints with metal are designed to release the metal into the water such as tin, copper, or zinc to slow the fouling growth on vessel bottoms. Because there is low circulation in enclosed basins and harbors, the metals can tend to build up in the water column and sediments and can reach toxic levels.



(Slide 4) Why are these metals a problem? Scientific research has concluded that elevated levels of tributyl tin, for example in the water column, have led to oyster deformations, to sex changes in whelks and also to overall effects in the food web by accumulating in lower organisms. These lower organisms are fed on by cetaceans, birds, and fish. In turn, it damages their reproductive and immune systems. Elevated levels of copper affect the growth, development, reproduction

(Slide 4 cont.) and survival at various life stages of: mussels, oysters, scallops, crustaceans, and sea urchins. There was a study done in 2003 by the Southern California Coastal Water Research Project. The study found that 95% of the dissolved copper released by antifouling paints comes from passive leaching while 5% comes from hull cleaning. Elevated levels of zinc affect the early stages of invertebrate growth, can destroy gill tissues, and also may bioaccumulate.

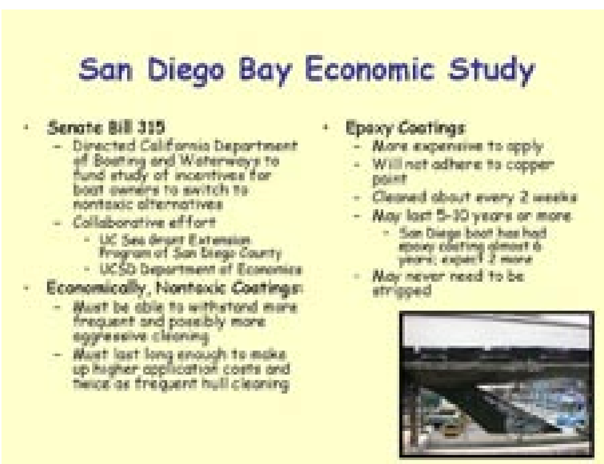
(Slide 5) Due to elevated copper levels in parts of San Diego Bay, the University of California Sea Grant Extension Program conducted a demonstration project on nontoxic, or biocide-free, coatings. The purpose was to help boat owners make decisions about nontoxic antifouling strategies. We tracked the performance of a silicone-rubber coating, an epoxy coating and a ceramic-epoxy coating on six different boats in San Diego Bay. Each coating was applied to a sailboat and to a powerboat. Throughout the project underwater hull cleaners reported on coating condition, fouling growth levels, diver effort levels and the type of cleaning tool used.



(Slide 6) A nontoxic antifouling strategy combines a nontoxic bottom coating with a companion strategy such as cleaning the coating more frequently (twice as often in San Diego Bay). Another companion strategy could be attaining high speeds. If a boat moves fast enough it can release the fouling and, as was mentioned before, that's why silicone coatings are also known as foul-release coatings. For recreational vessels a companion strategy could be storing the boat out of water with a boat lift or surrounding the boat with a slip liner.

(Slide 7) Some of our results: After one year the demonstration project vessels were hauled for inspection. We found that the powerboat and sailboat with the silicone coating were still in nearly new condition; however that product was recommended to be replaced every year. Due to the characteristics of silicone coatings, such as the need to attain high speeds so that the fouling releases and also their lack of durability and their fragility, they are probably not suitable for the typical recreational boater. They are more suitable to avid racers or commercial vessels that can attain high speeds.

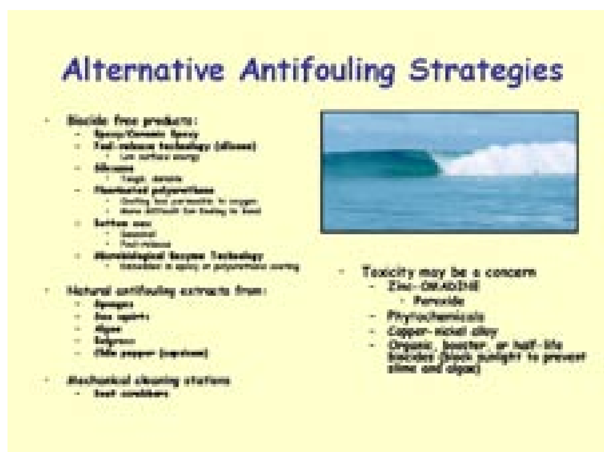
(Slide 8) The epoxy coating on the sailboat that entered our project was already almost 5 years old. After a year when we hauled it, the coating was still in pretty good condition and was expected to last another 2 years. The year-old epoxy coating on the powerboat was in nearly new condition as were the sail and diesel electric boats with the ceramic-epoxy coating. They were all still in pretty good condition. Economically, an important factor in switching to a nontoxic coating is the life of the coating. That is, how long is it going to last?



