



International Conference On
**Marine
Bioinvasions**

**FIFTH INTERNATIONAL CONFERENCE
ON MARINE BIOINVASIONS**

May 21-24, 2007
Convened at The Massachusetts Institute of Technology,
Cambridge, Massachusetts

ABSTRACT BOOK

Sponsored by the MIT Sea Grant College Program,
the International Council for the Exploration of the Sea (ICES),
the North Pacific Marine Science Organization (PICES),
the National Sea Grant





May 21, 2007

Dear Conference Participant:

On behalf of the Co-Conveners, James Carlton, Erkki Leppäkoski, and Yasuwo Fukuyo, and myself, we extend a warm welcome to you as attendees of the Fifth International Conference on Marine Bioinvasions. We are pleased to have the National Sea Grant College Program, the International Council for the Exploration of the Seas, the North Pacific Marine Science Organization, and the MIT Sea Grant College Program as sponsors of the meeting. We are also pleased to have support from Biosecurity New Zealand and the Woods Hole Oceanographic Institution Marine Policy Program for student travel to the conference. We thank our sponsors, our Steering Committee and advisors and all those who supported our efforts to bring this conference to you.

Once again, we have what promises to be an exciting conference program and we are committed to providing opportunities for networking and informally exchanging information. Of the many benefits that you will receive from attending this meeting, we hope that you will develop a greater awareness of the recent progress that has been made and the challenges we still face with marine and coastal invasions.

In the spirit of evolving towards a “green” conference, we have worked with the food caterer to minimize discards and to make every effort to recycle plastic ware, bottles and cans. We thank you in advance for understanding our commitment to protecting our environment and that we do not have a tote bag, badge or other free give away for you. We recognize that these are small steps, but we and MIT look forward to your suggestions for other ways to minimize our carbon use.

Once again, welcome to the Fifth International Conference on Marine Bioinvasions and our best wishes for a stimulating and rewarding experience.

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Judith Pederson
MIT Sea Grant College Program

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MAPPING INVASIONS IN REAL TIME

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Poster Presentation

The Marine Invader Tracking Information System (MITIS) is a one-stop resource for marine invasive species data in the northeast. Developed by the Center for Coastal Resources at MIT Sea Grant, the database behind MITIS contains marine invasive species sightings going back nearly 10 years, from scientists, citizen scientists, and public volunteers. The MITIS website features data entry pages where scientists and volunteers involved in various projects such as Hitchhikers (based on the Hitchhikers Guide to Exotic Species designed for the public), Divers (for recreational divers), MIMIIC (for non-government organizations and state citizen monitoring programs), Rapid Assessment Surveys (for taxonomic expert reports), and others can enter their sightings directly into the database through any internet connection. The data are made available through a variety of search queries, as well as through interactive maps and download features. The MITIS database is linked to the Smithsonian Institution's NISbase portal, which allows users to search multiple invasive species databases around the country from a single site.

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INVASIVE SPECIES ON KOREAN COASTAL WATERS

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Poster Presentation

Except for the intentional introduction of species, there are only a few reports of invasive species in coastal waters of Korea. According to these studies, some of sessile animals and benthos already invaded on Korean coast. These animals, the barnacles, *Balanus amphitrite* Darwin, *Balanus eburneus* Gould, and *Balanus improvisus* Darwin; a bivalve *Mytilus edulis* Linnaeus; and the tunicates *Ciona intestinalis* Linnaeus, and *Styela plicata* Lesueur were not common before 1980s in Korean coastal waters, but now are widely distributed. These animals initially invaded major harbors in the southeastern coast of Korea. The introduction of these invasive species may occur through ballast water and hull fouling.

The ecosystem of Jeju Island located at the southern part of Korean peninsula shows subtropic and temperate characteristics. However, recently tropical fishes, invertebrates, and even macroalgae species have been observed easily in coastal areas. According to flagellates monitoring, thirteen dinoflagellates were identified as tropic species (*Ceratium geniculatum*, *C. lamellicorne*, *C. proelongum*, *Dinophysis diegens*, *D. shuttii*, *Histioneis highlei*, *Ornithocerus calolinae*, *O. serratus*, *Oxytoxum reticulatum*, *Pharacroma cuneus*, *Podolampas palmipes*, *Pyrocystis hamulus*, and *P. lunula*). These species were not reported in Korean waters before. The occurrence of such tropical species might be related to current change of (1) the Kuroshio in terms of strength and direction, (2) global climatic change and/or (3) introduction from ballast water.

However, it is very difficult to understand exact mechanism of invasive species' introduction and survival strategy in new habitats due to the lack of information. Therefore the research on invasive species of marine ecosystem is very needed in national level with international cooperation.

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PATTERNS OF INVASIONS IN TIME AND SPACE

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Oral Presentation

In the framework of the Italian project Identification and Distribution of Nonindigenous Species (NIS) in Italian seas, launched by the Italian Central Institute of Marine Research (ICRAM) in 2002 and funded by the Italian Ministry of the Environment, ICRAM directed a comprehensive review of the status and distribution of NIS across the Mediterranean Sea. NIS has been grouped into eight broad categories covering all relevant taxa: macrophytes, ascidians, bryozoans, cnidarians, crustaceans, mollusks, polychaetes, and fishes. The number of NIS per category and per “Mediterranean geographical sectors” was recorded and discussed according to the following: rate of introduction, vectors of introduction, success of introduced species. The application of Geographic Information System (GIS) allowed us to analyze and register large quantities of data and to compare them rapidly and accurately through a spatial and historical perspective. The relative importance of the different taxa varied across space and time. Results showed that mollusks were the most important taxon, followed by fishes and macrophytes. The Suez Canal was the most important gateway to biological invasions across the Mediterranean, followed by maritime transportations. The analysis of temporal trends from 1850-1960 showed a gradually increasing NIS concentrated in the Levant Basin. The invasion assumed importance in the central Mediterranean since 1970 and in the western Mediterranean since 1990. The spatial analysis showed a heterogeneous NIS distribution across different geographical sectors of the Mediterranean. Such differences have to be interpreted as the consequences of historical processes and reflect the different oceanographic conditions of these sectors. Global change together with sea surface warming occurring in the last two decades in the Mediterranean and the related consequence on the deep current circulation system in the central Mediterranean area seem to play a role in the recent increase of the so-called tropicalization phenomenon.

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ADAPTING AQUATIC (FRESHWATER) WEED RESEARCH AND MANAGEMENT METHODOLOGIES FOR CONTROL OF INVASIVE SEaweEDS

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Oral Presentation

Containment, control and eradication of invasive seaweeds have rarely been achieved. At present, there is very limited practical knowledge of, no “standard” methodologies for, and almost no research focused on controlling invasive seaweeds. This contrasts with over 50 years successful management of freshwater macrophytes, including eradication in some cases. Basic and applied research for this purpose has been conducted for even longer. Even though seaweeds and freshwater macrophytes differ in their physiological and ecological characteristics, they also share some common features such as their aqueous growth medium, water-flow dynamics, anchorage to substrates (sediments, rock), uptake of nutrients, translocation of photosynthates, dispersal modes, and adaptation to low PAR. This suggests that adapting research approaches, and proven methodologies for controlling freshwater (aquatic) weeds will be useful for development of strategies for control of invasive seaweeds. For example, the implementation of herbicide/algaecide product development, searches for biological control agents, and design for mechanical methods could be initiated by small modifications in existing research facilities and through prioritization of target species and their associated invaded habitats. Likewise, studies of non-target effects, which are typically conducted in parallel with control “methods discovery” for freshwater weeds, need to be included. Rather than re-inventing “new” methods, it seems most sensible to use, and adapt basic and applied knowledge garnered from the decades of research and operational field practices. This can be accomplished through practical workshops whose participants include scientist and managers focusing on freshwater and marine systems, and managers who have environmental regulatory responsibilities. Such workshops would serve to identify specific research needs and modifiable approaches suitable for small-scale evaluations. The accelerating rate of invasive seaweed introductions, coupled with what are currently very limited response options, argue strongly for the proposed workshops, and for the research and methods that could result.

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FACTORS INFLUENCING DISTRIBUTION OF *DIDEMNUM* SP. IN NARRAGANSETT BAY

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Oral Presentation

The invasive colonial tunicate *Didemnum* sp. has been observed in Narragansett Bay, Rhode Island since 2000. The tunicate competes with native species and is a fast colonizer on hard substrates. To assess the spread of *Didemnum* in the bay, we conducted a survey of intertidal sites in October and November 2005, noting the animal's presence and the characteristics of the sites where it was present, including salinity, proximity to nearby commercial ports, number of boats in the vicinity, colony size, and type of substrate. Sites in the bay where *Didemnum* was present were more likely to have higher boat traffic and be closer to major ports; all were south of Quonset Point. In addition, we compared weekly larval settlement of the species in the bay over a six-month period in 2005 among three sites – Graduate School of Oceanography (GSO) dock, RI Department of Environmental Management pier at Fort Wetherill (FW), and the T-wharf on the southern tip of Prudence Island (SP). We found a significant difference in settlement among the sites ($P < 0.01$). GSO had the highest settlement of the tunicate, reaching peak values of 319 individuals per 100 cm² in September 2005. Additionally, we collected weekly environmental parameters (temperature, salinity, dissolved oxygen, pH, nutrient, and chlorophyll a concentrations) from each of the settlement sites. Of all environmental parameters collected, temperature and salinity correlated most strongly with settlement. Monitoring Narragansett Bay for increased tunicate spread is important as *Didemnum* sp. has the potential to invade other favorable substrates with increasing human use of the bay and warming ocean temperatures.

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**RECREATIONAL VESSEL HULL FOULING
AS A TRANSPORT VECTOR FOR AQUATIC INVASIVES**

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Poster Presentation

Hull fouling is recognized as a potential vector of aquatic invasive species; however most of the focus for this vector has been on commercial vessels. The role of privately-owned vessel hull fouling as a vector for the transport of non-native species along the U.S. eastern seaboard was assessed over a two-year period. Vessels and marinas in both southern “winter ports” and northern “summer ports” were surveyed for fouling organisms, and vessel hulls were sampled at stopover ports along the eastern seaboard. Data were collected from boat owners on hull maintenance, the history of the vessel movement and ports visited, and the routes taken. The hulls of more than 100 power and sailing vessels and the pilings and floating docks of 15 marinas were sampled. Divers surveyed and photographed the hulls to provide a quantitative estimate of percent cover of fouling organisms on the hulls, keels, rudders, propeller shafts, and propellers. Voucher specimens were collected using a suction sampler to confirm the identifications made from the digital images. Marina sampling included quantitative underwater digital photographs and quantitative suction-samples. The results of the field study will be discussed, including the degree and location of fouling, invertebrate taxa most commonly recorded, and a summary of boat maintenance and travel histories, as well as the follow-up extension programming to educate boaters on this potential vector of Aquatic Nuisance Species ANS.

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**PHENOTYPIC PLASTICITY IN CLAW MORPHOLOGY
OF THE INTRODUCED CRAB *CARCINUS MAENAS*
IN RESPONSE TO NATURAL VARIATION
IN PREY ARMOR AND WATER TEMPERATURE**

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Oral Presentation

Diet-induced plasticity in trophic morphology of introduced predators could facilitate biological invasions if the invader's foraging success is enhanced. Interactions between the invasive European green crab *Carcinus maenas* and a native northwest Atlantic snail *Littorina obtusata* offer an opportunity to test for diet-induced plasticity. *C. maenas* is a heterochelous species, whose populations possess larger crusher claws in the southern Gulf of Maine (GoM) where snail prey have thicker shells, than in northern areas where snail prey are thin-shelled. Observed biogeographic differences in shell thickness of *L. obtusata* likely reflect induced defensive responses to the green crab, but the extent to which claw size patterns reflect use-induced trophic responses to prey armor is unknown. In addition, it is not clear how an existing latitudinal gradient in water temperature might modify such a response. To test the importance of natural variation in prey resistance and water temperature on claw morphology, we reared male *C. maenas* on two diets (thick- or thin-shelled snails) in each of two water temperatures (16 °C or 10 °C) representative of summertime conditions in the southern and northern GoM, respectively. Our results demonstrated that crusher (but not cutter) claws of crabs reared on the thick-shelled diet grew significantly larger after one instar than did those of crabs fed the thin-shelled diet, and the response was restricted to the 16 °C treatment. Reduced foraging performance on thick-shelled snails likely prevented a diet-induced effect in the 10 °C treatment. These results may explain broad-scale post-invasion biogeographic patterns in claw morphology of *C. maenas* in the GoM. We predict that as ocean temperatures rise, crab trophic structures will be able to respond more readily to prey shell defenses, and an increase in foraging success should facilitate further range expansion.

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**NEW RECORD OF *PENILIA AVIROSTRIS* DANA,
1849 (CLADOCERA) IN THE GULF OF ST. LAWRENCE**

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Poster Presentation

The cladoceran, *Penilia avirostris*, was found in zooplankton samples from Colville Bay, Prince Edward Island (46°N 62°W) in the southern Gulf of St. Lawrence, in the autumns of 2000 and 2001. This is the first report of the species from Canadian waters, and represents a northeasterly range extension of 5 degrees of latitude or approximately 1130 km. The most likely vector for this introduction was ballast water from international shipping. This species was first detected in October 2000 with an observed population density of 0.073 individuals/m³, which represented less than 0.3% of the zooplankton community. One year later, the density increased just over 350-fold to an average abundance of 27.5 individuals/m³ and *Penilia* was the fourth most abundant zooplankton, accounting for 8% of the community. All females were parthenogenetic, but 0.3% of the individuals collected in 2001 were males, implying that sexual reproduction by resting eggs could occur in this population. The size of males (mean length 684 µm, range 591-773 µm) and parthenogenetic females (mean 840 µm, range 409-1000 µm) was similar to those reported in the literature. Three percent of the females were juveniles. Even though this species' increased abundance in Colville Bay in 2001 was much lower than that recorded from other temperate northwestern Atlantic waters, a reproducing population appeared to be well established.

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**APPEARANCE OF THE INVASIVE *CAULERPA RACEMOSA* VAR. *CYLINDRACEA* (SONDER)
VERLAQUE, HUISMAN, BOUDOURESQUE (BRYOPSIDALES, CHLOROPHYTA)
ALONG THE SANTA LIBERATA COAST (SOUTH TUSCANY, ITALY)**

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Oral Presentation

After sighting the invasive species *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman, Boudouresque, near the Santa Liberata beach Southern Tuscany, Italy, a series of surveys were carried out between 2005 and 2006, along a 800 m coast stretch, in order to describe phytobenthos distribution, *C. racemosa* morphometry and biomass and sediment features (porosity, bulk density, grain size and organic matter content). The morphometric, biomass and sediment parameters data collected were processed by one-way ANOVA and non-metric multidimensional scaling (MDS) analysis in order to detect significant differences among the sampling stations and to highlight the spread dynamic of *C. racemosa*. A distributive map of the phytobenthonic settlement was drafted by means of aero-photographic and scuba diving surveys. The results indicated that two main *C. racemosa* sampling station groups were significantly different and that *C. racemosa* spread to four main areas, two of which were located near two barrier-reefs of *Posidonia oceanica* (L.) Delile and inside the lying behind barrier-reef areas, at 1-3 m deep; the others two were located off-shore, at 4-5 m deep. In the first two areas, *C. racemosa* spreading was very high, as a consequence of the previous sudden regression of *Nanozostera noltii* - *Cymodocea nodosa* - *Caulerpa prolifera* mixed meadows. With regard to sediment parameters, statistical analysis showed that sampling stations were homogeneous. The results suggested that: (1) the invasive species tended to settle the areas lying behind-*Posidonia* barrier-reefs where it found more calm water and not much thick algal turf; (2) one of the off-shore area could be the starting colony of *C. racemosa* that spread through the studied coast stretch; (3) *C. racemosa* was the new colonizing species, in fact its biomass between 2005 and 2006, increased more than 80 times.

