Volume 6 Spring/Summer 2006

GREETINGS

By Holly Crosson, Coordinator, West Coast Ballast Outreach Project

Welcome to the *Ballast Exchange* newsletter, produced by the California Sea Grant Extension Program. Many of you are familiar with the first version of the newsletter, which was published by the West Coast Ballast Outreach Project (WCBOP) between 1999 and 2003. After a long hiatus, we are happy to announce the WCBOP is back. The new *Ballast Exchange* will be published twice a year and features information on issues related to ballast water, vessel fouling and marine invasive species that are of interest to the maritime industry, regulators and resource managers, researchers and the general public. We hope you like the new look of the newsletter and as always, we welcome your feedback. We also encourage contributions from our readers so please get in touch with us if you would like to write an article for a future edition of *Ballast Exchange*.

The second phase of the WCBOP began in September 2005 and will continue through December 2008 with funding from the CALFED Bay-Delta Program. Our goals remain much the same as during the first phase of the project: to provide education and outreach on marine invasive species, ballast water management and vessel fouling; to facilitate communication and coordination amongst the maritime industry, regulators and resource managers, and researchers concerned with these issues; and to foster the development of alternative ballast water management techniques that involve and meet the needs of the West Coast industry. Our outreach efforts include the *Ballast Exchange* newsletter, the revised and updated "Stop Ballast Water Invasions" poster and companion brochure, a brand new project website, and organizing and hosting special workshops and seminars that focus on ballast water, vessel fouling and other emerging marine invasive species issues of interest to stakeholders.

We are excited about maintaining the same high level of commitment to achieving our goals that you came to expect during the first phase of the project. While we intend to keep some continuity with the early years of the project, we are also enthusiastic about initiating some new approaches. We are especially looking forward to working with our Advisory Committee members, both returning and new, and extend our sincere appreciation for their expertise and dedication to the WCBOP. We held our first meeting on January 17, 2006 in Oakland, CA and were very pleased with the ideas and input we received from the committee. It is rewarding to work on common goals with such a diverse and talented group. Thank you for your role in helping us work towards successfully achieving our goals.

The articles in this issue of *Ballast Exchange* span a broad range of topics about ballast water, vessel fouling and marine invasive species – from regulation and policy, to research, treatment and outreach. They are written by colleagues from the West Coast of the U.S. and from as far away as New Zealand, emphasizing the truly global nature of ballast water and aquatic invasive species management issues. We hope you enjoy the newsletter. Please let us know if you have suggestions for articles in the next issue, to be published this fall.

Holly Crosson, Program Coordinator
Nicole Dobroski, Program Representative
Jodi Cassell, Program Director

In this Issue

California's Marine Invasive Species Program

Maurya B. Falkner,
California State Lands Commission

Begun under the auspices of the Ballast Water Management for Control of Nonindigenous Species Act in 1999 (Assembly Bill 703), the California Marine Invasive Species program has grown by leaps and bounds from its simple beginning of foreign ballast water management. The program now encompasses aspects of applied nonindigenous species (NIS) research, ballast treatment technologies, non-ballast vessel transport, and coastwise ballast water management.

The original 1999 law required that vessels originating from outside the United States Exclusive Economic Zone (EEZ–out to 200 nautical miles (nm) from land) carry out mid-ocean exchange of ballast water (replacing the water in ballast tanks with water taken from farther than 200 nm from land and greater than 2,000 meters deep), or use an approved ballast water treatment method, before discharging in California state waters (high tide mark out to 3 nm including mainland and islands). Prior to the sunset of that legislation, the act was recast in 2003 as AB 433, the Marine Invasive Species Act (Act), and the California State Lands Commission (CSLC) was charged with several additional responsibilities. Key among these were to develop regulations governing ballast water and coastwise travel (ships that move between ports on the West Coast without leaving the EEZ), provide recommendations on performance standards related to ballast exchange or treatment, evaluate the risk of other ship-mediated mechanisms of NIS introduction, expand biological surveys in California waters, and evaluate the feasibility of onboard treatment technologies.

A container ship negotiates a turning basin at the Port of Oakland, CA. Photo courtesy of Lynn Takata, California State Lands Commission

Enhanced Program Components

Coastal Traffic and Ballast Water Management Regulations. In the new Act, the ballast management requirements for vessels originating outside of the EEZ remained largely similar to those of AB 703, with the exception that vessels engaged in coastwise crude oil trade are no longer exempted from the regulation. In accordance with the Act, CSLC adopted ballast water management regulations for vessels originating from within the Pacific Coast Region as defined in Public Resources Code, Section 71200(j). These regulations, effective March 22, 2006, require that all vessels operating in California waters manage their ballast water. Vessels arriving from other West Coast ports are required to either retain all ballast water on board or conduct a near-coastal exchange (per California law farther than 50 nm from land and greater than 200 meters deep) of that ballast water prior to discharge in California waters. The development of these regulations was the result of several workshops and advisory group meetings attended by representatives of the maritime industry, scientific community, local, state and federal regulatory agencies, environmental organizations, and the public.