(Slide 9) The California Department of Boating and Waterways was directed by Senate Bill 315 to fund a study of incentives for boat owners to switch to nontoxic alternatives. This study was a collaborative effort between the University of California Sea Grant Extension Program of San Diego County and the University of California at San Diego Department of Economics. A 130 page research report resulted which was called "Transitioning to Non-Metal Antifouling Paints on Marine Recreational Boats in San Diego Bay." This report was delivered to the California Department of Boating and Waterways in

(Slide 9 cont.) November 2002 and then forwarded to the Legislature in early 2003.

The booklet "Making Dollars and Sense of Nontoxic Antifouling Strategies for Boats" is a summary of the economic study. The study found that economically, nontoxic coatings must be able to withstand more frequent and possibly more aggressive cleaning. They must also last long enough to make up the higher application costs and twice as frequent hull cleaning. Overall, the cost of maintaining a boat bottom is affected by how often the coating must be replaced and cleaned. Because nontoxic coatings do not deter fouling growth an important part of the project was to examine how fouling growth and best management practices affect the coating life. We found in the project that epoxy coatings were more expensive to apply. Also, and this has to do with the fact that they can not adhere to copper-based antifouling paints, the copper paint would have to be stripped off and that is an expensive process. The epoxy coatings and other nontoxic coatings also have to be cleaned more often; however we found that the epoxy coatings and ceramic-epoxy coatings may last about 5 to 10 years or more. I mentioned that one San Diego boat, which has now had the epoxy coating about 6 years, is still in pretty good condition. These nontoxic coatings may also never need to be stripped (go through that expensive process).



(Slide 10) Looking at some alternative antifouling strategies on the market today: We went over the epoxy and ceramic-epoxy coatings, also the silicone coatings were mentioned earlier. In addition, siloxane coating systems may be more durable than the typical silicone coating, providing more corrosion protection. The fluorinated polyurethane coatings also provide

(Slide 10 cont.) corrosion protection while the coating properties make it difficult for the fouling to bond to it. Bottom wax is more of a seasonal coating, an overcoating, which contains fouling release properties similar to silicone coatings. The microbiological enzyme technology is where microorganisms and enzymes are embedded in epoxy or polyurethane coatings. They remove the nutrients, which are the food source for the fouling organisms, preventing them from attaching. Their food source is eliminated. Extracts of marine organisms such as sponges, sea squirts, algae and eelgrass that prevent fouling themselves are being examined and tested for their natural antifouling properties. Some of you may have heard of using chile pepper extract in antifouling coatings to help further prevent fouling organisms. Other alternative products may contain zinc or organic booster or half life biocides, which were mentioned before, however toxicity may be a concern with these products. Replacing one persistent toxin such as TBT or copper with another may not be the best alternative. Phytochemicals and peroxides are also being used as alternatives to prevent fouling.

(Slide 11) Many new products are coming onto the market. Every time I look there are more of these headlines saying new nontoxic coatings are being researched and developed.

(Slide 12) No single, nontoxic or other, alternative antifouling strategy will suit every vessel. Independent studies of new strategies are needed in different geographic areas and on different types of vessels. For example, there was a coating that we tested in San Diego Bay which worked really well in northern Europe where the waters are much colder. The coating did not do very well in San Diego Bay. Coatings are going to do well on different types of boats and in different locations. We need to find a balance of water quality, fouling and invasive species control, cost, and technical feasibility. Some of these issues will come out in the breakout groups later this afternoon so hopefully this helps to provide some more background information.

(Slide 13) Thank you very much. ■

Workshop Panel Discussion

The Workshop presentations and discussions examined the issue of invasive species introductions through fouling on recreational and commercial vessels. A panel discussion followed the presentations.

Names are provided when persons contributing to the discussion could be identified from the recording.