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**RESOLVING THE 100-YEAR DEBATE OVER THE INTRODUCTION
OF *L. LITTOREA* TO NORTH AMERICA**

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Oral Presentation

The marine snail *Littorina littorea* is an abundant intertidal snail on shorelines of both coastlines of the North Atlantic. While definitively native to Europe, its ecological history in North America has been extensively investigated and debated for over 100 years. We used mtDNA sequences on nearly 400 snails on both sides of the Atlantic to explore signatures of an introduction to North America. We found several indications of a recent founder event of the snail in North America, including a vast reduction in overall genetic diversity in North America versus Europe, haplotype frequencies consistent with signatures of a recent introduction, and a divergence estimate of ~450 years ago from the European source. Overall, the most parsimonious conclusion for our data is a recent, human-mediated introduction of *L. littorea* from Europe.

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THE BARCODE OF LIFE DATA SYSTEM: A TOOL FOR WIDESPREAD AND EFFECTIVE INVASIVE SPECIES MONITORING ON CORAL REEFS

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Oral Presentation

Currently, invasive species are usually discovered after they have established viable populations. In such situations, it can be difficult to determine which species are native in a particular community in the absence of near complete biodiversity surveys that can act as baseline references. To begin to document and understand marine bioinvasions, a standardized and easily implemented system is needed to establish such baselines. The National Oceanic and Atmospheric Administration (NOAA) Coral Reef Ecosystem Division (CRED) leads a Pacific Reef Assessment and Monitoring Program (RAMP) which has been conducting large-scale biennial monitoring of 55 Pacific islands and atolls for the past six years. These surveys focus on macro species and large-scale monitoring. Through CRED's recent collaboration with the Census of Marine Life's, Census of Coral Reefs (CReefs) program, the group is now also involved with complementary biodiversity studies focusing on small and understudied organisms, which are likely to include introduced species that are difficult to identify using traditional means, particularly in high diversity systems like reefs. A recent CReefs expedition to French Frigate Shoals collected genetic samples from over 1100 specimens, which will be placed into the Barcode of Life Data System (BOLD). The BOLD system has the potential to play a large role in helping researchers and managers quickly detect invasive species, allowing them to be eradicated before they become too pervasive and widespread. CRED and CReefs are hoping to use their complementary surveys and monitoring efforts to build an extensive coral reef database of accurately identified species that have been genetically characterized within BOLD as a way to standardize small organism monitoring and better document and control invasive species.

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**REAL-TIME ASSESSMENT MODEL FOR
BALLAST WATER EXCHANGE IN ATLANTIC CANADA**

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Oral Presentation

In a typical year hundreds of vessels exchange their ballast water in the Scotian Shelf/Gulf of Maine region of North America, resulting in a continuous risk of invasion by Aquatic Invasive Species. A model that estimates the relative overall risk of invasion for possible exchange segments along a vessel track will be presented. The model is based on a set of dispersion metrics relevant to the risk of invasion for organisms released in simulated ballast water exchanges. Recently, the risk assessment model has been incorporated into a system that can provide real-time advice regarding the lowest risk region to exchange ballast water for an incoming vessel. The system is based on an operational shelf circulation model that provides the flow fields in which ballast water will be released, and an interactive web interface where the user enters the vessel track and model parameters. The details of this system will be described and a preliminary version of the system will be demonstrated.

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**ARE NATIVE EELGRASS (*ZOSTERA MARINA*) MEADOWS
AND INVASIVE PACIFIC OYSTER (*CRASSOSTREA GIGAS*) REEFS
IN WILLAPA BAY, WASHINGTON ALTERNATIVE STABLE STATES?**

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Oral Presentation

Disturbance can facilitate invasions by creating a pulse of resources that allows an invader to gain a foothold. Once established, however, invasive species often have major, persistent impacts on community structure. If positive feedbacks occur between the invader's abundance and population growth rate, then the native- and invader-dominated communities may be alternative stable states, with abrupt transitions depending on initial conditions. We tested for the existence of alternative stable states in eelgrass (*Zostera marina*) meadows in Willapa Bay, Washington that are invaded by Pacific oyster (*Crassostrea gigas*) reefs. We hypothesized that (1) oyster recruitment increases with reef size and (2) eelgrass inhibits reef expansion by reducing delivery of larvae and phytoplankton. We tested these predictions by removing eelgrass around reefs 0.01 to 4 m² in area and measuring oyster recruitment, growth, survival, and reef area over 2 yr. Recruitment density increased with reef size, but only for reefs surrounded by eelgrass. Removing eelgrass increased recruitment, particularly on small reefs. In addition to receiving higher recruitment, larger reefs were more persistent in the face of winter storm surge. We asked whether habitat characteristics could explain the patchy distribution of oysters and eelgrass by comparing eelgrass dynamics over 2 yr in 0.25 m² plots where reefs were removed and control plots with intact reefs. Shoot density in removal plots increased to levels comparable to adjacent meadows while density in control plots remained constant, indicating that either oysters or eelgrass can dominate a given site. These results illustrate feedbacks that could produce a threshold (i.e., reef size) for oyster invasion at the local patch scale. Data at larger spatiotemporal scales will be needed to determine whether eelgrass- and oyster-dominated patches are stable and whether a threshold for oyster invasion exists at the landscape level.

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GOING AGAINST THE FLOW: RETENTION, RANGE LIMITS AND INVASIONS IN ADVECTIVE ENVIRONMENTS

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Plenary Presentation

Increasing globalization has spread invasive marine organisms, but it is not well understood why some species invade more readily than others. It is also poorly understood how species' range limits are set generally, let alone how anthropogenic climate change may disrupt existing species boundaries. We find a quantitative relationship that determines if a coastal species with a benthic adult stage and planktonic larvae can be retained within its range and invade in the direction opposite the mean current experienced by the larvae (i.e., upstream). The derivation of the retention criterion extends prior riparian results into the coastal ocean by formulating the criterion as a function of observable oceanic parameters, by focusing on species with obligate benthic adults and planktonic larvae, and by quantifying the effects of iteroparity and longevity. By placing the solutions in a coastal context, the retention criterion isolates the role of three interacting factors that counteract downstream drift and set or advance the upstream edge of an oceanic species' distribution. First, spawning over several seasons or years enhances retention by increasing the variation in the currents encountered by the larvae. Second, for a given population growth rate, species with a shorter pelagic period are better retained and more able to spread upstream. And third, prodigious larval production improves retention. Long distance downstream dispersal may thus be a byproduct of the many propagules often necessary to ensure local recruitment and persistence of a population in an advective environment.

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HARBOUR SURVEY FOR INVASIVE SPECIES IN NEWFOUNDLAND, CANADA

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Poster Presentation

We are in the first year of a collaborative study joining Fisheries and Oceans Canada, the Newfoundland and Labrador Provincial Department of Fisheries and Aquaculture and Memorial University to determine the distribution and abundance of aquatic invasive species (AIS) that present a risk to ecosystem integrity and sustainability of the aquaculture industry. Abundance and biodiversity of native and invasive ascidian tunicates, crabs, ghost shrimp, bivalves and macroalgae are being determined in the harbours of Port-aux-Basques, Corner Brook, Botwood and Argentia. All four ports are visited regularly by a variety of ships sailing from the southern Gulf of St. Lawrence, a region currently experiencing severe invasion by a number of algal, crustacean and ascidian species. Quadrant samples, visual surveys and photographic records at the harbours are being collected by SCUBA divers from the Ocean Sciences Centre. Settlement plates (PVC) are moored at each of the harbours to determine recruitment of native and invasive ascidians and macroalgae. Additional environmental data (temperature, salinity, transparency, chlorophyll) are being collected in each harbour to provide an ecosystem context for the species identified. Early results indicate invasion of all four harbours by two bryozoan species, *Membranipora membranacea* and *Electra pilosa*, which settle on the fronds of a variety of kelp species, including *Laminaria* sp.¹ In addition, the potentially invasive ascidian *Botryllus schlosseri* has been discovered in high densities on the hull of a small vessel in Argentia. We are exploring the use of sequence analysis of the cytochrome oxidase I gene of mtDNA of ascidians to confirm taxonomic identification and to develop genetic markers for early detection of larvae and juveniles of native and invasive ascidians.

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¹Editor's Note: Some species of *Laminaria* are noninvasive and genus names have changed.

ORGANISM IMPACT ASSESSMENTS: RISK ANALYSIS FOR POST-INCURSION MANAGEMENT

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Poster Presentation

Risk analysis is a management tool to aid decision-making when faced with uncertainty and is becoming increasingly more common in biosecurity. Herein I present a risk analysis framework (referred to as an Organism Impact Assessment) that was developed to facilitate managing New Zealand introduced aquatic species incursions in a post-border scenario. Using expert heuristics, published and observed data, the likelihood that a target introduced species will impact ecological, social and economic issues is assessed. The consequence (impact and/or change) of such events are then determined to establish a relative risk ranking. Consequence matrices were developed to aid assessment of the ecological, social and economic issues and subcomponents. Examples of the ecological subcomponents examined via the consequence matrices include indigenous biodiversity, geomorphology and water quality. Similarly, social subcomponents examined included spirituality, family activities and enjoyment, and aesthetics. Economic subcomponents included primary industry, public sector and industry needs, and intrinsic values. To illustrate the model, components are drawn from two Organism Impact Assessments for incursions of the marine kelp *Undaria pinnatifida* and the freshwater diatom *Didymosphenia geminata*. The New Zealand biosecurity risk management framework follows a modern risk model, where socio-political (including economic) and ecological imperatives are determined simultaneously. By assessing ecological, social and economic issues congruently, the framework ensures that a transparent and objective framework is established with clearly stated ecological and socio-political imperatives.

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MARINE BIOINVASIONS: THE ASSESSMENT OF IMPACTS AND DIVERSITY

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Plenary Presentation

Older (the "10% Rule") and more recent (for example, Reise et al., 2006, Helgoland Marine Research 60: 77-83; Briggs, 2007, Journal of Biogeography 34: 193-198) conclusions that most introduced species have little or no impact on the communities that they have invaded, or, indeed, that introduced species enhance diversity (including functional redundancy) are examined relative to experimental and other evidence available to support such conclusions. The absence of detailed historical data for most marine communities (in terms of the abundance, distribution, and diversity of species), and therefore for their historical structure and function, combined with the insight that arises from experimentation (and thus the lack of such insight in the absence of experimental work), indicate that conclusions about the limited nature and scale of invasion impacts are not supported. Further, numerous and growing lines of evidence, enhanced by molecular techniques for the detection of cryptic species, suggest that the number of invasions occurring in the past 500 years has been severely underestimated. The combination of overlooking the scale of invasion impacts and the numbers of invaders in any given habitat or location suggests that the coastal ocean – if not the deeper shelves and the open seas – may have been structured remarkably differently not long ago, leading to a central axiom: that one of the most fundamental insights from – and importance and fascination of – invasion science is what the arrival of new species can tell us about the evolution, structure and functioning of natural communities.

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**ASCIDIANS OF THE SOUTHERN GULF OF CHIRIQUÍ, PACIFIC-PANAMA:
A NATIVE FAUNA AT RISK TO BIOINVASION**

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S. Sievert, Woods Hole Oceanographic Institution

Poster Presentation

A survey of ascidian species and mapping of the bottom topography were conducted in January 2006 in a variety of environments around islands in the southern Gulf of Chiriquí, Pacific coast of Veraguas, Panama. This is the first documentation of ascidians in Pacific-Panama waters. Ascidians were observed attached to hard substrates at water depths greater than three meters, in rocky benthic habitats of coral reefs, bays, and open sea between islands. Three species were located in the vicinity of Isla Canales de Tierra (7° 45' N latitude, 81° 34' W longitude) and Isla Pacora (7° 44' N latitude, 81° 35' W longitude) and identified: *Rhopalaea birkelandi*, *Ascidia ceratodes*, and *Eusynstyela* sp. cf. *tincta*. These basaltic islands with submarine slopes of varying degrees level off at between 55 and 80 m to form flat plains between the islands. We consider Isla Canales de Tierra, Isla Pacora and the southern Gulf of Chiriquí to be a region distinguished by a unique low diversity, native ascidian fauna. Increasing anthropogenic development along the Panama coastline may contribute to a change in the ascidian population, as increasing human coastal development is associated with increasing non-endemic ascidian species. Additionally, boats and ships are arriving at Isla Canales de Tierra on a regular basis from the mainland and periodically from international waters. Along with shipping traffic comes the possible vector for introduced invertebrates. Exotic species of ascidians live nearby in the Panama Canal. Future changes may occur in the ascidian fauna of the survey area, but for now the islands in the southern Gulf of Chiriquí are inhabited by a non-invaded native ascidian fauna.

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REATTACHMENT AND GROWTH STYLES OF NATIVE AND INVASIVE COLONIAL ASCIDIANS

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Poster Presentation

Native and invasive species of colonial ascidians varied in ability to reattach and grow in the natural environment during late autumn. Compound or colonial ascidians reproduce sexually and asexually through budding, but not all species have the ability to reattach and re-establish after removal from its original substrate or removal from the colony. Natural dividing or fragmenting occurs in some species and is a common occurrence, e.g., during major storms, in active harbors with dock and boat cleaning, scallop trawling, and other disruptions. Fragments were experimentally cut from ascidians living on a floating dock in an active marine pond and tested for their ability to recover during two months. We found that *Didemnum* sp. and *Botryllus schlosseri* had the highest ability to reattach, grow, express motility, and bud. *Botrylloides violaceus* initially had a high ability to not only reattach and increase in size and also to release larvae that attached and grew; after the second week, fragments did not increase in size and died. *Aplidium stellatum* displayed no ability to reattach. Invasive species *Didemnum* sp. and *B. violaceus* and native species *B. schlosseri* have unique styles of success and the ecologic advantage of being able to recover from fragmentation, even in colder water temperatures before winter. The establishment of invasive species of ascidians is due in part to their ability to grow rapidly on many kinds of substrates in a variety of coastal habitat. The ability to recover and reproduce after fragmentation through late autumn probably enables *Didemnum* sp., *B. schlosseri*, and *B. violaceus* to overwinter in a healthy state and maintain space in the harsh conditions of nearshore environment.

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A RAPID RESPONSE FRAMEWORK FOR ERADICATING MARINE INVADERS

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G.M. Ruiz, Smithsonian Environmental Research Center

Oral Presentation

In marine and estuarine systems, as on land and in freshwater, non-native species pose grave economic and ecological risks. Efforts to eradicate invaders in terrestrial systems are legion. Yet when new invaders are reported in salt water, the assumption is often made that the problem is one of management and control, rather than eradication. On the contrary, growing evidence from marine and estuarine systems indicates that in some cases, rapid eradication efforts can effectively stem incipient invasions. When recently established invaders are found, quick decisions must be made whether to devote often limited funds to management and control, attempt eradication, or do nothing. Using case studies of eradication attempts of varying success, we present a decision framework for effectively dealing with recently established invaders. Critical factors include invasion characteristics, life history, habitat, resources available for eradication or control efforts, and the ease of preventing re-introduction. We discuss applications for this framework such as prioritizing species for eradication efforts.