Performance Standards for Ballast Water Discharges Report. The CSLC is required to recommend specific performance standards to the state legislature, in consultation with the State Water Resources Control Board (SWRCB) and in consideration of recommendations provided by an advisory panel. CSLC staff convened a c ross-interest, multidisciplinary panel and facilitated deliberations over the selection of standards based on best available and economically achievable technology and designed to protect the beneficial uses of the waters of the state. Five meetings were held between March and August 2005. A variety of approaches was used to guide considerations. While questions remain regarding the effectiveness and economic achievability of technologies, and there is no strong scientific evidence that argues for a specific level of treatment, the CSLC believes the codification of performance standards is essential to move technology development forward. Furthermore, the CSLC believes that by setting a technology-forcing standard and mandating the review of treatment technologies as they relate to the implementation schedule, the intent of the Act can be achieved. All of these considerations were incorporated into a set of final recommendations that will be submitted to the legislature following agency administrative approval.

Other Ship-Mediated Vectors for NIS Introductions Report. Current state legislation requires that the CSLC, in consultation with the U.S. Coast Guard and a technical advisory group, submit a report to the legislature and general public analyzing the discharge of NIS from vessel vectors other than ballast water (i.e., hull fouling, sea chests, suction grids, propellers, chains, anchors, piping, tanks, etc. See article by Lynn Takata in this issue).

Research

In addition to the regulatory directives, the Act included mandates to address information gaps identified during the beginning years of the program that would improve it's ability to prevent NIS introductions. As listed here, the CSLC will be funding projects that evaluate alternative shipboard treatment technology, ballast water exchange, and hull fouling as a vector for NIS introductions.

Shipboard Technology. The CSLC has entered into a contract with Matson Navigation, Inc. to assist in the installation and evaluation of the Ecochlor experimental treatment technology on the bulk vessel *Moku Pahu*. Installation of the system was completed in fall 2005, and testing of the system is scheduled to begin in spring 2006. See article by Nicole Dobroski in this issue.

Ballast Water Exchange Verification. The Smithsonian Environmental Research Center (SERC) will be testing the application of Ballast Water Exchange verification (BWEv) methodology on vessel traffic arriving at ports along western North America. This work builds upon significant national and international efforts to implement a reliable, affordable, and easy-to-use method to verify that ballast water has been exchanged a required distance offshore.

Hull Fouling. The Aquatic Bioinvasion Research and Policy Institute (ABRPI), which combines SERC's marine expertise and Portland State University's freshwater expertise, will conduct a study to examine the potential for invasions to California through the fouling vector. The results of this project will provide a better understanding of the overall risk that vessel fouling poses for NIS introductions to California and will assist the state in identifying effective prevention measures. See article by Ian Davidson in this issue.

California Department of Fish and Game (CDFG) Invasive Species Survey. Under the 1999 legislation, the CDFG was the primary agency required to conduct a study to determine the distribution and range of NIS in California estuaries and coastal areas. The study focused on areas where introduced species from ballast water were most likely to occur, such as large ports and smaller harbors. The results of this study can be found at: http://www.dfg.ca.gov/ospr/MISMP.htm.

Because ballast water control measures were expanded to include coastwise traffic with the 2003 legislation, it was determined that the initial baseline survey conducted by CDFG should be expanded to include outer coastal habitats. Sampling of outer coast habitats was conducted in 2004. In addition, the new legislation required a monitoring program to determine if new introductions have occurred since the original baselines were established. Resampling of the San Francisco Bay sites occurred in 2005 and remaining ports will be re-sampled in 2006. As data becomes available, they will be posted at the aforementioned web address.

The program's high compliance rates, exceeding 95%, are attributable to multipronged outreach and communication activities. CSLC inspectors distribute printed and verbal information to ships' crews on regulations. Agents are notified monthly of their vessels' reporting compliance or non-compliance. Multi-agency, multi-interest advisory groups are continually convened and consulted regarding evolving policy considerations. CSLC has coordinated extensively with other states and the federal government on ballast water and hull fouling management issues. These efforts serve to maintain well-informed stakeholders, build working relationships with affected parties, and ensure that regulations are wisely developed.

More information on the state's program can be found at http://www.slc.ca.gov/Program_Pages/Program_Pages.htm.

Newsletter Evaluation Survey

We are interested in your opinion of the new West Coast Ballast Outreach Project newsletter, *Ballast Exchange*. We would greatly appreciate it if you took the time to fill out our online newsletter evaluation survey. The survey can be found at http://www.surveymonkey.com/s.asp?u=996051932215.

New West Coast Ballast Outreach Project Website

We have completely revamped our West Coast Ballast Outreach Project (WCBOP) website. The new website contains up to date information on general Aquatic Invasive Species (AIS) and ballast water issues, ballast water laws and regulations, ballast water treatment technologies, non-ballast vessel vectors (i.e. hull fouling), our WCBOP outreach materials including our "Stop Ballast Water Invasions" poster and brochure as well as previous issues of *Ballast Exchange*, a calendar of upcoming events, AIS literature, photo gallery and links to other invasive species and ballast water websites. The URL remains http://ballast-outreach-ucsgep.ucdavis.edu. Please check out our new website and fill out the brief "Website evaluation survey" found in the "About the Project" section.