Panel Discussion:

What is the trade off between the balance of water quality (especially with relation to biocidal paints) and the prevention of fouling? Are we likely to see a change and an increase in the number of fouling organisms when tributyl tin is phased out?
(Lynn Takata-California State Lands Commission)

This issue has received a lot of attention and discussion at the International Maritime Organization. The goals of society should drive the management priorities. If there is only a small amount of money with which to manage invasive species, where is the money best spent and what is it that you are trying to protect? Once this is ascertained for society, then the different vectors that can destroy those values should be evaluated and prioritized. It is important to know what is high on the list to be protected so that the resources can be prioritized.
(Ashley Coutts-Cawthron Institute, New Zealand)

In the case of Hawaii, the management recommendations aimed towards minimizing fouling introductions do not conflict with the water quality regulations, but tend to complement each other. The regulations on hull coating metal contamination prevent the dry docks from discharging fouling growth, which they scrape off vessels, directly into the harbor.
(Scott Godwin-B.P. Bishop Museum, Department of Natural Science, Hawaii)

What are the issues with regard to freshwater, in particular what has been done about the trailered boats that have no antifouling paints?
(David Breninger-Recreational Boaters of California and Placer County Water Agency)

There has been a fair amount of work done in the northeastern U.S. and in parts of Europe about transport of species by recreational craft as well as trailers. The most extensive work has been done on the Eurasian zebra mussel. There has been some empirical data collected and also some modeling to look at how the spread patterns of that organism relate to boat traffic patterns. Programs in a number of states are targeted at reducing the likelihood that invasive species will be transported by recreational boats hauled on trailers across land.
(Greg Ruiz-Smithsonian Environmental Research Center)

The U.S. Fish and Wildlife Service, a member of the Western Regional Panel on Aquatic Nuisance Species, has an active program surveying trailered boats. Prevention activities include highway signs that tell boaters coming from eastern U.S. states to western U.S. states about radio stations with information on preventing the transport of invasive species on their trailer, boat or live well.
(Jeff Herod-U.S. Fish and Wildlife Service)

The California Food and Agriculture State Quarantine recently intercepted seven boats with evidence of zebra mussels. However the program has been reduced due to state budget reductions. This would be a first line of defense that needs to be elevated to some degree. Public outreach is also needed.
(Valerie Van Way-California State Lands Commission)

How do slip liners, or boat baggies, work for recreational boats?

Some manufacturers suggest that to keep the boat baggie effective, chlorine base should be added, which is illegal in some places because of the toxicity of chlorine. Another option is to add fresh water to the slip liners, rather than chlorine, which can discourage fouling growth as well.
(Jamie Gonzalez-University of California Sea Grant Extension Program)

Also, a product called Chem-out, generally used for swimming pools in Australia, neutralizes chlorine. While there are concerns about chlorine intruding into the marine environment, containing the chlorine release followed by Chem-out treatment may be a potential solution.
(Ashley Coutts-Cawthron Institute, New Zealand)

What are the typical hull husbandry practices of the commercial fleet?
(Maurya Falkner-California State Lands Commission)

International standards exist for the cleaning of vessels depending on vessel class. The U.S. fleet follows these standards.
(Dragan Samardzic-Matson Navigation)

In the case of Hawaii, it is not the U.S. flagged vessels that typically pose 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.
(Scott Godwin-B.P. Bishop Museum, Department of Natural Science, Hawaii)

What role do military vessels play?
(Ted Grosholz-University of California, Davis)

In the U.S. the number of arrivals of U.S. Naval vessels is relatively low compared to arrivals of commercial vessels. Military vessels are a high risk, however, because they tend to sit in port longer then the traditional commercial vessels, and therefore tend to accumulate hull fouling organisms more readily.
(Greg Ruiz-Smithsonian Environmental Research Center)

The Navy is also trying to develop a system that scrubs the bottom and suctions all of the material so it is not released to the harbors.
(Maurya Falkner-California State Lands Commission)

Are there other companies that make these marine "Zambonis"?