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**INTRODUCTION OF THE WHITE SHRIMP *LITOPENAEUS VANNAMEI*
FOR AQUACULTURE PURPOSES: IS IT GOOD OR BAD FOR THAILAND?**

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Oral Presentation

The white shrimp, *Litopenaeus vannamei*, a native to Central and South America, was first introduced to Thailand for aquaculture purpose in 1999. At present, *L. vannamei*, is a major cultured shrimp species, and its production is more than 300,000 metric tons per year. Individuals of *L. vannamei* escaping from shrimp farms were first found in a wild in the eastern part of Thailand in 2005. However, the establishment of *L. vannamei* populations in the wild has not yet been detected. To determine the potential impact of *L. vannamei* on native shrimp species, laboratory experiments on feeding behaviors of *L. vannamei* and five native shrimp species were conducted and compared. In addition, stomach contents of native shrimp species and *L. vannamei* caught from the wild were analyzed. The results showed that *L. vannamei* was more aggressive than native shrimp species, and there was a diet overlap between introduced and native shrimps. Even though, *L. vannamei* is an economic important species to Thailand, the establishment of *L. vannamei* population in the wild can have significantly impact on the native shrimp populations.

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**RELATIVE INFLUENCE OF PREDATION AND RECRUITMENT LIMITATION
ON THE INVASIVE ASIAN MUSSEL (*MUSCULISTA SENHOUSIA*)**

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Oral Presentation

The factors that influence the abundance and distribution of non-native species are of primary concern to invasion ecology. Asian mussels (*Musculista senhousia*) are a global invader that is established in Australia, New Zealand, the Mediterranean, and the west coast of North America. In southern California, recent evidence indicates that this invasion is intensifying in abundance and has negative effects on native flora and fauna. We are determining the relative roles of native predation (invasion resistance), recruitment limitation and habitat suitability in influencing patterns of mussel distribution. In Mission Bay, San Diego, Asian mussels are highly abundant in back bay locations but are near absent towards the mouth of the bay. Within this back bay region, Asian mussel density is highly variable (0-10,000 m⁻²) among sites with similar habitat characteristics. Preliminary evidence indicates that predation is spatially variable, with greater mortality in the front bay than in the back bay region. However, predation was highest at front bay sites with nearby rocky habitat, a source of native predators. Ongoing work will determine how predation and recruitment interact to influence the invasion of *Musculista senhousia* and if these processes are related to other environmental metrics such as flow, food supply, and temperature.

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RECENT INVASIONS BY ASIAN COPEPODS IN THE COLUMBIA-SNAKE RIVER SYSTEM, WASHINGTON, USA

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Poster Presentation

At least nine species of Asian planktonic copepods have invaded estuaries on the Pacific coast of North America. Except for a few isolated records, eight of these copepods have until recently been confined to San Francisco Bay and the Sacramento/San Joaquin estuary. However, plankton sampling in the lower Columbia and Snake River system and the Columbia River estuary has demonstrated that some of these copepods have also invaded this river-estuary system in the past 10 years. In addition to the calanoid copepod *Pseudodiaptomus inopinus*, which invaded in the 1980s, the Columbia River system now also appears to have established populations of three other Asian copepods, the calanoids *Pseudodiaptomus forbesi* and *Sinocalanus doerrii*, and the cyclopoid copepod *Limnoithona tetraspina*. Sampling in the lower Columbia river and estuary in 2004 and 2006 and in the middle Columbia and Snake rivers in 2006 indicates that (1) *P. forbesi* and *S. doerrii* appear to have displaced the previously introduced *P. inopinus*; (2) *P. forbesi* has moved upstream into at least the first five reservoirs on the Columbia and Snake rivers; (3) the other three species are still confined to the tidal-fresh and brackish regions of the lower river; and (4) the invasive copepods can dominate the holoplankton in the lower river and estuary, but in the middle Columbia River and the Snake River, they are relatively rare where the holoplankton is dominated by native copepods and cladocerans. The successful upstream movement and negotiation of hydroelectric dams by invasive copepods has apparently not been seen elsewhere in the region. Whether or not they will continue to move upstream and eventually successfully compete with native fresh water species is unknown and warrants investigation, particularly at this early stage of their invasion.

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CONTROL OF POTENTIALLY INVASIVE SPECIES PRESENT IN BALLAST WATER THROUGH SHIPBOARD CHLORINE DIOXIDE TREATMENT

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Poster Presentation

The introduction of invasive species via the discharge of ballast water constitutes a major threat to the integrity of coastal ecosystems. Many environments already display the effects of such introductions, from altered foodwebs jeopardizing local fisheries to nuisance species in prolific growth or to the introduction of pathogens. Methods providing effective, environmentally sound, practical and affordable control are needed by the maritime industry to curb the spread of potentially harmful species. One promising ballast water treatment uses chlorine dioxide (ClO₂) as a biocide. We are currently determining the effectiveness and reliability of ClO₂ at eliminating organisms present in ballast water of a commercial ship, the M/V Atlantic Compass, under actual operating conditions. The biocide is delivered directly to the incoming ballast water (from Newark Harbor, New Jersey) immediately after safe and simple shipboard generation of ClO₂ by the Ecochlor system at a calibrated rate to obtain a final concentration of 5 mg L⁻¹. Two protocols have been implemented using two treatment tanks and two control tanks. The first protocol is a time course study designed to follow the decay of ClO₂ concentration and the response of the planktonic assemblage over time. The second protocol represents an endpoint approach, where the planktonic assemblage and biological parameters are sampled once, just prior to deballasting. Early results indicate that the 5 mg L⁻¹ ClO₂ concentration effectively inactivates zooplankton, phytoplankton, and bacteria (including *Vibrio cholerae*, *E. coli*, and *Enterrococci*) within the first 24 hours. Time to undetectable ClO₂ residuals varies between 6 and 50 hours. Whereas no significant growth of zooplankton and phytoplankton occurs subsequent to the disappearance of ClO₂ residuals, non-pathogenic bacterial activity usually resumes after four days. Sampling will continue through 2008 in order to test the effectiveness of the treatment on various planktonic communities under a range of environmental conditions.

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**INVASION AND TERRESTRIALIZATION OF INTERTIDAL
SALT MARSH BY AN EXOTIC TREE, *TAMARISK***

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Oral Presentation

One of the most problematic invaders in the western United States is the habitat-altering tree, tamarisk (or salt cedar, *Tamarix* spp). While the impacts of this exotic plant in riparian and desert ecosystems have been well-documented, it has typically not been considered an invader of marine ecosystems. However, the intertidal salt marshes of the Tijuana River National Estuarine Research Reserve have now become heavily invaded by this tree, where it is displacing native, low-lying species, such as *Sarcocornia pacifica* (= *Salicornia virginica*). Our research demonstrates that multiple species and hybrids of *Tamarix* are invading the estuary, in an apparent “hybrid swarm.” *Tamarisk* in the marsh is having ecological effects stemming from its ability to dramatically alter the physical environment through ecosystem engineering, including altering light regimes, sediment properties, and canopy architecture. It is also entering the wetland food web, as indicated by stable isotope studies. More broadly, this tree is resulting in a “terrestrialization” of the salt marsh, whereby it alters natural successional processes and hastens conversion of marine habitats to upland.

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INCREASING VALUE OF AQUATIC INVASIVE SPECIES: THE RISKS AND BENEFITS OF INCENTIVE-BASED CONTROL PROGRAMS

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Oral Presentation

Potential control measures for aquatic invasive species often include the implementation of community-based physical removal programs (e.g., hand-picking, trapping). These programs sometimes include incentives, ranging from small tokens (e.g., hats, t-shirts) to potentially substantial financial rewards (e.g., bounties, commercial sales or fisheries). Providing incentives is believed to increase participation and directed effort, thereby enhancing the success of the programs. However, financial incentives may generate risks through increasing the monetary value of an invasive species and in the case of fisheries, creating a market. Possible risks include decreasing motivation to reduce pest populations and increasing the potential for intentional spread or culture of pest species. While concerns about the biological, economic and social efficacy of incentive programs are many, evaluations of such programs are lacking, thereby hindering their successful use in management. Using case studies we examined the risks and benefits realized by incentive programs for control of aquatic invasive species. These programs varied dramatically in their intent, design, administration and implementation. Some were organized by local managers, while others originated from community or private groups. Although all programs examined appear to have educated the public about target pests, their success as population control measures was limited. Based on these analyses, we will highlight our findings on risks and benefits and provide recommendations for enhancing the efficacy of incentive programs. Finally we will discuss potential applications of our recommendations using the invasion of the Chinese mitten crab, *Eriocheir sinensis*, in California as a model system. Proposals for developing incentive programs for the management of *E. sinensis* have been the subject of considerable debate.

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INFLUENCES OF ANTIFOULING TREATMENTS ON MARINE INVASION PATHWAYS

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Either One Presentation

Hull fouling has been identified as a primary vector for marine invaders; however few studies have examined the different opportunities for invasion presented by commercial ships versus recreational yachts. One important difference between commercial and recreational vessels relates to the fact that for the past two decades the active biocidal agent in antifouling paints used by most commercial vessels has been tributyltin (TBT), whereas recreational boats have been restricted to copper-based paints. We investigated the development of sessile assemblages on settlement plates deployed in two recreational and two commercial estuaries in New South Wales (NSW), Australia.

The plates were painted with copper diuron, copper zinc or TBT antifouling paint around their edges and deployed at multiple sites within each estuary. Preliminary sampling after three months suggests that abundances of nonindigenous or native biota differ between commercial and recreational estuaries and between antifouling treatments. Specifically, nonindigenous species (NIS) are more abundant in recreational estuaries, while native species are more abundant in commercial estuaries and NIS are least abundant on TBT-treated plates. The outcomes of this study will have implications for the monitoring and management of recreational vessels as a major source of marine invaders.

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**YOU CAN LEAD HORSES TO BALLAST WATER INFORMATION,
BUT YOU CAN'T MAKE THEM REMEMBER IT:
EVALUATING THE WCBOP'S AQUATIC INVASIVE
SPECIES BALLAST WATER OUTREACH**

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Poster Presentation

A primary goal of the West Coast Ballast Outreach Project (WCBOP) is outreach about ballast water management and treatment technologies, vessel fouling and aquatic invasive species (AIS) along the West Coast of the North America. Outreach materials include our “Stop Ballast Water Invasions” poster, companion brochure, biannual newsletter *Ballast Exchange*, and a website. While these materials have reached thousands of individuals, this alone does not indicate assimilation and use of the information. To determine the effectiveness of the WCBOP’s outreach materials, feedback on the materials and resulting changes in AIS knowledge/awareness will be obtained using online and emailed surveys, personal interviews, and presence/absence surveys, depending on the audience. Our audience includes the maritime industry, research sector, port/harbor staff, instructors, regulators, and legislators. Evaluation is an essential aspect of any outreach project. Our poster will present lessons learned from our evaluation process that will help guide future outreach efforts for a wide variety of AIS projects, leading to enhanced AIS spread prevention and improved management of new invasions.

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**GENETIC EVIDENCE FOR MULTIPLE CRYPTIC INTRODUCTIONS
OF THE INVASIVE COLONIAL HYDROID *CORDYLOPHORA* SPP**

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Poster Presentation

The colonial hydroid *Cordylophora* spp. is a Ponto-Caspian native that has recently expanded its range globally, and is now successfully established in northern and Western Europe, the Americas, and Southeast Asia. Introduced populations of *Cordylophora* spp. flourish in both brackish and fresh-water habitats, suggesting ecological plasticity, rapid evolutionary transitions, and/or cryptic diversity within the genus. This broad salinity tolerance has contributed in part to taxonomic uncertainty associated with the taxon. Although there is precedence in the literature for recognizing both a fresh-water species (*C. lacustris*) and a brackish-water species (*C. caspia*), the two species names more recently have been presented as synonyms for a single, ecologically plastic species. Here we present the results of DNA sequence analysis from multiple introduced *Cordylophora* populations, indicating that at least two species of the genus have successfully established outside the native range. Sequence data from two mitochondrial loci (COI and 16S) and one nuclear locus (28S) all reveal genetic divergence between two well-supported clades, each comprising *Cordylophora* populations from multiple non-native sites. Levels of divergence between these clades are consistent with independent species status. This conclusion is supported further by the failure of cross-clade amplification by recently developed microsatellite primers. Moreover, there appears to be a significant correlation between clade affiliation and salinity preference, suggesting that the taxonomic distinction between *C. lacustris* and *C. caspia* deserves reconsideration.

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USING GENETIC TOOLS TO ASSESS THE INTRODUCTION AND REGIONAL EXPANSION OF EUROPEAN GREEN CRABS (*CARCINUS MAENAS*)

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Oral Presentation

The European green crab *Carcinus maenas* is a widely successful invasive species, having established introduced populations on all continents outside of its native range except Antarctica. Historical observations suggest that establishment of non-native green crab populations has been mediated by various vectors, including ballast water discharge, and demographic studies indicate that regional expansion is in part the result of current-driven larval transport. Here we report on the development and utilization of genetic tools for analyzing the introduction and spread of *C. maenas*. First, we describe the results of population genetic analysis based on both mitochondrial DNA sequence and highly variable microsatellite markers. This approach allows assessment of genetic relationships between native and introduced populations of *C. maenas*, evaluation of changes in genetic diversity associated with introduction events, and estimation of genetic connectivity within regionally-expanding invasive populations. Second, we describe the development of a DNA-based assay for the specific and highly sensitive detection of *C. maenas* larvae in mixed plankton samples. Development of this assay was based on sequence data derived from the mitochondrial cytochrome C oxidase subunit I (COI) locus of globally distributed specimens of both *C. maenas* and its sister species, *C. aestuarii*, as well as numerous non-*Carcinus* crab species. The assay is capable of detecting single larvae in a background of over 1 gram (dry weight) of non-target biomass, including plankton communities drawn from ballast water samples. Given the importance of larval dispersal to the expansion of *C. maenas* populations and the possibility of additional introductions via ballast water transport, this assay should prove a powerful monitoring tool for researchers and managers concerned with the introduction and spread of this species.

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A BIOPOLLUTION INDEX FOR ASSESSING THE INVASIVENESS OF ALIEN SPECIES

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Oral Presentation

There are several ways of defining the invasiveness of an alien species. One definition is based on exponential growth and a rapidly expanding range. Other definitions relate to the level of impact caused by their presence either to human activities or to ecological processes. Assessments based on environmental impacts require logical and accurate quantification which is often difficult to acquire especially when data available from one region may not exist for another. To overcome this difficulty we propose a scale involving five levels of biopollution. This study considers practical aspects of the use of the biopollution index at the community, habitat and ecosystem levels. We demonstrate how this index may be used for an assessment of an alien species and how a comparison between different alien species and different regions may be achieved. We also apply the index for monitoring biopollution caused by the same alien species in the same ecosystem for different periods of time. The use of this index may help in drawing up priority target lists of alien species that may be capable to spreading to new regions based on their known impacts in different world regions. This study is supported by the European Union FW6 Integrated Project 506675 ALARM “Assessing Large-scale environmental risks with tested methods.”