Vessel Fouling: New Attention to an Old NIS Vector

Lynn Takata, California State Lands Commission

For managers, policy makers and researchers dedicated to the prevention of marine and estuarine nonindigenous species (NIS) introductions, ballast water has occupied much of the center stage during the last decade. However, a less well-understood mechanism has been gaining attention as another important vehicle for introductions: vessel fouling.

Fouling forms on submerged portions of hard surfaces, both natural and artificial. On pier pilings, tide pool rocks, oil platforms and the like, mussels, seaweed, anemones and sea squirts may be attached to the surface. Barnacles, other seaweeds, and the plant-like limbs of bryozoans may be attached to mussel shells. Mobile organisms such as shrimp, worms and sea snails may be tucked in nooks created by the larger animals. Associated microorganisms, though unseen by the naked eye, are also part of the "fouling community."

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

Aerial view of the Suisun Bay National Defense Reserve Fleet. (Photo courtesy of Bryan Vogel, Maritime Administration).

Despite these efforts, recent studies indicate that fouling is still an important vehicle by which nonindigenous organisms can be transported to new regions. Vessels that move at slow speeds, spend long periods in port, or are repainted infrequently, tend to accumulate more fouling. Unlike the harsh exposed areas of the hull that experience strong water motion, sheltered recesses of vessels appear to be more hospitable for fouling organisms. Thus, studies have documented extensive fouling communities on towed vessels, in sea chests, and on recreational vessels. In Hawaii, fouling is believed to be responsible for more successful marine introductions than any other mechanism. For North America, one study estimated that at least 36% of introduced invertebrates and algae arrived via fouling.

Since 2000, the California State Lands Commission (CSLC) has administered California's ballast water management program. In 2003, California Assembly Bill 433 expanded these responsibilities, directing the agency to formulate recommendations to prevent introductions through non-ballast, commercial vessel vectors–essentially vessel fouling. As required by the legislation, the CSLC assembled a technical advisory group composed of representatives from state and federal resource agencies, the commercial shipping industry, and the scientific research community.

Advisory group meetings were kicked off in May 2005 with a workshop held in cooperation with the California Sea Grant Extension Program. Invited speakers included experts on antifouling coatings and commercial fleet maintenance, and marine invasion scientists from New Zealand, Hawaii and the Smithsonian Institution. During the workshop and three subsequent meetings that extended through December 2005, discussions explored the status of scientific knowledge on fouling and introductions; the lack of public awareness of the issue; management frameworks adopted by other regions and nations; and the pros, cons and applicability of potential recommendations for California. Based on input from the advisory group and further background research, the CSLC will submit a report to the state legislature with recommendations to address the commercial vessel fouling risk.

The impending movement of the vessels in the Suisun Bay (California) National Defense Reserve Fleet highlights the potential for NIS spread via fouling, as well as the need for a management infrastructure to address the risk. The so-called "Mothball Fleet" vessels are under the custody of the Maritime Administration and have been stored in the bay in case of emergency or war. Most have been moored for years if not decades, and have undergone little if any hull maintenance. Consequently, invasive species experts agree that the likelihood of heavy fouling and the potential for NIS transport on these vessels would be very high if any were relocated. The Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 requires the disposal of non-purposed members of the reserve fleet by the end of September 2006, and several are slated to be scrapped, sunk or donated for public display. Without a preventative NIS strategy, the native and non-native fouling organisms attached to these vessels will be transferred with them as they are moved to other regions for disposal.

The CSLC has begun working with the U.S. Coast Guard, other West Coast states, and the research community to develop management and outreach strategies to curtail the risk for NIS translocation via the Mothball Fleet vessels and others like them. It is hoped that these first steps will be a springboard for coordinated action that will prevent the movement of non-native fouling organisms to California, as well as their export from California to other regions.

See page 12 for references

Ships' Sea Chests: An Overlooked Mechanism for Species Transfers

By Ashley Coutts, Cawthron Institute, Marine Biosecurity Group, Nelson, New Zealand

Ships have long been recognized as major carriers of marine pests around the globe, in ballast water or as hull fouling. However, recent research undertaken at Cawthron Institute in Nelson, New Zealand indicates that we must also consider "sea chests" as a third dispersal mechanism. Sea chests are the built-in recesses on a ship's hull that house the intake water pipes for engine cooling, ballast and fire-fighting (Figure 1). The way sea chests are designed makes them ideal places for marine stowaways to live and seek shelter because they provide a relatively protected environment in contrast to the outside of a ship's hull. Furthermore, the toxins in the anti-fouling paints used on ships' hulls are often less effective in these protected areas. This is because many anti-fouling coatings rely on constant, relatively high water flows over them to keep the toxins in the paint exposed (and thus effective), and sea chests seldom have constant high water flows running through them.