In Hawaii, the Navy developed a remotely operated hull cleaning machine that is being put into commercial service. So the technology is there but as with any new technology, there are several layers of bureaucracy for checks and balances. The ability to perform a rapid in-water cleaning that does not introduce the fouling growth directly to harbors will be an extremely important development for preventing fouling AIS establishment. The drawback is that these hull cleaning machines are not effective in the recessed areas, such as around rudder posts and props. Since these areas are where much fouling growth occurs, they would still have to be cleaned manually by divers. (Scott Godwin-B.P. Bishop Museum, Department of Natural Science, Hawaii)

Matson is also working with a "Zamboni" manufacturer and indicates that such equipment is available to clean foul-release coatings on commercial ships, although it does not work effectively on propellers.
(Dragan Samardzic-Matson Navigation)

How are the self-polishing coatings working?
(Raynor Tsuneyoshi-California Department of Boating and Waterways)

Most of Matson's ships have a top-shelf self-polishing coating. Most of the ships run over 20 knots (20 to 23 knots). It is critical to have a clean ship because fouling growth causes a noticeable reduction in the speed and an increase in fuel consumption. This is a real financial concern to companies.
(Dragan Samardzic-Matson Navigation)

Is there any activity within the state agencies to coordinate their protocols for controlling invasive species with regard to recreational boaters?
(Mari Lou Livingood-Association of Marina Industries)

The California Department of Fish and Game gets together with California Department of Boating and Waterways and California State Lands Commission and others to discuss what the programs are and how they can be integrated better. One of the priorities is education and outreach. Also, the Resources Agency and the California Department of Food and Agriculture have been collaborating on some action item recommendations. They are interested in input from stakeholder groups.
(Susan Ellis-California Department of Fish and Game)

Comments on the Clean Marina policy
(Raynor Tsuneyoshi-California Department of Boating and Waterways)

One of the hesitations on a national Clean Marina policy is unless you get all the stakeholders together to talk about it, marinas throughout the country have different sea conditions and different organisms that they have to deal with. In addition, there are differences between the northern Californians and the kinds of things they have to deal with versus the southern Californians. It would be very difficult to get a "one size fits all" policy unless you really worked it out with all of the participants. For example, a Great Lakes marina has totally different conditions from California. Is there enough latitude so that it makes up for regional differences? ■

Breakout Discussion Session

During the afternoon, participants were separated into three discussion groups, each consisting of a mix of scientists, regulators, environmental organizations, recreational vessel stakeholders, and commercial shipping stakeholders.

Groups were asked to address five questions:

1. Does ship/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 AIS 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 deliberations. Points of general (but not necessarily unanimous) agreement or discussion are included in this summary.

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

The majority believe 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.

One point was that the commercial industry should not be held entirely responsible for the coastal transport of invasive species. The recreational boating community likely has some level of responsibility, but to what extent is unknown.

Recreational boaters may be less of a risk due to their shorter and less frequent voyages, however surveys are required to confirm this hypothesis. The operational dynamic is more important than the total area of a hull surface. It is important to evaluate the vessels that are sitting still for long periods of time and then traveling distances into other regions. Studies in Hawaii have found that these types of trips may serve to expose a single destination to repeated inoculations of AIS.

This topic raised a few points about risk of transfer as a result of commercial vessels. In Hawaii, studies have shown the regularly scheduled vessels are not a problem. In terms of hull fouling, the slow moving barges and vessels with irregular routes are of most concern.

Discussions for commercial vessels focused particularly on antifouling paints, as well as sea chests, anchor housings and chains. Discussions for recreational boaters included topics such as how often a boat is used, types of uses (racing versus leisure), distance traveled, and the lifespan of a particular boat.

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

Goal: to reduce the number of organisms associated with the bottoms of boats and ships.

► 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 are:

- Vessel behavior (speed, mooring time)
- Vessel type
- Hull husbandry practices
- Season
- Age of antifouling paint
- Vessel voyage route
- Port region/location

► Consider what amount of burden would be carried by the vessel owners, operators, marinas, or companies that would be responsible for invasive species prevention.

► Some species may not be a problem now but could be in the future and some species are more harmful in certain areas than in others.

► 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.

► Consider funding for prevention.

► Within and between state transfer.

► With eradication control, government agencies pay the costs through taxpayer monies, whereas with prevention a lot more of the cost will go to the boating/commercial shipping community.

► Values are a big consideration. Many different values affect perspective on public response: environmental values, social values, and economics come into play especially with large commerce. These would have quite a large influence on decisions.

► Community outreach and regulatory framework: representatives of the recreational boating community strongly advocate outreach and education as the primary method of problem solving while representation from the commercial maritime industry seemed to lean towards some form of hull management guidelines or regulatory framework.

► Overall, regulatory needs should be assessed based on the level of willingness of the community to adopt best management practices and evidence that the BMPs are effective and compliance is high.

► Management procedures for the commercial maritime industry will most likely be different from the recreational boating community.