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ASSESSING COMMERCIAL VESSEL BIOFOULING ON THE U.S. WEST COAST: DENSITY, MAGNITUDE AND FREQUENCY OF PROPAGULE DELIVERY

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Oral Presentation

Very few studies have assessed the propagule delivery patterns for the contemporary commercial hull fouling vector. In particular, a lack of data on propagule density, magnitude and frequency associated with commercial biofouling is inhibiting our understanding and possible management options for this historically potent vector. As a critical step toward assessing the scope of hull fouling as a vector along the U. S. Pacific Coast, we conducted: (1) vessel sampling at the Port of Oakland, California to provide initial data on the extent and composition on biofouling on in-service commercial vessels and (2) an analysis of shipping patterns and the estimated magnitude of underwater hull surface (wetted surface area, WSA) arriving to West Coast ports. The submerged surfaces of vessels were sampled on two occasions using divers and a remotely operated vehicle (ROV) for a combined total of 21 ships. Numerous taxa were encountered, including algae, barnacles, bryozoans, bivalves, polychaetes, hydroids and tunicates. The overall coverage in relation to the surface area of the ships was generally very low, but known hotspots for fouling accumulation (such as the rudder, stern tube and intake gratings) were associated with dense organism assemblages. For the analysis of WSA and shipping patterns, 29,282 vessel arrivals to West Coast ports over two years were analyzed. An estimated WSA of 265.6 million m² arrived during this period. Ships arriving from overseas accounted for approximately two-thirds of the traffic, and one-third of arrivals were from domestic coastwise voyages. Overall, containerships dominated the patterns and there were differences among ship types in terms of mean WSA, frequency of arrival, voyage routes and destination ports. These differences may be especially relevant to hull fouling transfers of nonindigenous species because of the external nature of the vector, although more data on biofouling densities are required.

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**HIGH-DENSITY VECTOR EVENTS AND BIOINVASION RISK REDUCTION:
ASSESSING THE INFLUENCE OF TRANSIT AND IN-WATER CLEANING ON
THE BIOFOULING OF OBSOLETE VESSELS**

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Poster Presentation

The U.S. Maritime Administration (MARAD) is mandated to dispose of obsolete vessels from its National Defense Reserve Fleets (NDRF), which requires that the vessels be towed from the fleet to other locations where ship-breaking occurs. The transfer of these ships may represent high-density vector events of biofouling organisms, creating a risk of biological invasion. We conducted two pilot studies to provide a preliminary assessment of the fate of biofouling assemblages (1) after vessel transfers between California and Texas and (2) after in-water cleaning of a vessel at the James River Reserve Fleet, Virginia. For both studies, pre- and post- 'treatment' sampling was carried out with biological samples and photo-quadrats used for analysis. Vessels in California had dense fouling assemblages, consisting of 22 taxa dominated by *Conopeum osburni* (bryozoan), *Balanus improvisus* (barnacle) and numerous mobile species associated with the fouling matrix. The Asian clam, *Corbula amurensis*, a ballast water-associated invader of San Francisco Bay, was also recorded in 9% of biological samples collected. After transit to Texas, via the Panama Canal, numerous changes in the biofouling assemblages were recorded, including: (a) biomass was greatly reduced with an average decrease of 56% cover of branching species per quadrat; (b) surprisingly, the number of species recorded increased to 58, and live specimens of at least 25 were collected; (c) *Corbula amurensis* was not recorded but other non-natives to Texas were. In the second study, in-water cleaning had the effect of causing similarly significant reductions in biofouling percent cover, but the number of species was also reduced even though live specimens of dominant taxa, including *Conopeum chesapeakeensis* (bryozoan), *Ischadium recurvum* (bivalve) and numerous amphipods, remained. Further data is required to determine the risk reducing effect of these treatments to ensure unintentional bioinvasions are minimized.

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ARE CITIZEN SCIENTISTS THE SOLUTION TO EARLY DETECTION?

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Oral Presentation

Understanding the probability of detection is critically important for the field of invasion biology and arguably all fields of ecology. False negatives (not detecting something that is actually present) are probably quite common in monitoring, no matter the scale or the sampling approach. For eradication to be feasible, detection of the bioinvaders must be accomplished at an early stage, when the population is localized and at a low density. Unfortunately, introduced species often remain undetected or are usually only detected years after the initial colonization, when eradication is no longer an option. We conducted an experiment in rocky intertidal areas to determine how effective different levels of sampling intensity using various sampling techniques were in detecting different mobile and sessile targets. Given high levels of sampling intensity and the right approach, false negatives were infrequent even at low densities of the introduced species. These small-scale experiments allow us to quantify and incorporate the uncertainty in large-scale empirical datasets (e.g. survey data) and determining the number of searchers needed to monitor a given area. However, given real-world limitations (insufficient funding, personnel), we are currently under-prepared for early detection on a large scale. Volunteer-based monitoring could be a potential solution to this problem by supplementing scarce resources, provided their results are accurate. We validated a monitoring network using approximately 1,000 volunteer citizens to assess the presence of invasive (*Carcinus maenas* and *Hemigrapsus sanguineus*) and native crabs within the intertidal zones of seven coastal states of the U.S., from New Jersey to Maine. Citizen scientists, even at low levels of training, collected data with high levels of accuracy.

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**TECHNIQUES TO TREAT SEED MUSSELS (PERNA CANALICULUS) ON
FARMS INFECTED WITH THE INVASIVE SEASQUIRT (DIDEMNUM
VEXILLUM) IN THE MARLBOROUGH SOUNDS, NEW ZEALAND**

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Poster Presentation

The colonial ascidian, *Didemnum vexillum*, has the potential to severely affect the aquaculture industry in New Zealand, and has already become a significant fouling pest on mussel farms to which it has spread. The New Zealand Mussel Industry Council (NZMIC) commissioned Cawthron to assess several techniques to eliminate *Didemnum*, but leave seed mussels (*Perna canaliculus*) unaffected. Acetic acid was initially proposed as a potential treatment as it has proven to be effective elsewhere in controlling fouling organisms. Detailed field work examined *Didemnum* and mussel mortality using acetic acid (and freshwater). Although 80% of the *Didemnum* colony was killed, this species proved to be much harder to totally eradicate with 100% mortality recorded in only 3/243 treatments. As acetic acid proved to be ineffective in treating *Didemnum*, this led to the testing of several other chemicals to control this species. This pilot study identified bleach as a potential treatment and a detailed study was conducted examining the effect of bleach on *Didemnum* and seed mussel mortality. From this work we determined that dipping *Didemnum* in 0.5% bleach for 2 minutes was a 100% effective treatment to treat *Didemnum* but left seed mussels relatively unaffected. Currently the use of bleach is being tested at the industry-scale.

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THE MANAGEMENT OF AN INVASIVE SEA SQUIRT, DIDEMNUM VEXILLUM IN NEW ZEALAND

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Oral Presentation

In October 2001, *Didemnum vexillum* was recorded for the first time in New Zealand, smothering wharf piles and moorings in a northern harbour. A heavily-fouled barge was then responsible for translocating the ascidian to an international shipping port some 500 km south, near the heart of the New Zealand Greenshell™ mussel industry. Its presence was regarded as a significant threat to the mussel industry because of its demonstrated invasiveness and its ability to over-settle and smother mussels. After consideration of a benefit-cost analysis, an eradication program for *D. vexillum* was instigated in late 2003 by the regional regulatory agency and local port authority. While many of the response methods were completely effective at eliminating *D. vexillum* from different affected substrata, the program overall failed to eradicate the organism from the region. Even though a subsequent benefit-cost analysis suggested further eradication efforts would have net benefits, uncertainty over the timeframe, costs, and the likelihood of success, undermined stakeholder confidence to the extent that they chose to abandon the program. Over the next three years various anthropogenic vectors were responsible for spreading the ascidian throughout the Marlborough Sounds. By the middle of 2006, *D. vexillum* had successfully affected several mussel farms throughout the Marlborough Sound with alarming consequences. A *Didemnum* Working Group consisting of various interested stakeholders was formed and a consensus made to attempt a second *D. vexillum* eradication and control program. A variety of novel methods were developed and used to treat both artificial and natural substrates, namely wharf piles, jetties/pontoons, moorings, vessel hulls, mussel lines, salmon cages, seabed, seaweed beds and immersed trees. The various treatment methods used, the success of the program to date, and the valuable lessons learned will be the focus of the presentation.

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INVASIVE SPECIES DISRUPT THE LONG-TERM DEVELOPMENT OF A SUBTIDAL FOULING COMMUNITY IN THE SOUTHWESTERN GULF OF MAINE

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Oral Presentation

Rates of establishment and success of nonindigenous tunicates in shallow-water subtidal and fouling communities has risen in recent years. However, their long-term impact on community composition, development and diversity are less well understood. In this study we examine the effect of invasive species on community development by comparing temporal changes in succession (1979 to 1982; 2003 to 2006). We replicated an earlier study conducted by Harris and Irons (1982) that documented the development of a marine fouling community on 0.1m² Plexiglas panels from 1979 to 1982 beneath a cement pier at the mouth of the Great Bay Estuary in Portsmouth Harbor, Newcastle, New Hampshire. Photographs and observations of the 1979 to 1982 community on the pier indicated the fouling community was dominated by sponges, hydroids, anemones and large barnacles. Soft corals, tunicates, encrusting and erect bryozoans, and mussels were interspersed throughout these assemblages. Since this study four invasive species, *Membranipora membranacea*, *Botrylloides violaceus*, *Botryllus schlosseri* and *Didemnum* sp. have become dominant members of the community. Results revealed a significant difference in species composition and a shift in community development, resulting in the formation of a novel community driven by invasive colonial ascidians. Given the ubiquity of invasive species in coastal and estuarine systems, this comparative study is essential to elucidate the effects of invasions on species composition and succession.

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A RARE EXAMPLE OF HABITAT EXPANSION BY AN INTRODUCED MARINE PREDATOR

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Poster Presentation

We report here a rare example of habitat expansion by an introduced species in the ocean. The rocky intertidal Asian shore crab *Hemigrapsus sanguineus*, the only varunid (grapsid) crab established north of Chesapeake Bay, was discovered in New Jersey in 1988; by 1993 it was established in Long Island Sound. We surveyed for *H. sanguineus* in multiple intertidal and shallow-water habitats in southern New England. *Hemigrapsus sanguineus* was found in six of seven habitats sampled (rocky intertidal zone, rocky subtidal zone, salt marsh, subtidal fouling communities, submerged aquatic vegetation (eelgrass beds), and subtidal mud bottoms) but not in subtidal sand flats. In its native Asia *H. sanguineus* is entirely associated with the rocky intertidal zone; it is absent from subtidal communities, salt marshes, and seagrass beds. In North America *H. sanguineus* has expanded into habitats it apparently does not occupy in its native range. The relative roles of the processes that drive this habitat expansion (such as broad physiological plasticity, an omnivorous diet, competition, predation, and other phenomena) remain to be investigated. These data provide an early 21st century baseline for a long-term understanding of the role of habitat expansion in invader success, as well as a picture of the distributional ecology of *H. sanguineus* and other crab species prior to the arrival of its Asian congener, *H. takanoi* (= *H. penicillatus* of Atlantic authors), already established in western Europe.

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**THE ROLE OF COMMERCIAL SHIPPING IN AQUATIC SPECIES
INTRODUCTIONS: ANALYSIS OF VESSEL TRAFFIC
AND BALLAST WATER DISCHARGE PATTERNS IN CALIFORNIA**

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Oral Presentation

The ballast water and sediments of ships is considered one of the major vectors by which nonindigenous species are introduced to marine and estuarine habitats. California law requires commercial vessels to conduct ballast water exchange, or use an approved treatment method, before discharging ballast in state waters. Compliance with the law is tracked by the California State Lands Commission through ballast water reporting forms which are required from vessels upon departure from each port of call in the state. These forms provide valuable information on vessel traffic and discharge patterns. Since 2000, the number of vessels calls to California has increased steadily; approximately 11000 vessels called on California ports in 2005 and over 6000 called in the first half of 2006. Vessel arrivals are dominated by container ships (45%), tankers (15%), and bulkers (9%). Over 50% of vessel calls originated from other west coast ports, including other California ports, and one third originated from Asian ports. While the percent of vessels discharging ballast water in California has dropped steadily since 2000 to a low of 15% (85% of vessels retain ballast water onboard), the volume of ballast water discharged has increased over that same period. Of the 21.5 million metric tons of ballast water discharged in California between 2004 and the first half of 2006, 88% by volume was correctly managed through exchange. The majority of non-compliant ballast water came from Mexico or other West Coast ports. The California State Lands Commission is working to address non-compliant ballast water discharges through enhanced enforcement, inspection, and education and outreach efforts to the regulated industry.

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EFFECT OF HABITAT ALTERATION AND INVASION BY EXOTIC SPECIES ON MANGROVE ECOSYSTEMS IN FLORIDA

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Either One Presentation

Habitat alteration or loss, invasion of exotics, and declines in native biota frequently occur simultaneously, making it problematic to determine the relative importance of habitat loss versus exotic species on the decline of native species. In mangrove ecosystems, abiotic constraints limit the diversity of native plants and prevent invasion by most exotics. However, recent alterations to mangrove habitat have changed substrate elevations and hydrological regimes, now leaving it vulnerable to invasion by exotic plants and native plants never before found in mangrove-dominated systems. The purpose of this study was to compare abundances of three native mangrove species, *Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia germinans*, at human altered and pristine mangrove sites in Canaveral National Seashore, Florida. Line transects were used to survey vegetation at all sites (n = 14). Pristine sites were dominated by the three native mangrove species and associated halophytic plants. Species richness was higher at the disturbed sites than at pristine sites due to an increase in native woody shrubs and weedy species. In addition, we found two exotics present at the disturbed sites, *Schinus terebinthifolius* (Brazilian pepper) and *Lantana camera* (shrub verbena). Changes in floral composition occurred adjacent to the intertidal region at disturbed sites; this suggests alterations to the landscape are allowing invasion of exotics and native species into areas formerly dominated by mangroves. In this system, invasion by exotic species is a result of habitat alteration and may not be the primary cause of declines in native mangroves and other salt marsh flora. The decreased abundance of mangroves at disturbed sites is a result of changes to the hydrological properties of the system allowing a greater diversity of flora, native and exotic, to compete with native mangrove species.

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POTENTIAL TRANSFER OF VIBRIO CHOLERAE BY SHIPS AMONG PORTS IN THE MEDITERRANEAN SEA: THE PORTAL PROJECT

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Poster Presentation

The PORTAL project (PORT surveys in the Mediterranean Sea for ship-transported ALien organisms) was a preliminary study—a targeted survey of ports—funded by CIESM (Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée). Its aim was to identify alien species that may be disseminated by shipping. Selected phylogenetic groups (macrophytes, bryozoans, serpulids, hydroids, ascidians, mollusks, barnacles) and organisms that pose significant risk to human health (here, the bacterium *Vibrio cholerae*, agent of cholera) were identified. Water samples collected from 11 Mediterranean ports were filtered, fixed, and sent to the United States, where they were analyzed for the presence of two toxigenic serogroups of *Vibrio cholerae*, O1 and O139. Samples were stained with a fluorescent antibody and examined using fluorescence microscopy. A subset of the fixed samples was also examined for the presence of *Vibrio cholerae* O1 or O139 using a rapid colorimetric immunoassay kit (Cholera Smart II, New Horizons Diagnostics, Inc.). Unfixed samples were also sent from some ports; they were grown in nutrient broth and subsequently tested for the presence of *V. cholerae* using a biochemical protocol that provides no information regarding their serogroup. Samples examined with fluorescent antibodies were positive in 4 of 12 ports sampled (13 of 83 samples were positive for one of the toxigenic serogroups). Interestingly, all ports were in Italy. All 51 'Cholera Smart' assays were negative or inconclusive. Of the unfixed samples tested, half (5 of 10) were positive. These preliminary data indicate the potential for toxigenic serogroups of *V. cholerae* to be transported among ports in the Mediterranean Sea. Future studies of invasive species within this area should include the transfer of pathogens, such as *V. cholerae*, and should quantitatively determine pathogen abundance. Of special concern is the potential transfer of pathogens into areas with aquaculture operations.