> "...these findings indicate the importance of managing the ship as a whole..."

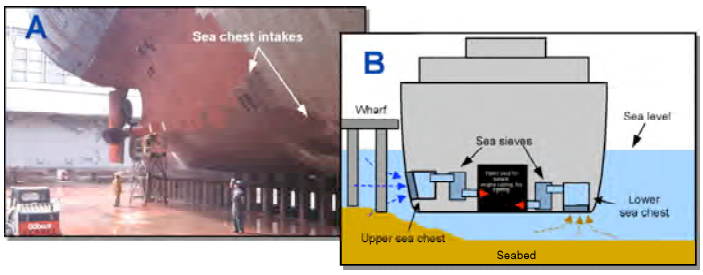


Figure 1.
A) Location of sea chest intakes on a typical merchant ship.
B) Schematic of a sea chest system.
Photo by Ashley Coutts

Since 2000, Cawthron has sampled 53 sea chests from 42 vessels (with gross tonnages ranging from135 to 13,621) at dry docks and slipways around New Zealand. Vessel types included fishing boats, research vessels, bulk carriers, roll-on/roll-off ferries, container ships, dredges, frigates, cruise ships, tankers and tug boats. Twenty three of the vessels were local New Zealand craft while the remaining 19 were international.

Altogether, 151 different species of marine life were collected, consisting of: one plant species (mangrove seeds) and 150 animals of almost every major group. These included sponges, jellyfish, anemones, marine worms, shellfish, sea mosses, crabs, shrimps, starfish, sea urchins and fish. Of these, 61 were New Zealand natives, 21 were foreign species that have previously become established in New Zealand, 15 were foreign species not found in New Zealand before and 55 were of unknown origin (Figure 2).

An interesting and important observation was that 85 of the animal taxa collected from 45 of the sea chests were mobile. Among these were 10 snail species, 19 crabs, 4 fish, a sea urchin, a sea cucumber, and a starfish. Most of the foreign species, that is one species of isopod (sea louse), 3 species of amphipod ("hoppers"), 6 species of mollusc (shellfish) and 5 species of decapod (crabs and shrimps), were found on vessels operating between the South Pacific and New Zealand.

The results from this study show that a wide variety of organisms are capable of surviving inside sea chests, highlighting the potential for sea chests to disperse organisms around the world. The presence of adult, mobile stages is particularly significant and indicates that sea chests may be of greater importance than ballast water or hull fouling for dispersing certain marine species. This is because many of the mobile sea chest-living animals are small enough to be able to escape from their temporary homes on arrival in a new "host" port. If they are adults, (particularly females carrying eggs) and conditions suit them, they are potentially more likely to be able to reproduce than many marine species that may be discharged as tiny larvae into the same port in ballast water.

When considering species transfers in general, these findings indicate the importance of managing the ship as a whole rather than concentrating on any particular transfer mechanism (be it ballast water, hull fouling or sea chests) in isolation. However, knowing that sea chests are hosts to this wide variety of marine life is just the start. The big question still remains: what can be done about it? In this regard, Cawthron intends to investigate the survival rates of marine organisms inside the sea chests of local vessels sailing between New Zealand ports, and also to look into the development of practical, cost-effective treatment methods for sea chests.

Figure 2. Examples of adult mobile taxa found inside sea chests of vessels from New Zealand.
Photo by Ashley Coutts

Styela clava Invades New Zealand

By Ashley Coutts, Cawthron Institute, Marine Biosecurity Group, Nelson, New Zealand

The sea squirt *Styela clava*, commonly referred to as the clubbed tunicate or leathery sea squirt, originates from the northwestern Pacific around the Japanese, Korean and Siberian Coasts. The species has been accidentally introduced to Scotland, England, France, Spain, Canada, the United States, Australia and now New Zealand.

Styela clava was first detected in New Zealand waters in August 2005 by two visiting marine scientists from the United Kingdom who (rather ironically) were attending the Fourth International Conference on Marine Biological Invasions. The scientists found the sea squirt growing on marina walkways in Auckland's Viaduct Basin in the North Island.

Although *S. clava* is often considered relatively harmless in areas where it is accidentally introduced, the species is known to be a notorious fouling pest among the Prince Edward Island mussel industry in Canada, where its smothering effect of cultivated mussels has reduced farm production by up to 40% in a year. Therefore, the presence of this species in New Zealand is a severe threat to the local Greenshell™ mussel culture industry (approximately $USD 100 million annually) and other highly valued marine environments around New Zealand.

Not surprisingly, Biosecurity New Zealand (BNZ) commissioned a nationwide scientific survey for the species and began an extensive public awareness campaign, encouraging the public to report any sightings of *S. clava*. Outreach efforts have included a fact sheet for general marine users, a waterproof identification card for divers, and widespread advertising in newspapers, specialist magazines and on radio.

Furthermore, BNZ has worked closely with the aquaculture industry and other potentially affected parties such as marinas, ports, shipping and divers to keep them informed of developments and to generate active industry surveillance. The aquaculture industry has produced and distributed an identification guide for marine farmers and harvesters, and has developed a "Code of Practice" to minimize the risk of spreading *S. clava* on vessels, stock and aquaculture equipment.