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

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

► Once hull management strategies (or regulations) are in place, there will be some need for verification or validation that the procedures are effective over time.

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

Though there was no 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.

► Periodically maintain antifouling coatings, with a preference for biocide-free coatings.

► Coating application or cleaning regularity could be certified to verify that a vessel has been maintained properly. At this time, however, it is recognized that some nontoxic coatings are initially very costly, and are still currently undergoing testing and further development.

► Economic incentives such as tax credits and fee waivers could be employed to encourage the use of nontoxic coatings.

► Remove fouling organisms regularly from hulls as well as from other areas such as sea chests, anchors, etc. Ideally for AIS 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.

► A code for "Best Management Practices" could be adopted for fouling maintenance.

► Vessels could be cleaned upon departure from California and inspected upon return.

► Maintenance will depend on the willingness of the vessel operators to incur the costs.

► Use a stepwise approach:
- 1st level: Educating vessel owners
- 2nd level: Awareness/warning
- 3rd level: Regulation/hammer

► Commercial Maritime Industry Practices
- Generally dry dock for hull cleaning on a set schedule
- If fuel efficiency is poor, then hull cleaning is performed

► Recreational Boating Community Practices
- Generally clean hulls before each summer season depending on geographic location
- Competitive racing boats are cleaned more often
- In northern California, boaters would feel imposition if hull cleaning is required more than once every two years
- In southern California, recreational boaters clean hulls about once every month

► Silicone-based paints
- Some are the same price per square foot as other common hull antifouling paints
- Largest cost is to strip previous paint coatings before application
- Provides a smooth surface that increases fuel efficiency
- Simply maintained by wiping the hull down between dry docking
- Requires dry docking approximately once every five years
- Most difficulty is convincing the industry that it is a worthwhile investment

► Silicone-based paint issues relevant to the commercial maritime industry

• May be good for Matson type commercial vessels which are typically container carriers with +20 knots operating speed
• May not be so good for Chevron type commercial vessels which are typically tankers that seldom reach above 18 knots operating speed and have longer port stays
• In New Zealand, high rates of survival have been found in sea chests and anchor housing
• Silicone-based paints have been found to be highly effective in sea chest areas

► Silicone-based paint issues relevant to the recreational boating community

• Little economic incentive to strip and re-paint hulls of recreational boats
• Boat owners only tend to keep boats six to seven years
• Possibly more favorable to high speed racing boaters

Vessels' hulls are microcosms with many living organisms that have been found to be highly durable. Hull husbandry practices should carefully consider preventative measures. Suggestions included using slow-release biocide blocks in sea chests or some other practice such as regular freshwater flushing.

► Mechanical in-water scrubbing services for recreational boats

• Most opposed mechanical service and favored divers
• Compromise might be:
  -mechanical cleaning every six months
  -diver cleaning every six weeks

► Possible management solution could be a certificate program

• Require certificate of hull cleaning
• Show how often hull has been cleaned
• Document length of time vessel is in marina or port

Question 4. What information gaps need to be closed?

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

► Current maintenance practices of vessels. 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

► Management practices of high-risk boats and vessels need to be determined

► Develop better communications among members of inter-agency working groups

► Vessel movement patterns

► Economic and ecological impacts of AIS

► Survey vessel owners and harbor masters:

• Identify what they are doing via existing practices
• Learn from existing models

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

► In general, outreach and education were deemed to be very important, and were particularly advocated for and by representatives of recreational boating. Therefore, potential vehicles for outreach that were discussed applied largely to the recreational community. Programs such as Sea Grant may be good avenues to develop outreach to the recreational boating community:

• Information on early detection
• Lessons learned from New Zealand, Australia, Minnesota, Hawaii
• Monitoring for AIS: Public can be trained to help
• Report findings: need website and contact information to answer questions

► Develop prevention materials: Once AIS are established they are difficult to eradicate. Focus on prevention.

► Partner with industry for outreach: strengthen collaborations.

► Work with boating associations to extend information to boaters and industry.