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AN EXPERIMENTAL TEST OF EUROPEAN GREEN CRAB (*CARCINUS MAENAS*) FORAGING EFFECTS ON WINTERING SHOREBIRDS

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Oral Presentation

We used a novel manipulative field experiment and dietary analysis to examine the effects of European green crab (*Carcinus maenas*) predation on the diet of Dunlin (*Calidris alpina*) wintering in Bodega Harbor, California. We serially enclosed first green crabs (for two weeks) and then Dunlin (*Calidris alpina*, for one low tide period) in cages (4 x 4 x 1.5 m) in a randomized complete block design. Crab density served as the treatment, and effects were quantified by measuring invertebrate densities and examining Dunlin stomach contents. Stomach contents were also compared to non-captive birds captured in mist nests. Background prey density during this experiment was at a record low. Under these conditions, experimental crabs significantly reduced density of tanaids (*Leptochelia dubia*), but not of other invertebrate prey (e.g. the bivalve, *Nutricola* spp.). Dunlin reduced the density of polychaetes (*Lumbrineris* sp.) in areas where no green crabs foraged compared to areas where a high density of green crabs foraged. Additionally, Dunlin reduced the density of *Nutricola* spp. in cages with a high density of green crabs compared to those where no green crabs were enclosed. Unlike results of previous studies in this location, less than 30% of experimental Dunlin stomach samples contained *Nutricola* spp.; most *Nutricola* were <2 mm. Of the non-captive Dunlin stomach samples examined, 100% contained bivalves (either *Gemma gemma* or *Nutricola* spp.). Our results indicate that green crab foraging affects prey consumption of wintering Dunlin, but in some unanticipated ways that may be contingent on post-invasion impacts. We suggest that facilitation and prey partitioning by type and size occurred in this experiment, and that competition is an unlikely mechanism by which the crab and Dunlin interact currently. Whether these effects are negative or positive to Dunlin, and shorebirds in general, remains to be determined.

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“INCONSPICUOUS” IMPACTS OF SPARTINA ALTERNIFLORA IN TEMPERATE EASTERN PACIFIC ESTUARIES

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Oral Presentation

Nonindigenous smooth cordgrass (*Spartina alterniflora*) is one of the most conspicuous and widespread nonindigenous aquatic species in many eastern Pacific estuaries of North America. Smooth cordgrass introductions, both accidental and intentional, have occurred in many estuaries in the western United States and Canada. In estuaries where smooth cordgrass has invaded, it is widely held to be destructive to habitat and wildlife, and moreover to be a threat to the local economy, founded largely on harvest of marine resources. Despite all of this concern over the most conspicuous impacts of smooth cordgrass, little attention has been given to the role of smooth cordgrass production in the detritus based estuarine food webs where it has invaded. In order to better understand this role, we examined the growth rates and production base of nonindigenous Pacific oysters (*Crassostrea gigas*) in two estuaries (Willapa Bay and Grays Harbor, where smooth cordgrass is absent) of Washington State, USA. We measured naturally occurring stable isotope ratios of C, N, and S in adult and post-settled larval oysters, and several organic matter sources, including smooth cordgrass, eelgrasses, benthic algae, seston, and terrestrial leaf litter. We compared patterns in growth and production base as a function of landscape scale system attributes and found that there were spatio-temporal trends in both growth rates and the diet of Pacific oysters. In addition, it appears as though there is substantial transport of smooth cordgrass derived organic matter from Willapa Bay to nearby Grays Harbor, where smooth cordgrass is absent. Consequently, the presence of smooth cordgrass may have far-reaching impacts on ecosystem processes in eastern Pacific estuaries.

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ECONOMIC ANALYSIS OF MARINE INVASIVE SPECIES MANAGEMENT AND POLICY

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Poster Presentation

The economic analysis evaluates policies including pre-shipment treatment requirements, inspection and enforcement, liability, environmental bonds, taxes and subsidies by quantifying incentives for shippers and regulators to control uncertain arrival of marine invasive species in a cost-effective manner. The empirical analysis involves data from North America (Canada, U.S., and Mexico) and can be transferable elsewhere because it explores policies for solving a transboundary pollution problem with more than one port of entry to address trade-related marine invasive species risk. The analysis also includes the necessary focus on hull fouling in addition to ballast water as a vector of marine invasive species arrival. These policies have been developed primarily based on scientific risk assessment without economic analysis of the response of shipper and importers to port enforcement policies. Existing policies are based on the reasoning that increased enforcement effort will result in higher detection levels, or more specifically, that increased inspection will result in a higher number of interceptions and in turn, higher compliance. In addition to a deterrence effect where shippers and importers respond to increased enforcement with increased control, importers may respond in ways that regulators do not intend in order to avoid enforcement. For example, importers may choose to not bring goods into the country, or may ship a reduced amount. High-risk importers may also engage in “port shopping,” routing shipments through ports where enforcement is perceived to be weakest, or timing their shipments to arrive at a port when inspection staffs are low. Even low-risk firms have incentives to avoid the time and costs associated with border inspections. These decisions concerning port choice may have significant effects on pest populations and pest risk as well as spatial damages or vulnerability.

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NON-NATIVE AQUATIC ORGANISMS IN THE COASTAL WATERS OF CALIFORNIA

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Poster Presentation

The Marine Invasive Species Program is an effort to control the introduction of non-native species from the ballast of ships into our coastal California waters. The initial phase involved both field collections and a literature review which resulted in creation of a database that includes information on all known nonindigenous aquatic species in the marine and estuarine waters of the state. The current 5-year phase will include a resurvey of the ports and estuaries surveyed in 2000, as well as a more intensive survey in the San Francisco Estuary and, for the first time, a comprehensive survey of California's outer coast. This poster will show data sources for the California Aquatic Non-Native Organism Database (CANOD), a project timeline, and a summary of main findings from the study. The survey found a total of 607 organisms that were categorized as introduced or were considered likely to have been introduced. All areas of the California coast studied have experienced some level of invasion. Species totals are greatest in the two major commercial ports, San Francisco and Los Angeles/Long Beach. However, the smaller ports, harbors, and bays along the coast also have a substantial number of non-native species. Annelids, primarily polychaete worms, were the dominant taxon and arthropods (crabs, shrimp, etc.) were the second most abundant taxon identified. Other common taxa identified included molluscs, fish, and cnidarians. The most common potential pathways of introduction were ballast water, hull/ship fouling, and aquaculture, but pathways were unknown for many species. Most species introduced to California appear to have come from the northwest Atlantic, the northwest Pacific, and the northeast Atlantic. The database and reports submitted to the Legislature can be found on the Web at <http://www.dfg.ca.gov/ospr/organizational/scientific/exotic/MISMP.htm>.

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**ALIEN SPECIES IN THE MEDITERRANEAN SEA—
PATTERNS OF INVASION IN TIME AND SPACE**

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Oral Presentation

As part of a European Commission sponsored comprehensive inventory of alien species in Europe, an authoritative dataset was assembled tracing the origin, date and manner of introduction, current distribution, rate of spread, and actual and potential impacts of the 513 alien metazoan species recorded in the Mediterranean Sea. Since the 1950s political and economical changes in peri-Mediterranean countries impacted the rate and means of introduction: though the Suez Canal remained the main access route for alien species, the rate of introductions by vessels and mariculture has been higher. Of the 120 alien species known in 1950, 74% entered the Mediterranean through the Suez Canal, 19% and 6% were vessel-transported and mariculture introductions, respectively. Of the 393 alien species recorded since 1950, 50% were Erythrean aliens, 32% and 10% respectively were vessel-transported and mariculture introductions. Once established in the Mediterranean the temporal dynamics of the alien species are markedly varied. Most alien species are littoral and sublittoral benthic or demersal. Since the coastal benthos has been extensively studied, the chances that new arrivals will be encountered and identified are higher. Also, the species most likely to arrive by the predominant means of introduction are shallow water species. A comparison of alien species between the coasts of Spain and France, and an equivalent stretch along the Levantine coastline, shows marked differences in their numbers, origin and means of introduction. There are four times as many alien species along the Levant (382) as in the westernmost Mediterranean (95). The majority of Levantine aliens entered through the Suez Canal (73%, 13% vessel-transported, 2% mariculture), whereas mariculture (44%) and vessels (37%) are predominant in the western Mediterranean. Consequently, the native ranges of the western Mediterranean aliens are spread over 'the seven seas', while the Levantine aliens mostly originate in the tropical Indo-Pacific or parts thereof.

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NONINDIGENOUS INTERTIDAL SPECIES IN BRITISH COLUMBIA, CANADA

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Poster Presentation

British Columbia (BC) has a long history of introduction of nonindigenous intertidal species, beginning with importation of eastern oysters, *Crassostrea virginica*, and invasion by *Mya arenaria*, in the late 1800s. Eastern oysters are no longer imported and only a relict population remains in Boundary Bay. Pacific oysters, *Crassostrea gigas*, are abundant in southern British Columbia. European flat oysters, *Ostrea edulis*, are still transplanted for aquaculture and have successfully recruited in Barkley Sound. Kumamoto oysters, *Crassostrea sikamea*, are cultured but have not been collected in the wild. A suite of species arrived with oysters. In general, gastropods (*Batillaria attramentaria*, *Cecina manchurica*, *Crepidula convexa*, *Myosotella myosotis*, *Nassarius fraterculus*, *Nassarius obsoletus*, *Ocenebrellus inornata* and *Urosalpinx cinerea*) have become established in few locations and dispersed anthropogenically. Some bivalves (*Mercenaria mercenaria*, *Neotrapezium liratum*, and *Petricolaria pholadiformis*) have limited distributions while others (*Musculista senhousia*, *Mya arenaria*, *Mytilus edulis*, *Mytilus galloprovincialis*, *Nuttallia obscurata*, *Teredo navalis* and *Venerupis philippinarum*) are more widely distributed. Several species (*Clanculus ater*, *Lyrodus takenoshimensis*, *Sabia conica* and *Thais clavigera*) either failed to become established or were extirpated. Two plants introduced with oysters (*Sargassum muticum* and *Zostera japonica*) have dispersed widely, while recent introductions (three species of *Spartina*) are still limited to few locations. European green crab, *Carcinus maenas*, recently established local populations on the west coast of Vancouver Island. These populations may serve as larval sources for further northward dispersal if oceanographic and climatic conditions are favorable. Invasive species diversity is highest in the Strait of Georgia and decreases in outside waters and with increasing latitude. Although aquaculture was the predominant historical introduction vector, ballast water and hull fouling vectors are currently of greater concern. Some species' distributions are limited by temperature; their range within and beyond British Columbia could increase if climatic projections are accurate.

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WILL THE EUROPEAN GREEN CRAB PERSIST IN THE PACIFIC NORTHWEST?

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Oral Presentation

A strong cohort of young green crabs, *Carcinus maenas*, appeared in estuaries along the coasts of Oregon, Washington, and the west coast of Vancouver Island following the strong El Niño of 1997-98. Unusually strong northward-moving coastal currents (up to 50 km/day from September 1997 to April 1998) must have transported green crab larvae from more established source populations in California to the Northwest. Coastal transport events and recruitment of young green crabs have been much weaker in recent years. While it was hoped that green crabs would go extinct in the Pacific Northwest once the original colonists reached the end of their life span of 6 years and no new larvae arrived from California, this has not happened. Local recruitment has occurred in Oregon and Washington estuaries and inlets on the west coast of Vancouver Island. Good coast-wide recruitment in 2003, 2005 and 2006 is linked to warm winters and shore-ward transport in March when larvae are believed to be settling out. An extensive survey by Fisheries and Oceans Canada biologists found green crab populations on the west coast of Vancouver Island, with densities of over one per trap in some inlets. However, no green crabs were found in the inland sea between Vancouver Island and the mainland. Therefore outreach efforts should continue to prevent the establishment of this invader in these waters via ballast water or shellfish transport.

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PUBLIC MONITORING AND GOVERNMENTAL MANAGEMENT OF MARINE BIOINVASIONS IN THE NETHERLANDS

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Oral Presentation

Especially over the last ten years, marine invaders have had a dramatically increasing impact on temperate water ecosystems around the world. In 2005 and 2006 alone, 16 new invasive species have been recorded for the Dutch coast. This is the highest number ever recorded in The Netherlands within a two-year time span. Some of these species have destroyed complete marine ecosystems in other temperate water areas. Although much attention is given to the Japanese oyster *Crassostrea gigas*, most of the new invaders are not given the same attention as in e.g. New Zealand, the USA and Canada, where funds and infrastructure are available for more immediate action and research. In The Netherlands marine invaders are mainly recorded by volunteer based monitoring networks. In 2006 some governmental institutes have officially suggested that marine bioinvasions deserve more direct attention by professional researchers. Therefore several management plans are developed at present. Some potentially dangerous recent invaders do not receive much or any professional attention in Dutch waters yet, e.g. [1] The comb jellyfish, *Mnemiopsis leidyi*, which has settled in The Netherlands in 2006, but has not caused any problems yet. When this species invaded the Black Sea, it devastated large areas by over-predation of local zooplankton populations. [2] The population of the colonial sea-squirt *Didemnum* sp. has expanded its populations in The Netherlands since 1996. It has covered hundreds of square kilometers of substrate surface, overgrowing almost everything on its way in e.g. New Zealand, the USA and locally along the Dutch coasts. [3] The Japanese, predatory gastropod *Rapana venosa*, which is known as an invader that can wipe out complete bivalve populations. The first sightings in The Netherlands in 2005 have triggered several newspaper articles, but no further official action was taken. Its current distribution is unknown.

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**POTENTIAL ECOSYSTEM CHANGES CAUSED BY AN INTRODUCED RED
ALGA, *GRATELOUPIA TURUTURU* YAMADA IN LONG ISLAND SOUND**

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Poster Presentation

Grateloupia turuturu Yamada was observed in eastern Long Island Sound along the Connecticut shoreline in 2004. This red alga, reported as particularly invasive, is native to Japan and has previously been introduced to Europe (1969) and Rhode Island, USA (1994). *Grateloupia turuturu* is reported to be tolerant of nutrient enriched waters, and is found in salinities from 15 to 37 psu, and temperatures from 4°C to 28°C. It inhabits low intertidal and subtidal areas frequently populated by the native red alga, *Chondrus crispus* Stackhouse. Since these two species have different morphologies, a change in the abundance of the native *C. crispus* may change the habitat for the native flora and epifauna. A newly established population of *G. turuturu* has been monitored monthly on a cobble beach at Millstone Point in Waterford, Connecticut, and more recently on a rocky platform. This monitoring will establish a baseline to assess its impact on the native community. *Grateloupia turuturu* appears to colonize freshly exposed areas more quickly than *C. crispus*. For example, after a scouring event due to a storm, cobbles were quickly colonized by *G. turuturu*. Such rapid colonization of these cobbles may be indicative of high spore output. This study will determine the fecundity of tetrasporophytic and cystocarpic blades, as well as the phenology of the blades. Preliminary results show little difference in the abundance and variety of invertebrate species in samples consisting of both the introduced *G. turuturu* and the native *C. crispus* as opposed to samples consisting solely of *C. crispus*. Further invertebrate identification and analysis will provide a more accurate evaluation of these two algal species as habitats for local native and non-native organisms.