The survey results so far have shown that the sea squirt is widespread throughout the Auckland region, and a small population is also present in Lyttelton Harbour, about 1,250 miles south of Auckland in the South Island. The species has been found mainly on artificial structures such as harbor and marina piles, walkways, ropes, buoys, vessel hulls and on oyster and Greenshell™ mussel farms around Auckland.

Styela clava seems to prefer artificial structures in sheltered areas of slow water movement, from the waterline to at least 80 feet beneath low-tide mark and is able to grow and spread rapidly in temperate marine environments. The larvae are active for about 12 hours, and their dispersal period, which depends mainly on tidal movement, lasts about 24 hours. As a result, the maximum distance larvae may be carried in the water will be about the same distance as the tide will flow over a complete cycle.

Styela clava *hanging from a pontoon in Auckland's Viaduct Harbour, New Zealand.*
Photo by Ashley Coutts

Given the competency period of the larvae, it is highly unlikely the species arrived in New Zealand via ballast water. It is more likely the species arrived in New Zealand attached to the hull or in the sea chests (sea water intakes) of a visiting vessel and the adults spawned during their visit. While the species could have originated from any one of the Northern Hemisphere populations, the species probably originated from nearby southern Australia. Now that the species is present in both islands of New Zealand, the challenge is to effectively minimize its spread to highly valued areas around the country via a number of potential vectors (e.g., infected aquaculture equipment, ballast water, fouling on hulls).

For more information, visit http://www.biosecurity.govt.nz/pest-and-disease-response/pests-and-diseases-watchlist/sea-squirt.

CAWTHRON

The Clubbed Sea Squirt *Styela clava* in North America

By Nicole Dobroski, California Sea Grant Extension Program

The discovery of the clubbed tunicate *Styela clava* in New Zealand (see associated article by Ashley Coutts) is a reminder that this hardy, marine invasive species is already present in North America.

The first populations of *S. clava* to be found outside its native range in Asia were discovered in California in the 1930s. *Styela clava* was discovered in Newport Bay, CA in 1932 and later in Elkhorn Slough in 1935 (although no *S. clava* have been found in Elkhorn Slough since that time). During the late-20th century, *S. clava* spread throughout North America. The tunicate is currently found from British Columbia, Canada to Baja California on the North American West Coast and from Prince Edward Island (PEI), Canada to New Jersey on the East Coast. *Styela clava* was first discovered on the North American East Coast in Massachusetts in 1970.

The introduction of *S. clava* to California in the 1930s was likely as fouling on ship hulls or in sea chests. This same vector is thought to be responsible for the recent introduction of *S. clava* to New Zealand. An additional vector that may have been responsible for the introduction of *S. clava* to Elkhorn Slough in 1935 is the oyster industry. Japanese oyster farming was common near Elkhorn Slough between 1929–1935 and small individuals of *S. clava* may have reached Elkhorn Slough as fouling on the shells of adult imported oysters.

In North America, *S. clava* is commonly found on artificial surfaces, i.e., navigation and mooring buoys, marina floats and pilings, cultured mussels and oysters, and on boat hulls and fishing gear. On PEI, Canada, mussel growers must dispose of a million pounds of *S. clava* from mussel lines and gear each year.

Adverse impacts from *S. clava* in the United States are currently limited to fouling of boat hulls and marina floats. However, mussel and oyster farmers from both coasts of the United States, as well as British Columbia, are aware of the serious economic impact *S. clava* has had on the mussel industry on PEI, Canada. These farmers, particularly in the Pacific Northwest, are understandably alarmed by the presence of *S. clava* in their waters. A few *S. clava* have recently been reported from oyster lines in British Columbia. Gretchen Lambert, a marine biologist at the University of Washington Friday Harbor Laboratories, comments, "We cannot predict whether *S. clava* will in fact become a major fouler in [British Columbia and Washington State], but vigilance and rapid response will be necessary to prevent a situation like PEI from happening."

For more information about *Styela clava* in North America, visit http://www.exoticsguide.org/.

Online Resources

Aquatic Bioinvasion Research and Policy Institute
http://www.clr.pdx.edu/abrpi/

Aquatic Nuisance Species (ANS) Task Force
http://www.anstaskforce.gov/

California State Lands Commission
http://www.slc.ca.gov/

Great Lakes Panel on Aquatic Nuisance Species
http://www.glc.org/ans/panel.html

Global Ballast Water Management Programme
http://globallast.imo.org/

National Ballast Water Information Clearinghouse
http://invasions.si.edu/nbic/

National Invasive Species Information Center
http://www.invasivespeciesinfo.gov/

Northeast-Midwest Institute - Aquatic Invasive Species
http://www.nemw.org/biopollute.htm