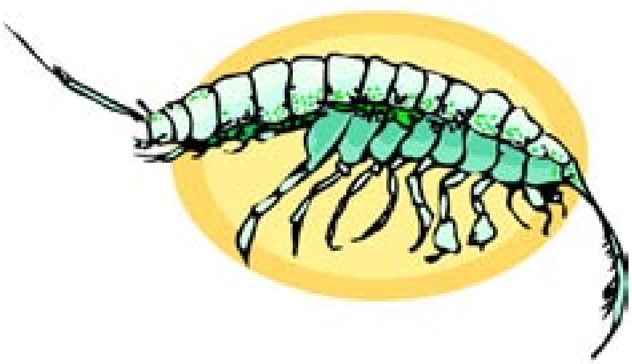
► Boat and marine supply stores are best way to extend information to California boaters.

► Need to see relationship between efforts to protect water quality from impacts of copper antifoulants and efforts to control invasive species in hull fouling.

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

► Suggestions that could be applied to the commercial industry include:

- Advertisements/articles in industry publications (magazines)
- Distribution of posters and brochures to commercial community
- Internet/email distribution of information
- Communication between agencies involved with maritime issues 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.) ■



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Closing Discussion Key Points

The following is a summary of the points of consensus between the breakout groups in terms of the management considerations for controlling the hull transport of invasive species:

► A risk-based approach should be used to develop the best strategies for management based on:

- vessel behaviors
- vessel types
- hull husbandry
- seasonal components
- age of paint
- vessel origins and destinations
- different trade groups

► Studies are needed to determine what maintenance measures are most effective to control AIS.

► Solutions will need a cost/benefit analysis.

► It will also be important to consider who should be responsible for the costs of prevention.

► A vector approach should be used for managing prevention and control of AIS on hulls, anchors, ballast, sea chests, etc. Use the species-specific approach for education/case studies.

► Resources should be focused on prevention and on high risk species.

► There should be continued inter-agency communication for management, the continual sharing of research data, production of educational handouts, and public service announcements for the radio and television.

► It is also important to continue the research and development of technologies for fouling prevention and AIS control such as environmentally sound foul-release coatings. During this research and development, keep in mind the costs to consumers to utilize potential products, beware of claims made for new and unproven technologies and recognize the need for independent testing of products and testing protocols. ■

Workshop Participants

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Evaluation: Managing Hull Transport of Aquatic Invasive Species (AIS)
May 11, 2005 Workshop Proceedings

Would you please help us to evaluate the effectiveness of the proceedings by completing and returning the evaluation form? Thank you!

Please put an X by all of the groups to which you belong:

_____ Recreational Boat Owner
_____ Marina or Yacht Club Manager
_____ Boat Repair Yard Company
_____ Paint/Coating Company
_____ Port or Harbor Authority Commissioner
_____ Other Elected/Appointed Official
_____ University Researcher
_____ Boating Association
_____ Trade Association Manager
_____ Environmental Organization
_____ Underwater Hull Cleaning Company
_____ Port of Harbor Authority Staff
_____ Other Government Agency Staff
_____ Consultant
_____ Commercial Fishing Boat Owner
_____ Commercial-Passenger Fishing Boat Owner
_____ Other:____

Please indicate the state and/or country where you are located ______________________________

Please circle the number that indicates how much you agree with the following statement, using this rating system:
1 = Do not agree, 2 = Agree slightly, 3 = Agree somewhat, 4 = Agree very much, 5 = Agree extremely

1 2 3 4 5 The information in the proceedings will be USEFUL TO ME in understanding and making decisions about preventing the introduction of aquatic invasive species (AIS) due to hull transport.

Please place an X beside each topic in the proceedings that provided you with NEW information:

_____What aquatic invasive species (AIS) are

_____Types of AIS that may be transported on vessel hulls

_____Vessel hulls as a vector of AIS

_____Structural, socio-economic, and ecological impacts of AIS introduced due to hull fouling

_____Status of AIS hull transport and control measures in Hawaii and New Zealand

_____Effects of vessel use patterns on attachment and development of fouling organisms

_____Laws, regulations, and agencies governing control of hull-borne AIS, fouling growth, and water quality

_____Impacts of antifouling paints on water quality

_____Potential technological control measures for AIS hull transport

_____Pros and cons of each type of technological control measure

_____Management measures and policies suggested to implement effective prevention and control of AIS hull transport in California

_____Differences in hull transport risks posed by ships vs. recreational/fishing boats

_____Research, education and management measures that may help to control AIS while protecting coastal water quality

Please comment or suggest other AIS related information or research projects that would be useful to you or that are needed for preventing/controlling AIS introductions:

Thank you for helping us to evaluate the effectiveness of our programs!!

Please fax, mail, or e-mail the completed evaluation to:
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