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MINIMIZING THE EXPOSURE OF THE NORTHWESTERN HAWAIIAN ISLANDS MARINE NATIONAL MONUMENT TO MARINE ALIEN SPECIES

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Oral Presentation

The Northwestern Hawaiian Islands Marine National Monument (NWHI-MNM) was created by Presidential proclamation on June 15, 2006. The NWHI-MNM is the single largest conservation area under the U.S. flag, and the largest marine conservation area in the world. It encompasses 137,792 square miles of the Pacific Ocean - an area larger than all the country's national parks combined. The extensive marine communities of the NWHI-MNM comprise one of the last relatively intact coral reef ecosystems in the world. The Hawaii Institute of Marine Biology has developed baseline information for the NWHI-MNM concerning marine alien species and mechanisms of transport, which has been used to develop management strategies. The key points of the baseline study are as follows:

- Eleven marine alien species have been recorded in the NWHI-MNM, with eight confirmed to be established.
- Of the eight marine aliens established in the NWHI-MNM, the majority are associated with anthropogenic habitats.
- The 343 marine alien species recorded from the main Hawaiian Islands (MHI) represent the most likely source of invasive species for the NWHI-MNM based on the proximity and pattern of maritime activity associated with the MHI.

Efforts were begun in 2005 to minimize the transport of marine alien species to the NWHI-MNM through a management strategy based on maritime vessel traffic and associated activities. These efforts involve mandatory management steps for vessel platforms that focus on a suite of vectors that are associated with both commercial and research activities. This presentation will provide the baseline information for the study and detail the management steps being taken to minimize the likelihood of the NWHI-MNM being exposed to marine alien species.

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WHO ARE THE MOST IMPACTING INTRODUCED AQUATIC SPECIES IN EUROPE?

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Oral Presentation

As per one of its objectives, the European Union-funded Programme "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, see also www.daisie.se) collected detailed information on the most impacting introduced aquatic species in Europe. This presentation provides a complete list of the species selected, their habitat(s), the current European distribution and will also indicate their (economical and ecological) impact. Further the potential to spread and possible impact scenarios of the most recent aquatic invaders in north-western European coastal waters are outlined.

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**THE NEW EUROPEAN ON-LINE JOURNAL “AQUATIC INVASIONS”:
AN IMPORTANT PART OF THE EUROPEAN EARLY WARNING SYSTEM
ON AQUATIC INVASIVE SPECIES**

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Poster Presentation

Aquatic Invasions is a rapid on-line journal focusing on biological invasions in European inland and coastal waters and potential donor areas of aquatic invasive species for Europe (ISSN: 1818-5487, <http://www.aquaticinvasions.ru>). The journal provides the opportunity of timely publication of first records of biological invaders for consideration in risk assessments and early warning systems. Also, the journal provides the opportunity to publish relevant technical reports and other accounts not publishable in regular scientific journals. *Aquatic Invasions* is an important part of the developing Pan-European and regional early warning systems on aquatic invasive species, with an important service of protection of author rights on primary geo-referenced records on introduced species and biological monitoring and surveys. In 2006, more than fifty research articles and short communications in four regular issues of first volume of *Aquatic Invasions* included geo-referenced information on range expansions and first records in European coastal waters of such highly invasive species as Conrad's false mussel *Mytilopsis leucophaeata*, Wedge clam *Rangia cuneata*, grapsid crab *Percnon gibbesi*, Chinese mitten crab *Eriocheir sinensis*, ctenophore *Mnemiopsis leidyi* and round goby *Neogobius melanostomus*. *Aquatic Invasions* is published on behalf of the International Association of Theoretical and Applied Limnology (SIL) with support of the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors. The journal copyright is with the European Research Network on Aquatic Invasive Species (ERNAIS, <http://www.zin.ru/rbic/projects/ernais/>). Start-up funding for *Aquatic Invasions* is provided by the European Commission Sixth Framework Programme for Research and Technological Development Integrated Project ALARM (GOCE-CT-2003-506675). Manuscripts submitted to *Aquatic Invasions* are reviewed by independent experts. Accounts on inland invaders may be submitted to Vadim Panov (rbic@zin.ru) and for coastal invaders please approach Stephan Gollasch (sgollasch@aol.com).

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**STYELA CLAVA INCURSION RESPONSE:
AN OVERVIEW OF THE NEW ZEALAND GOVERNMENT'S
RESPONSE TO A MARINE INVADER**

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Oral Presentation

The rate and extent of marine biological invasions has become increasingly apparent over recent years. While this is attributed to ever increasing trade and tourism, it is also a direct result of increased awareness and recognition of the risks posed by marine invaders and increased surveillance effort. Marine invasion biology is a relatively young discipline compared with terrestrial invasion biology and this is clearly evidenced by the disparity in the biosecurity systems that are in place for the management of marine versus terrestrial biosecurity systems. *Styela clava* was first detected in the Viaduct Harbour, Auckland, New Zealand, in August 2006 initiating a preliminary investigation by Biosecurity New Zealand followed by an incursion response. Co-ordination and management of this marine response utilized and adapted effective terrestrial response structures and procedures and aligned these with existing general and marine biosecurity processes ensuring consistency and transparency. This paper provides an overview of Biosecurity New Zealand's response to *Styela clava*.

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CAN OPEN-OCEAN BALLAST EXCHANGE PREVENT INVASIONS BETWEEN FRESHWATER PORTS?

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Oral Presentation

Mandatory ballast water exchange (BWE) was implemented for vessels carrying ballast water into the Great Lakes in 1993. Despite this, little data are available on its effectiveness, and additional invaders continue to be reported in the Great Lakes. In this study, we conducted experiments to assess the efficacy of BWE on six operational transoceanic vessels traveling from the Great Lakes to European ports. Each vessel had paired ballast tanks, one of which was designated as a control that remained filled with Great Lakes water while the other was exchanged with mid-ocean water. Community composition was assessed after tanks were filled and again prior to water discharge in European ports. BWE was verified by ship records and, in two cases, in-tank sensors. BWE was highly effective (>99% loss) for reducing concentrations of freshwater zooplankton, exceeding proposed IMO ballast water performance standards. Live sentinel amphipods and oligochaetes deployed in incubator chambers sustained nearly universal mortality in tanks that experienced BWE. Also, it is likely that BWE reduced in situ recruitment of zooplankton from diapausing eggs present in ballast sediments, via mortality of previously hatched freshwater individuals upon exchange and/or suppression of hatching cues due to exposure to saltwater. Collectively, these studies support the contention that BWE by transoceanic vessels provides very strong protection against invasions both pelagic and benthic species between source and donor freshwater ports.

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PATTERNS AND IMPACTS OF MARINE BIOINVASIONS IN SOUTH AFRICA

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Oral Presentation

Ten marine invasive species are currently confirmed from South Africa, with a further 22 classified as cryptogenic. Five of the ten confirmed species were first recorded after 2000 and all but one are restricted to harbours, sheltered lagoons and estuaries, mostly in the Western Cape. Only four have known ecological or economic impacts. The Japanese oyster, *Crassostrea gigas*, has recently established itself in three southern Cape estuaries. It can be harvested, but poses little threat to indigenous species. The ascidian, *Ciona intestinalis*, causes significant mortality by smothering farmed mussels on suspended ropes. The European shore crab *Carcinus maenas* supports dense populations in Cape Town docks, appears unable to establish on the wave-exposed open coast, but poses a major threat to nearby aquaculture sites. The Mediterranean mussel *Mytilus galloprovincialis* is now the dominant rocky shore organism along 1 500 km of coastline, from Namibia to the Eastern Cape. It is faster growing and more tolerant of aerial exposure than indigenous mussels and has dramatically extended the up-shore extent and biomass of mussel beds. It has profound ecological impacts, including competition with indigenous mussels and limpets for primary rock space. This has greatly reduced the populations of larger limpet species, although other smaller species thrive by becoming stunted and living on the valves of individual mussels. The dense mussel matrix also provides increased habitat for in faunal species. Because *M. galloprovincialis* occur higher in the intertidal, they have greatly increased food availability to terrestrial predators, particularly Oystercatchers and humans. Although they have radically altered the appearance and structure of rocky shore communities they are not thought to have eliminated any indigenous species. They also form the basis of significant local mariculture industries and wild stocks hold potential for small scale subsistence exploitation.

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**SEASONAL COEXISTENCE OF THREE INVASIVE COLONIAL ASCIDIANS
(*BOTRYLLOIDES VIOLACEUS*, *BOTRYLLUS SCHLOSSERI*
AND *DIDEMNUM* SP.) IN THE GULF OF MAINE**

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Oral Presentation

The influence of abiotic factors in the establishment and seasonal patterns of invasive species remains difficult to determine for most ecosystems. However, examining this relationship is critical to predict the spread of invasive species and which habitats will be most vulnerable to invasion. In this study we correlate the seasonal abundance patterns of three introduced colonial ascidians *Botryllus schlosseri*, *Botrylloides violaceus* and *Didemnum* sp. to abiotic factors (e.g. temperature and salinity) and potential biotic controls. To examine latitudinal abundance patterns of colonial ascidians, 100 cm² panels were deployed for three months at four sites (Eastport, Maine; Damariscotta, Maine, Newcastle, New Hampshire and Salem, Massachusetts). In addition to these studies, we deployed 0.1m² Plexiglass panels beneath a cement pier at the mouth of the Great Bay Estuary in Portsmouth Harbor, Newcastle, New Hampshire in July 2003. Panels were photographed monthly for three years. Results revealed a seasonal pattern in species abundances that correlated with abiotic factors, primarily temperature and salinity. These results will help elucidate the mechanisms for the success of invasive colonial ascidians in the Gulf of Maine.

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**IDENTIFYING THE ORIGIN OF THE CRYPTOGENIC
ASCIDIAN *MOLGULA MANHATTENSIS* (DE KAY, 1843)**

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Oral Presentation

Molgula manhattensis is a common member of fouling communities in temperate waters on both coasts of the North Atlantic Ocean. It was recently introduced on the Pacific coast of the US, in Japan and Australia. Possible vectors of introduction are hull fouling, ballast water and oyster shipments. Based on its disjunct ampho-Atlantic distribution, the observed recent introductions to other areas, association with various transport vectors, and inconclusive reports of the inferred introduced status of this species, *M. manhattensis* is qualified as a cryptogenic species in the North Atlantic Ocean. The number of cryptogenic species in the ocean is greatly underestimated. Biological invasions are generally seen as a modern-day phenomenon. However, biologists only started investigating coastal communities in the 18th century, whereas the advent of shipping was many centuries before. Wooden hulls, long journeys, slow speeds and long port residence times created an ideal opportunity for uptake, en route survival and introduction of nonindigenous species. Taxa that were introduced then may be important components of coastal communities now, but may falsely be viewed as native. In this study we investigated the historical biogeography of *M. Manhattensis* with the use of molecular tools. We sequenced a 530bp fragment of the mtDNA COI subunit of *M. manhattensis* specimens of from nine populations in the North Atlantic, one population from San Francisco Bay and a Japanese population. Additionally, we sequenced a few individuals from museum collections, dating back to the 19th century. Based on the geographic distribution of haplotypes and haplotype diversities, the native range and the timing of spread of *M. manhattensis* were analyzed.

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POINTING FINGERS: HOW WAS THE AMUR GOBY (*RHINOGOBIUS BRUNNEUS*) INTRODUCED TO NORTH AMERICA?

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Oral Presentation

Identifying the specific vector responsible for a new nonnative species introduction can greatly improve efforts to reduce subsequent spread. However, because aquatic invasive species often travel via multiple pathways, it can be very difficult to link a new introduction to a precise source. The common lag time before discovery of a new introduction compounds this problem. Incorrect association of a nonnative species with a specific source can misdirect future management activities and cause problems for those receiving the blame. This challenge will be explored by examining the recent North American introduction of the Amur goby, *Rhinogobius brunneus*. The Amur goby was discovered in the Columbia River estuary and an important Columbia River tributary in 2006; earlier reports indicate these fish were introduced at least one year earlier. Identifying the source of this nonnative fish has been complicated by the fact it has a minimal history of invasion outside its native range in Asia/far-eastern Russia. Genetic analysis revealed at least one specimen from Washington derives from the Shinjiko Lake population found in parts of Japan, China, and Korea. Analogous introductions of fish from this region suggest both ballast water and the aquarium trade could be likely pathways, but we have found little direct evidence to link this species to either. Consequently, ongoing efforts to detect this fish in other water bodies and reduce secondary spread have remained general in nature. Improved methods to confirm specific introduction vectors would more effectively steer post-invasion management activities for cases like the Amur goby.

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**THE IMPACTS OF THE INVASIVE CRAB *HEMIGRAPUS SANGUINEUS* ON
A CRUSTACEAN-FEEDING GUILD OF FISHES IN LONG ISLAND SOUND**

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Poster Presentation

Consideration of the potential ecological impacts of the invasive crab *Hemigrapsus sanguineus* has been limited to intertidal habitats. Recent observations demonstrate the expansion of the species into the shallow subtidal habitats in Long Island Sound where it has the potential to impact the crustacean-eating guild of fishes through direct and indirect interactions. The overall objectives of this project were to: (1) determine the relative importance of native and introduced prey items in the food habits of nearshore fishes, and (2) determine the degree of selectivity of fishes to native and introduced prey taxa. Gut content analyses were performed on individuals collected from the field and analysis of similarities was used to determine which prey species were driving differences in diet composition. In addition, prey choice experiments were conducted in the laboratory. Chi-square analyses show that some fishes consume more *H. sanguineus* when concurrently offered native crab species as prey. Results of this research will help to determine the impacts of the crab on the food web dynamics of crustacean-feeding fishes and aid in the understanding of the potential for these fishes to act as an effective biological control. Understanding how the communities respond to changes in food web structure (i.e. predator or prey increases or declines) is vital to the management of our region's coastal fisheries.