Oregon Department of Environmental Quality
http://www.deq.state.or.us/

Sea Grant Nonindigenous Species Site
http://www.sgnis.org/

Stop Aquatic Hitchhikers!
http://protectyourwaters.org/

U.S. Coast Guard Ballast Water Management Program
http://www.uscg.mil/hq/g-m/mso/estandards.htm

Washington Department of Fish and Wildlife
http://www.wdfw.wa.gov/

Western Regional Panel on ANS
http://www.fws.gov/answest/

West Coast Ballast Outreach Project
http://ballast-outreach-ucsgep.ucdavis.edu/

Matson Tests Ballast Water Treatment System Designed by Ecochlor on the *ITB Moku Pahu*

By Nicole Dobroski, California Sea Grant Extension Program

A chlorine dioxide generation system designed by Ecochlor, Inc. to treat ballast water and sediments is being tested by Matson Navigation Company, Inc. (Matson) aboard the integrated tug-and-barge (ITB) bulker *Moku Pahu*. Matson installed the system aboard the carrier in September 2005.

The Ecochlor™ Ballast Water Treatment System injects a dilute solution of chlorine dioxide into the vessel's ballast water as it is boarded. Residual levels of chlorine dioxide persist in ballast water for up to 24 hours after treatment in order to kill the more robust ballast organisms. The residual decays after approximately 24 hours and released water contains no detectible levels of chlorine dioxide. Ecochlor Technical Manager Michael Hasson states that for shorter coastal voyages, the level of chlorine dioxide can be modified to reach a residual concentration below detection limits within 12 hours, while still maintaining a high treatment efficacy.

ITB Moku Pahu *Photo courtesy of Matson Navigation Company, Inc.*

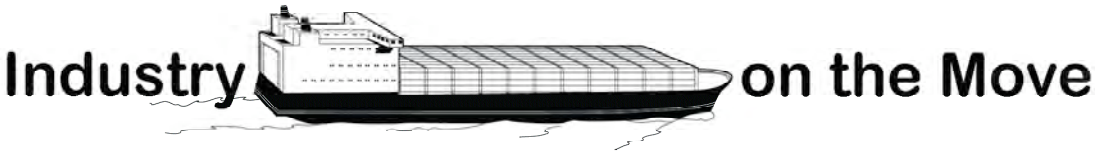
The *Moku Pahu,* which is owned by the Hawaiian Sugar and Transportation Cooperative and operated by Matson, carries raw sugar between Hawaii and California. The vessel has also operated with the United Nations World Food Program and other humanitarian organizations to ship food aid to Mongolia, Pakistan, Indonesia, Bangladesh, North Korea and Ethiopia. The *Moku Pahu* carries 17,000 metric tons of ballast water. While the vessel is capable of flow-through exchange of ballast water, the time and effort required led Matson to investigate ballast treatment as an alternative to exchange. The Ecochlor™ System was installed in a spare parts locker approximately 7.5 square meters in size. Initial testing of the Ecochlor™ System on the *Moku Pahu* was conducted on a voyage to Djibouti, Africa in December 2005 and thereafter to Hawaii. Ecochlor, Inc. staff were on hand to monitor system operations. Results thus far look very promising. After off-loading grain in Djibouti, the *Moku Pahu* successfully loaded and treated ballast water (based upon chlorine dioxide residuals). Analysis of the biological efficacy of the Ecochlor™ System in treating ballast water aboard the *Moku Pahu* will take place in coming months.

The *Moku Pahu* is the second vessel to be outfitted with the Ecochlor™ System. The first vessel to test the system was the Atlantic Container Line M/V *Atlantic Compass,* a Swedish-flagged combination RORO (Roll-On Roll-Off)/containership operating between Europe and North America. The *Atlantic Compass* carries 24,000 metric tons of water; two out of 35 ballast tanks were used in the initial testing of the system. The University of Rhode Island conducted a study of system efficacy on the *Atlantic Compass* and found that the Ecochlor™ System effectively kills nearly all zooplankton and phytoplankton in ballast water and reduced bacteria to non-detectable levels within the first 24 hours in comparison to an onboard control tank. Residual regrowth of bacteria seen after three days may have been due to biofilm (a thin layer of microscopic bacterial or algal growth) accumulation on the vessel sides. These results and potential implications are still being investigated.

Ecochlor™ System installation aboard the *Moku Pahu* was jointly funded by Matson and Ecochlor. Matson also received funds from the California State Lands Commission under the California Marine Invasive Species Program. Based upon the results from the *Moku Pahu,* Matson and Ecochlor have applied to the U.S. Coast Guard (USCG) Shipboard Training and Evaluation Program (STEP) in order to receive USCG approval of the Ecochlor™ System.

The Ecochlor™ System is the second ballast water treatment technology that Matson has tested. In 2003 Matson tested the OptiMar Ballast Water Treatment System aboard the M/V *R.J. Pfeiffer.* Matson Manager of Environmental Affairs Lisa Swanson commented that Matson is excited to take the initiative to test innovative ballast treatment technologies. "We feel that not enough is being done to develop alternative treatment technologies. There are on-going discussions on the international, national and state levels regarding performance standards for ballast discharges; however the fact is that there are no proven technologies out there to meet the standards that are being proposed."

For more information about the Ecochlor™ System or about the *Moku Pahu,* contact Mike Hasson (mdh@ecochlor.com) or Lisa Swanson (lswanson@matson.com). For information about the USCG STEP Program visit:
http://www.uscg.mil/hq/g-m/mso/step.htm



Examining the Potential for Invaders to Hitchhike on Ships at the Aquatic Bioinvasion Research & Policy Institute (ABRPI)

By Ian Davidson, Portland State University

The Aquatic Bioinvasion Research and Policy Institute (ABRPI), is a joint initiative between Portland State University and the Smithsonian Environmental Research Center (SERC), which was established on October 26, 2004. Its primary goal is to advance an array of collaborative and coordinated research, education and outreach activities that focus on the biological aspects of invasions in aquatic (marine and freshwater) ecosystems. In particular, the institute combines the relative strengths in freshwater and marine ecology of both partners, as well as experience with both plant and animal invasions on the U.S. Pacific and Atlantic coasts, to promote a multi-faceted approach to the complex issues involved in biological invasions.

Much of the work carried out in the first year of the ABRPI has focused on vectors of nonindigenous aquatic species–primarily shipping. One of the first projects initiated by the Institute was a pilot project focused on harmonizing state and federal ballast water reporting. The project is a joint effort between the National Ballast Water Information Clearinghouse (based at SERC) and the Oregon ballast water database, which is maintained at the Institute. The aim is to determine how the quality and quantity of the ships' data can be enhanced while duplicative effort is reduced.

Another project, and a topic of ongoing research, is focusing on the influence of hull fouling as a vector of nonindigenous species. Fouling organisms consist of numerous species that can attach to solid/hard structures and substrates in bays and estuaries throughout the world. If a ship's hull is the structure to which they attach, these fouling organisms can then be transported great distances in short periods of time with the possibility of establishing new populations in previously uncolonized regions, perhaps to the detriment of that region.

One project recently completed examined the threat of hull-mediated introductions to the Lower Columbia River. One of the main conclusions from this project is that vessels are translocating nonindigenous aquatic species to Columbia River ports, but due to the dominance of fresh water (riverine) conditions, most species do not establish populations in the new region. Therefore the threat of hull-mediated introductions to the system is lower than to other West Coast port systems, not because the species are not being delivered (propagule pressure is high), but because of the system's higher resistance to these potential invaders.

Following work on the Lower Columbia River project, the institute is broadening its investigation of hull fouling to include California and Washington ports as well as those in Oregon. The California State Lands Commission (CSLC), working in collaboration with the institute, has funded projects to examine the flux of international and coastwise shipping throughout the U.S. Pacific Coast and how this relates to hull surfaces and species transfers. Another component of this work will assess the accumulation of hull fouling organisms on ships in California ports. The goal of this project is to determine how shipping patterns and observed hull fouling coincide with current nonindigenous aquatic species distributions and whether these data can help to predict future bioinvasion threats. The results of this project will also be used by the CSLC to determine how best to manage and reduce the risk of hull-mediated introductions to California waters. Our results will be available through agency and scientific publications, the first of which will be available later this year from the U.S. Coast Guard's Research & Development Center.

For more information on projects at the ABRPI, please visit: http://www.clr.pdx.edu/abrpi/.

Fouling organisms, including bivalves and barnacles, on the propeller of a vessel examined in dry dock.
Photo courtesy of California State Lands Commission

Dry docking of vessels provides an opportunity to assess the extent and composition of biofouling organisms on ships.
Photo courtesy of Matson Navigation Company, Inc.

Invasive Seaweed Threatens California's Coastline – An Update

Rachel Woodfield, Merkel & Associates

What is *Caulerpa taxifolia*?

Caulerpa is a group of seaweeds that occurs naturally in tropical waters worldwide. Prized for their beauty and ability to uptake excess nutrients, many species of *Caulerpa* are now widely used in saltwater aquarium systems. In the 1980s, a cold-tolerant and fast-growing strain of the species *Caulerpa taxifolia* was cultivated in Germany and eventually distributed to aquarists worldwide. The prolific growth of this strain allows it to rapidly overtake aquariums, with routine thinning often necessary to control it.

Why is *Caulerpa taxifolia* a problem?

Although many species of *Caulerpa* are used in aquariums, the aquarium strain of *Caulerpa taxifolia* is of greatest concern. In 1984, this invasive strain was accidentally released from the Oceanographic Museum of Monaco into the Mediterranean Sea, where it formed one small patch that rapidly grew into a large bed. Spread by small fragments transported primarily by boat anchors and fishing gear, *C. taxifolia* now blankets over 30,000 acres of seafloor off six Mediterranean countries. Extensive dense carpets of *Caulerpa* have smothered diverse natural communities and dramatically reduced biodiversity by displacing native seaweeds and animals. Fisheries and tourism have suffered as a result, and in some cases boating restrictions have been instituted to slow the spread of the species. Aquarium releases in Australian waters have also resulted in extensive infestations of bays and harbors. Because *Caulerpa* contains toxins that make it inedible to many grazing animals that feed on other seaweeds, it encounters no native enemies in the waters it has invaded.