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PREDICTING THE FUTURE SPREAD OF AN INVASIVE TUNICATE ALONG BRITISH COLUMBIA'S COASTLINE

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Oral Presentation

The invasive tunicate *Didemnum* sp. has been reported in Canadian waters and has the potential to negatively impact native flora and fauna. In British Columbia, limited surveys have found *Didemnum* sp. in the Strait of Georgia and at sites along the west coast of Vancouver Island. This tunicate possesses several traits that likely enhance its invasion success including its ability to grow and sexually reproduce quickly, smother competing or co-occurring organisms, and its tolerance of a wide variety of environmental conditions. *Didemnum* sp. has the potential to negatively impact water quality, macrophytes, invertebrates, fishes, and aquaculture facilities. We conducted a spatially explicit risk assessment for near shore areas of British Columbia (BC) based on estimates of propagule pressure and environmental suitability. The key vectors for *Didemnum* sp. dispersal along the BC coastline are movements of small/recreational vessels and aquaculture equipment. Hence we estimated propagule pressure based on the spatial distribution of aquaculture and boating facilities. Environmental suitability was modeled based on the current invaded range along the North American west coast using ecological niche modeling. We divided the Canadian west coast into eight separate zones and determined the risk for each zone separately. As a sensitivity analysis we calculated the relative risk for all current locations of *Didemnum* sp. on the BC coastline, which were all predicted to have a high predicted risk. The same approach identified Central, North, and South Vancouver Island at high risk of future invasions. Johnstone Strait receives high vector input, but the environmental suitability is predicted as lower than other study areas. The approach presented here allows a spatially explicit risk prediction, which provides a basis for focused and effective management efforts.

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FROM PRINCIPLE TO PRACTICE: IMPLEMENTING EARLY DETECTION AND RAPID RESPONSE EFFORTS IN MASSACHUSETTS WITH LIMITED RESOURCES

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Oral Presentation

In Massachusetts, Aquatic Invasive Species (AIS) are managed by several state environmental agencies. Since gaining state and federal approval for the Massachusetts AIS Management Plan in 2002, these agencies have worked together to improve Early Detection and Rapid Response (EDRR) capabilities. In principle, it is best to eliminate the threat posed by AIS before small populations become established and widespread. While putting this principle into practice, Massachusetts is working to overcome several challenges related to effective monitoring, species confirmation, and determining the potential impact and manageability of new species without full-fledged risk assessments. Using limited resources, the stakeholder agencies in Massachusetts have developed resources to address these questions and moved one step closer to making EDRR a reality. One important resource developed by the state is a species evaluation questionnaire that gathers pertinent information and structures an informed decision-making process in the absence of formal risk assessments. The questionnaire, inspired by the Galveston Bay Invasive Species Risk Assessment Final Report, evaluates a species based on its potential impact to ecosystems and the economy, and its potential manageability. By incorporating qualitative and quantitative information, the questionnaire promotes a robust discussion and assessment of a particular species, and helps set appropriate objectives for a rapid response. Three other EDRR resources are also described in the presentation including: a volunteer marine invasive species monitoring network, a verification and reporting network, and a control methodology evaluation. Together, these resources are necessary parts of an EDRR plan that is adaptive and flexible while creating a rigorous and organized process that will document the decision rationale, and will help allocate limited AIS resources more effectively.

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THE INFLUENCE OF SPATIAL SCALE ON THE RELATIONSHIP BETWEEN NATIVE DIVERSITY AND INVASION

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Oral Presentation

The existence of community resistance to the addition of new species, either as colonization or biological introduction events, remains controversial despite strong support from theoretical models and empirical work. In terrestrial systems, the predicted negative relationship between invasion and resident diversity has been demonstrated in small scale manipulations, yet a positive relationship is frequently observed over larger scales. This apparent dichotomy was 'resolved' by Shea and Chesson (2002) who suggested that the spatial scale was paramount in explaining whether a positive or negative relationship between resident species richness and invasion probability was relevant. At local scales invasion probability is influenced by local resident species richness resulting in a negative relationship, whereas larger scales transcend habitats of varying environmental conditions and quality resulting in a positive influence of resident species richness on invasions. This suggests that as the spatial scale of evaluation increases, a shift from negative to positive slopes in the relationship between native and introduced species is anticipated. Few marine studies have evaluated native and introduced species relationships at multiple spatial scales using consistent methods. Here, we evaluate the results from 39 port baseline evaluations of Australian ports where samples were collected in consistent fashion from epibenthic (fouling) communities at 10-1 m² and replicated at the berth, region of port, port, bioprovince and continent transcending ten orders of magnitude. Our results suggest that extant epibenthic communities in our studies do not conform to the expected relationship. Instead a consistent, but weak, positive relationship between native and introduced species is detected at all spatial scales.

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**THE INVASION OF THE ATLANTIC AND CHANNEL COASTS OF FRANCE
BY THE ALIEN OYSTER, *CRASSOSTREA GIGAS*: ASSESSMENT, CAUSES,
ECOLOGICAL AND SOCIO-ECONOMICAL CONSEQUENCES. THE
PROGIG RESEARCH PROGRAM**

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Poster Presentation

The Pacific oyster *Crassostrea gigas* was introduced in oyster farms along the coast of France in the early seventies. On the South coasts the species spawned constituted “natural wild populations” in the eighties. Since the nineties, this phenomenon extended to the north, facilitated by the global warming in more and more sites. A multi-disciplinary program “PROGIG” (PROliferation GiGas) (2006-2008) is driven to respond to the main scientific questions asked by this phenomenon and to identify the management options to mitigate the negative consequences for the environment and the users of the littoral zone. The objectives of the “PROGIG” program are: (1) To describe dynamics of the colonization for which a monitoring program is established with a network of sites along the coasts to survey spatfall, growth, and mortality; (2) To identify the main causes of the phenomena (climatic change, phenotypic and/or genetic adaptation); (3) To define the habitats colonized, the tolerance to salinity, depth, temperature, and hydrodynamics; (4) To describe biological interactions induced by the introduction of this species in the trophic network of the local communities and the ecological impacts on the functional biodiversity; (5) To analyze the impacts of the biological activities of *C. gigas* (filtration, biocalcification and biodeposition) on the ecosystem functioning (experimental approach); (6) To analyze the interactions with the human activities (oyster farming, hand fishing, boating, seaside resort...); and (7) To propose management solutions to minimize the problems, by a risks analysis and scenarii of evolution. The first results available show that the invasion is already a strong ecological problem and which will increase in the next few years. It underlines the scientific interests to extend the raised questions in the international context.

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MOLECULAR TOOLS FOR INVASIVE SPECIES DETECTION WHEN SPECIES-LEVEL TAXONOMIC KNOWLEDGE IS SPARSE

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Oral Presentation

“Molecular Barcoding” is shorthand for standardized molecular genetics data used to identify species. Implementation of barcoding requires a library of data defining each species and its molecular tag -- the sequence data for a segment of genetic material. The mitochondrial gene “CO1” has become the standard tag. Barcoding is effective in identifying organisms whose distinguishing physical characters are difficult for non-specialists to recognize. Thus barcoding should provide relatively fast and certain identification of alien species. However, taxonomic context is required. Many invasive species such as tunicates and marine algae are poorly known even in their native ranges; some are undescribed or misidentified. Invasive fishes (e.g. suckermouth catfish and Asian gobies) are commonly reported as species complexes. Similar-appearing species may diverge in modes of feeding, reproduction, and dispersal, hence in invasiveness. Basic taxonomic work to delineate species must precede formal barcoding. If there are several closely related species that have not been resolved taxonomically, all must be sampled at their type localities, referred to type specimens, and the genetic data linked to voucher specimens, morphological descriptions, and ideally, data on the species’ life history. It is not good enough to identify an invasive “species” as a species complex. Barcoding is validated by calibrating the genetic differences that define species within a genus. Some taxa show little interspecific divergence in the CO1 gene, while others show substantial intraspecific variation. CO1 data allow standardization across taxa and rapid assay, but taxonomic understanding of invasive species may require additional analysis, e.g., sequencing a nuclear gene. Examples are drawn from several invasive taxa in order to recommend strategies for rapid, positive identification of invasives. Barcoding is a wonderful methodological tool, but must be used with respect for natural diversity. It is not intended as a substitute for serious taxonomic and biogeographic research.

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GENETIC VARIATION OF A RECENT INVASION; DIVERSITY WITHIN AND AMONG POPULATIONS OF THE CHARRU MUSSEL

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Poster Presentation

In 1986, a population of *Mytella charruana*, the Charru mussel, was discovered in Jacksonville, Florida. This mussel has an indigenous range that extends along the Pacific from Mexico to El Salvador and along the Atlantic from Trinidad to Argentina. The initial Jacksonville invasion did not likely persist as the mussels disappeared by the end of the winter in 1987, likely due to cold temperatures. In August 2004, *M. charruana* was discovered further south, in the Indian River Lagoon along the Florida intercoastal waterway, where the population has since persisted. During 2006, more northerly populations of *M. charruana* have been discovered along the Atlantic coast as far north as the northern Georgia coast. Here, we sought to better understand the nature of the founding event by comparing genetic variation among four populations of *M. charruana* from throughout their currently invaded range. We analyzed DNA variation by sequencing approximately 600 base pairs of the mitochondrial cytochrome oxidase 1 gene from 25 – 50 individuals from each population. We discovered that all populations of *M. charruana* contain high levels of genetic diversity with about 10 – 15 haplotypes per population. Moreover, the maximum uncorrected sequence divergence among any two samples is over 5%. However, using samples from the genus *Perna* as an outgroup, the *Mytella charruana* from the invaded populations form a monophyletic clade. Using these data, we plan to determine whether the invasions along the United States Atlantic coast were founded by a single event with subsequent migration, or by multiple founding events.

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**DO HISTORY AND GENETICS AGREE?
THE INVASION OF BIVALVE *GEMMA GEMMA***

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Oral Presentation

Invasive species are a serious threat to marine conservation priorities. Thus, research on factors enabling species to become invasive is critical. The role of genetic diversity in invasion success, while potentially important, is not well understood. The goal of this study was to examine the genetic diversity of an invasion at three levels: (1) between the introduced and source region, (2) under varying scales of introduction events, and (3) over the course of the invasion. Populations of the introduced clam *Gemma gemma*, in both the source (U.S. Western Atlantic) and introduced (California) regions, were analyzed using mitochondrial cytochrome oxidase subunit 1 gene (COI). *Gemma gemma* are associated with oyster reefs in their native range, and were introduced to California as a result of oyster transplantation. The approximate source region and the scale of introduction events occurring over several bays/estuaries were determined through documentation of these oyster plantings. Specimens from San Francisco Bay were collected during (1899 and 1936) and after major oyster planting occurred (1975 and 2005), allowing us to track changes in haplotypes over time. Preliminary results revealed: (1) no significant difference in haplotype diversity between contemporary source and introduced populations (Mann-Whitney U test, $p > 0.05$), (2) a slight negative correlation between haplotype diversity and the scale of introduction events, and (3) haplotype diversity increased during the period of oyster plantings (1899-1936) and declined markedly after plantings ended (1975-2005). Contemporary patterns of genetic diversity may obscure the historic picture of how diversity changes.

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BIOSECURITY RISKS POSED BY VESSEL HULL FOULING AND INCURSION RESPONSE TOOLS FOR THEIR MANAGEMENT

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Oral Presentation

Hull fouling is an important vector for the dispersal of nonindigenous marine species. This presentation overviews some of the research at the Cawthron Institute (New Zealand) that investigates risks from slow-moving barges (and their tugs) and seeks to develop management tools for them. We have sampled five international barges and three tugs over the past year. Preliminary analyses indicate that fouling levels on the general hull area are relatively low, with more advanced fouling observed in areas of poor paint condition, and in niche areas such as sea-chest gratings and propeller shafts. Factors determining the en route survivorship of fouling organisms, over a range of vessel types, have been also investigated. Preliminary analyses reveal that vessel speed is the main factor, with lower survival rates observed on faster moving vessels. The importance of hull location and voyage duration remains unclear. We have also investigated in situ techniques to clean the hulls of high risk vessels, as an alternative to dry-docking. The efficacy of two different in-water rotating brush systems developed in New Zealand is presently being trialed. Preliminary findings indicate that both systems are effective in removing fouling (>90%) from settlement plates; however in some cases intact organisms have been observed on the plates following treatment. The systems retain a large proportion of the material defouled from the plates, although 100% capture has not been achieved. A higher proportion of material is captured when the systems defoul flat surfaces compared with curved ones, and when fouling communities are less advanced. The majority of fouling lost to the environment appears to be crushed and fragmented; however viable organisms (e.g., small barnacles) are sometimes present. The efficacy of other incursion response tools, such as hull encapsulation techniques, will also be discussed.

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CRITICAL ANALYSIS OF THE IMPACTS OF INVASION TO THE NATURAL PROCESSES IN HIGHLY VULNERABLE COASTAL AREAS OF BANGLADESH

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Poster Presentation

In this paper impact of human invasion in terms of economic benefits to the highly vulnerable but resourceful low lying coastal areas of Bangladesh specifically Khulna-Jessore Drainage Rehabilitation Project (KJDRP) area would be discussed and analyzed for basic quantitative evaluation. The impacts of invasions to the natural coastal processes are innumerable. The detailed evaluation would help to see deep insight into the physical processes and analysis would help to select strategic remedial option. To evaluate the impacts of invasion, comprehensive cost-benefit analysis would be done considering parameters as detailed as possible and following basic principles of cost benefit analysis. The complicated KJDRP comprising 100600ha of area is located in Bangladesh. The area is characterized by numerous tide dominated rivers and depressions, which provide passage to natural flow and maintain ecological balance. The coastal tidal systems of the area were in a dynamic equilibrium about 30 years ago. With the increasing demand for crop, in 1960-70's a series of embankments had been built to develop low-lying lands for agricultural purpose ignoring the requirement for coastal flora-fauna and environment. It was an invasion to the prevailing natural coastal process and resulted serious problems such as drainage congestion, extinction of invaluable coastal resources, flora-fauna etc. At that time engineering community was not that aware of the environmental consequences of such invasions. To mitigate the impacts of this invasion, different strategic options are considered. Cost-benefit analysis against different alternative options is carried. Analysis shows that economic benefits (NPV) for the tidal river management option are far greater than the status quo option. That is, economic consequence of such invasion is huge and needs immediate management measures. Mathematical modeling is required to find optimum management option against prevailing situation and would be discussed in brief.

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**TOWARDS AN ICES CODE OF BEST PRACTISE
FOR THE MANAGEMENT OF SHIPS HULL FOULING**

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Oral Presentation

The International Council for the Exploration of the Seas (ICES) has for some 40 years identified and addressed various problems related to the spread of nonindigenous aquatic species. Aquaculture and shipping have been focal points as main vectors. The Working Group on Introductions and Transfers of Marine Organisms (WGITMO) has been instrumental in developing the ICES “Code of Practice” set forth to reduce the risk for accidental introductions when employing non-native species for aquaculture purposes. In 2002, a Working group on Ballast water and Other Ship Vectors (WGBOSV) that collaborates with the International Marine Organization and Intergovernmental Oceanographic Commission was formed to reflect the emerging understanding of ship’s surfaces as an important transport in itself. The WGNOSV has now been given the task to develop a “Code of Best Practice for the Management of Hull Fouling. The knowledge base and framework for this manual is outlined.

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**TESTING INVASIBILITY THEORY IN MARINE INVERTEBRATE COMMUNITIES BY
MANIPULATING THE PROPAGULE SUPPLY OF NONINDIGENOUS SPECIES**

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Oral Presentation

Biological invasions are notoriously difficult to reverse. Consequently, a great deal of experimental research has aimed to identify community attributes that confer invasion resistance. Experiments are usually conducted by manipulating invasive propagule supply. By far the majority of this work has been conducted in terrestrial plant communities (e.g. adding seeds). We have developed three novel techniques for exposing marine sessile invertebrate communities to controlled numbers of invasive bryozoan propagules. Using these techniques we have compared the invasibility of assemblages that differ in age, resource availability, physical disturbance, and pollution exposure. Results show that invasibility decreases with increasing assemblage age and increases with increasing resource availability, physical disturbance and pollution exposure.