Careless disposal of Caulerpa *removed from overgrown aquariums can lead to infestations in the wild.* *Photo courtesy of L. Gonzalez*

Has *Caulerpa taxifolia* been found in California?

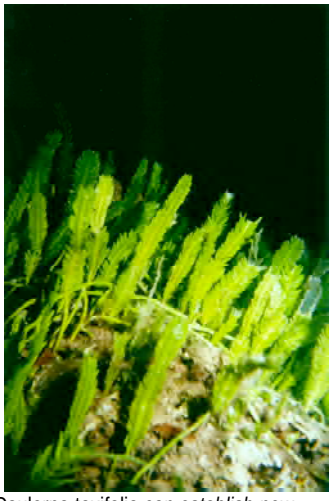
In 2000, *C. taxifolia* was discovered growing in two embayments in Southern California. Genetic studies concluded that both California infestations were the same aquarium strain that has invaded Mediterranean and Australian waters. The California infestations resulted from releases of *C. taxifolia* from saltwater aquariums. Because the infestations were detected while they were still confined, eradication efforts were promptly initiated. The treatment approach involved covering the *Caulerpa* with heavy black PVC tarps and injecting chlorine underneath. After more than five years of work and expenditure of over $7 million, those eradication efforts will likely be declared successful by spring 2006.

What does it look like?

Caulerpa taxifolia is a distinctive saltwater seaweed with these features:

- bright green color
- feather-like fronds
- long horizontal runners

Caulerpa taxifolia grows low to the bottom, typically 6–12 inches high, with some fronds up to 24 inches in height. It can grow in calm or rough waters, on any substrate. Fragments do not float and it is therefore not likely to be found on docks, boat hulls or in ballast water.



Caulerpa taxifolia *can establish new infestations from even a 1mm fragment, rapidly expanding to cover mud, sand, or rock.* *Photo courtesy of R. Woodfield*

Is this seaweed still available?

The threat from this species is so great that it is currently illegal to possess or sell *Caulerpa taxifolia* in California under California Fish and Game Code 2300. Due to the invasive nature of other *Caulerpa* species, as well as the difficulty of differentiating between them, eight other species of *Caulerpa* are also banned, including *C. racemosa*, known as grape *Caulerpa*, another seaweed widely used in saltwater tanks. Any person or pet shop that violates the code is subject to a civil penalty of $500 to $10,000 for each violation. In addition, the aquarium strain of *C. taxifolia* is on the Federal Noxious Weed List, so it is illegal to import it into the U.S. or to transport it across state lines. Nevertheless, this species is still used by some in the aquarium trade and is readily available on the Internet. Visit www.sccat.net to see pictures of the banned *Caulerpa* species.

What can you do to help?

Prevent new infestations:

- Do **NOT** use, buy, sell or distribute *Caulerpa* for use in saltwater aquariums.
- **NEVER** release *Caulerpa* or any aquarium contents (including water) into gutters, storm drains, creeks, bays, estuaries, lakes or the ocean.

- Properly dispose of *Caulerpa* by freezing it in a bag for 24 hours and placing it in the trash; drain aquarium water into a sink or toilet.
- Report sightings of *Caulerpa* in aquarium and pet stores.

If you find *Caulerpa* in the wild:

- Note as much information as possible (location, depth, bottom type, size of the patch).
- Record the location with a GPS and make a map if possible.
- Carefully collect a small piece and press it flat in newspaper.
- Take a photo if possible.

Report all sightings to the National Marine Fisheries Service at (562) 980-4043, California Department of Fish and Game at (858) 467-4218, or the Southern California *Caulerpa* Action Team online at www.SCCAT.net/.

The aquarium strain of *C. taxifolia* can grow in warm or cold waters. Given the wide availability of this saltwater aquarium plant, coastal states across the U.S. should be aware of the threat posed by the release of this species into the wild. Efforts to find, contain and eradicate the next infestation will be costly and may not be successful, and will likely lead to restrictions on boating, fishing and other recreational water uses.

Southern California *Caulerpa* Action Team

The successful eradication efforts in California were the result of a rapid response by a coordinated task force known as the Southern California *Caulerpa* Action Team (SCCAT), consisting of federal, state and local agency representatives, invasive species experts, marine resource scientists and local stakeholders. The success of this project hinged upon the early detection of the infestations, prompt acquisition of funding, and the cooperative discussions and timely actions of SCCAT. It is hoped that the approach taken by SCCAT will serve as a model for successful rapid response to new infestations of *Caulerpa* or other invasive species, and that ongoing outreach and education efforts will prevent future introductions.

Caulerpa taxifolia *is identified by its bright green color, rubbery texture, feather-like fronds, and horizontal runners, called stolons.*
Photo courtesy of R. Woodfield

For additional information, please visit www.sccat.net/ or contact rwoodfield@merkelinc.com.

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