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RESEARCH ACTIVITY ON INVASIVE SPECIES IN MARINE ENVIRONMENTS OF KOREA

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Oral Presentation

Studies focused on nonindigenous species in terrestrial and freshwater ecosystem, called exotic or introduced species, have been reported considerably in Korea. However, few studies on invasive species in marine ecosystem have been conducted by a few scientists. There are several reports of indigenous species invaded by nonindigenous species such as *Mytilus edulis* Linnaeus occupied an equivalent niche in Korean coastal water, but there is little known about mechanism of the species composition and distribution in whole coastal waters of Korea. Previous studies have mainly focused on the control and management of ships' ballast water, whereas the transfer mechanism of harmful organisms and pathogens, including exotic species and their adaptive biology, has been reported very little. The Ministry of Maritime Affairs and Fisheries (MOMAF) of Korea, which is in charge of marine environment conservation, has recently enacted the Law of Conservation and Management of Marine Ecosystem including investigation and management of invasive species on September, 2006. The law has several characteristics: 1) monitoring and management of exotic species and LMO (living genetically modified organism) in marine ecosystem, 2) research of exotic species and LMO, 3) national census of organisms in marine environment, 4) international cooperation for prevention of invasive species distribution. Therefore, The National Fisheries Research and Development Institute (NFRDI) of MOMAF is preparing the mid-, and long-term blueprint of research on marine ecosystem disturbing organisms. The NFRDI will conduct systematic studies to investigate disturbing species in 2007 and biofouling organisms on ship hulls in 2008 on the basis of the blueprint.

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**A RISK ASSESSMENT OF THE CLUBBED TUNICATE
STYELA CLAVA (ASCIDIACEA) IN NEW ZEALAND**

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Poster Presentation

The clubbed tunicate *Styela clava* (*Styela*) is a sedentary filter-feeding invertebrate native to the North Western Pacific. Hull fouling is a key transport pathway for *Styela*, and it has been introduced to various locations in the Northern Hemisphere as well as a handful of localities in Australia. *Styela* has a demonstrable invasion history, and has been especially problematic as a high-density fouler of commercial aquaculture and fishery equipment. Given the invasion potential of this organism, its discovery in New Zealand in late 2005 prompted an incursion response by Biosecurity New Zealand. As part of this response, we undertook a risk assessment of *Styela* that addressed the consequences and likelihood of the organism's effects on core values (environmental, commercial, Maori cultural and spiritual values, human health, and social). We identified ten core value subcomponents, and for each assigned a consequence and likelihood value (e.g. moderate and unlikely, respectively), or range of values, based on lines of evidence and uncertainties regarding *Styela*'s potential effects. We then characterized risk (extreme, high, moderate, etc.) based on consequence–likelihood combinations. The assessment indicated that *Styela* poses an extreme risk to New Zealand's marine aquaculture (esp. mussels); risks to other core value subcomponents tended to span across multiple categories (e.g. negligible to moderate risk to biodiversity) because of high degrees of uncertainty surrounding the organism's biology and ecology.

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**VESSEL BIOFOULING AS A VECTOR FOR INVASIVE MARINE SPECIES:
BIOSECURITY NEW ZEALAND'S RESEARCH PROGRAMME**

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Oral Presentation

Vessel biofouling has been recognized as a vector in many historical introductions of marine species into New Zealand, such as Pacific oysters (*Crassostrea gigas*), and continues to contribute to both the international and domestic spread of marine species. Biosecurity New Zealand is the lead agency charged with the protection of New Zealand's indigenous fauna and flora from invasive species. In the marine environment, shipping movements provide a vector for both international and domestic translocations of species that would otherwise be impossible. Ballast water has received the most attention with several high-profile introductions, such as the zebra mussel (*Dreissena polymorpha*) in North America's Laurentian Great Lakes, proving the catalyst for international action. However, ships have other vectors for translocations such as biofouling of sea chests, cooling and ballast plumbing, and hull surfaces. Biosecurity New Zealand has been pursuing a research program into the potential risk posed by marine biofouling, surveying four categories of vessels arriving in New Zealand ports. International yachts, fishing and passenger vessels, commercial vessels, and slow moving barges and oil platforms are all being surveyed over a two-year period to correlate ship type, geographical movement, fouling level and fouling organisms. Results from this research will help inform risk analysis that will combine known life-history characteristics, probability of (re)introduction, probability of establishment, and probability of spread to provide a hierarchical list of high risk invasive species. Such analysis will consequently allow for the development of prevention, mitigation and management measures.

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**NINE-YEARS OF *HEMIGRAPUS SANGUINEUS* IN RYE, NY:
POPULATION DYNAMICS AND INFLUENCE OF HABITAT**

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Poster Presentation

The Asian Shore Crab *Hemigrapsus sanguineus* has been a resident of the low energy, rocky intertidal community in western Long Island Sound since 1984. The population dynamics of the invader, resident crabs, and *Littorina littorea* have been followed from 1998 to 2006. During that time, resident intertidal crabs have been virtually extirpated, and *Littorina* abundance has dropped by 75%. Substrate dimensions influence *Hemigrapsus* abundance, though the effect does not appear to be spatially constant. Ontogenetic differences in habitat use by *Hemigrapsus* are also evident, with smaller crabs predominating in the upper intertidal zone.

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***MOLGULA FICUS*, AN ASCIDIAN NONINDIGENOUS TO THE EAST PACIFIC**

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Oral Presentation

The first records of the solitary ascidian *Molgula focus* (MacDonald, 1859) in southern California were two sites in San Diego Bay in October 1994. Unfortunately, it was incorrectly identified as the native *M. verrucifera*, an error only recently discovered. Since 1994 it has spread to many more sites and increased in number, extending its known distribution in the U.S. from San Diego to Port Hueneme, just south of Santa Barbara. In October 2005 during a comprehensive survey of many sites in San Francisco Bay by the Moss Landing Marine Lab, the first specimens of *Molgula focus* were collected at a single site, the Bellona Isle Marina, a small artificially enclosed marina for privately owned pleasure craft. No large commercial ships dock at this marina; specimens were most likely transported via hull fouling on private craft from southern California. The first published east Pacific record of this species was *Antofagasta*, Chile, 1997, on suspended ropes containing cultured scallops. *M. focus* is known from numerous sites in Australia (the type specimen was described from Shark Bay), and has been reported from Hong Kong, the South China Sea, and Singapore.

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**BALLAST WATER TREATMENT OF PHYTOPLANKTON: HOW DO WE
MEASURE IF A TREATMENT TECHNOLOGY MET THE MARK?**

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Poster Presentation

Ballast water discharge is a recognized pathway for the introduction of potentially harmful, nonindigenous species of phytoplankton to coastal waters. International, federal, and state standards of allowable numbers of phytoplankton in discharge water have not been finalized. However, the International Maritime Organization (IMO), State of California, and United States legislation have pending regulations based on an allowable number of “viable” organisms in a volume of ballast water. A variety of technologies are being developed that treat ballast water to meet these proposed standards, including electrolytic sodium hypochlorite generation, ozone, filtration, and UV light treatments. No standard method is accepted for assessing phytoplankton survival after ballast water treatment. We examined different enumeration methods that determine the response of phytoplankton to ballast water treatment, and evaluated whether these methods provide an endpoint to satisfy ballast water management standards. Methods include size fractionated chlorophyll _ determination, flow and solid state cytometry employing vital stains, direct counts, and a novel method we developed based on the Most Probable Number (MPN) technique. Each method has intrinsic advantages and disadvantages in relation to their applicability for regulatory enforcement and monitoring. Determining phytoplankton ‘viability’ after treatment is of particular concern, because each technique measures viability in a different way. Using these methods, viability may be defined as the ability of a cell to reproduce, an indication of enzymatic activity within a cell, or the ability of a cell’s membrane to resist a stain (i.e. maintain membrane integrity). Treatment experiments utilizing filtration, UV light, and chlorine were conducted to compare the usefulness of the assessment methods.

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PREVENTING BIOINVASIONS FROM BALLAST WATER: MARCH OF THE TREATMENT TECHNOLOGIES

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Poster Presentation

Ballast water is a major vector for the transfer of nonindigenous aquatic species from one region of the world to another. We analyzed the zooplankton composition of 246 ships that entered Puget Sound, Washington. Zooplankton were classified as a potentially high risk group consisting of known nonindigenous species (NIS) plus coastal organisms in regions other than the northeast Pacific, and a low risk group consisting of oceanic species and those of undetermined origin. Our data indicated that despite Washington state regulations requiring mid-oceanic exchange, and apparent compliance by ship operators, sampled ships had relatively high densities and/or percentages of NIS and/or non-native coastal species. Ballast water treatment technologies offer an alternative to mid-oceanic exchange. We examined the efficacies of treatment technologies from bench scale to full-scale shipboard installations. Technologies included ultraviolet light (UV), ozone, sodium hypochlorite, SeaKleen®, and a sequential filtration and UV light system. Each technology had positive and negative attributes. For example, the biocides ozone and sodium hypochlorite showed excellent efficacies against the variety of organisms present in seawater and could maintain low levels of viable organisms if a residual chemical concentration was maintained. However, many people inherently oppose biocides even though these two biocides could be neutralized before discharge. All technologies will be challenged by pending regulations and legislation that list discharge standards. The proposed International Marine Organization (IMO) discharge standards fractionate organisms into a >50 µm fraction and a 10 to 50 µm fraction. Permissible levels of viable organisms for the two fractions are 10 per cubic meter and 10 per mL, respectively. Both sets of numbers are much less than what can be achieved by mid-oceanic exchange. Therefore, the risk of bioinvasions would be much less if treatment technologies were successfully installed on ships.

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DESIGNATING AREAS FOR BALLAST WATER EXCHANGE

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Oral Presentation

It is widely accepted that ballast water carrying vessels are considered to be one of the most significant vectors contributing to the translocation marine pests. An International Convention for the Control and Management of Ships' Ballast Water and Sediments exists to ensure a globally consistent approach to the management of marine pests in ships' ballast water and sediments. Due to Australia's geographical layout and location, ships entering an Australian port from an overseas port will generally be able to comply with the exchange requirements outlined in the Convention. However, ships transiting between Australian ports are much less likely to be able to meet these requirements without significantly deviating from and delaying their original voyage, resulting in significant costs to the shipping industry. The aim of this project is to assess the risks of potential exchange areas to ensure that any threat of harm to the environment, human health, property or resources is known and such risks are minimized in determining appropriate designated ballast water exchange areas for Australia. Minimizing additional costs imposed on the shipping industry also remains a major consideration. The designation of ballast water exchange areas will consider a combination of practical issues, economic costs and biological risks. Experts specializing in colonization of marine pests were asked to assess the risks of invasion over a range of scenarios to quantify the biological aspects of risk. Estimates of risk derived from these results were then overlaid on geographic information system (GIS) data to combine the biological, practical and economic information and explore the management options available.

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FURTIVE FOES: THE ROLE OF VIRUSES IN PLANKTON DYNAMICS

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Oral Presentation

Viruses are abundant, diverse and ubiquitous in the world's oceans. They infect representatives of all major taxa of algae, causing host-specific lysis. While we are only beginning to understand the biology of algal viruses, it is apparent that viruses influence phytoplankton population dynamics, genetic diversity and ultimately the biogeochemical cycling of nutrients. As obligate parasites viruses require a host for reproduction and proliferation. However, evidence suggests that in some environments, such as marine sediments, infectious algal viruses may persist for years or even decades without reproducing. The role of these viruses in the transmission of infection is yet unknown. While the transportation, retention and persistence of algal viruses in marine systems remains to be fully explored, I will provide examples that suggest we need to examine these factors before we will understand the role of viruses in phytoplankton populations, especially within the context of biological invasions.

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PREDICTIONS IN AN INVADED WORLD - PART I: USING NICHE MODELS TO PREDICT DISTRIBUTIONS OF MARINE/ESTUARINE SPECIES AT THE HABITAT SCALE

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Oral Presentation

Niche models can be used to predict the distributions of marine/estuarine nonindigenous species (NIS) over three spatial scales. The goal at the biogeographic scale is to predict whether a species is likely to invade a geographic region. At the regional scale, the goal is to predict which specific estuaries or oceanic segments within a biogeographic province are most likely to be invaded. At the habitat scale, the goals are to predict which community types are most vulnerable and to elucidate niche requirements of invaders. As an initial step in evaluating several niche models over these spatial scales, we are comparing model performance for species with known distributions on the Pacific Coast of the United States. Here we discuss nonparametric multiplicative regression (NPMR) to predict habitat-scale distributions. NPMR incorporates interactions among variables, allows qualitative and categorical habitat variables, and in contrast to some other niche models, utilizes absence as well as presence data. This effort utilized more than 660 benthic samples in estuaries and on the continental shelf from Alaska to California from the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program. Distributions of 13 native, 10 nonindigenous and five cryptogenic benthic species were modeled using four quantitative and seven categorical habitat variables. Most species were adequately modeled with three or four habitat variables. Latitude was the most frequently included variable, being incorporated into 27 of the 28 species' models while salinity class was incorporated into 23 models. Qualitative estimates of the presence/absence of major habitat types (e.g., seagrass, marsh) were incorporated into more models than quantitative measures of depth or percent silt/clay. Results to date indicate that NPMR performs well at the habitat scale with a large sample size and habitat-scale distributions of nonindigenous and cryptogenic species are predicted as well as those of native species.

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WISH YOU WEREN'T HERE: GEOGRAPHIC PATTERNS OF INVASION IN PACIFIC COAST ESTUARIES OF THE UNITED STATES

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Poster Presentation

As part of its effort to develop the Pacific Coast Ecosystem Information System (PCEIS), the US Geological Survey and the U.S. Environmental Protection Agency are synthesizing the geographical distributions of native and nonindigenous species across the entire suite of 219 estuaries on the Pacific Coast of the United States. To date, more than 300 nonindigenous invertebrate species have been reported from the estuaries of California, Oregon, and Washington. Of the 108 estuaries where there is at least minimal biological information, at least one invader has been reported from 82 estuaries. The most invaded estuary by the number of nonindigenous species is the San Francisco Estuary, with over 200 nonindigenous invertebrates. The next most invaded estuary is Puget Sound with almost 120 nonindigenous invertebrates. Other estuaries with more than 75 reported invaders include the San Diego Estuary, San Pedro Bay, Humboldt Estuary, and the Coos Bay Estuary. This pattern reflects, at least in part, the more intensive sampling efforts in the larger estuaries, and an effort is being made to normalize the extent of invasion as the ratio of the number of nonindigenous to native species. The most widely distributed invaders are the bivalve *Mya arenaria*, the spionid polychaetes *Polydora cornuta* and *Pseudopolydora paucibranchiata*, and the amphipods *Monocorophium acherusicum* and *Grandidierella japonica*, each of which has been reported from more than 30 estuaries. The high proportion of soft-bottom invaders with wide distributions compared to hard substrate invaders may reflect the greater number of soft-bottom surveys. Some of the patterns emerging from this regional synthesis are that even the smaller, “pristine” estuaries are vulnerable to invasion and that there is a substantial pool of nonindigenous species already distributed across Pacific Coast estuaries that could potentially invade other estuaries via anthropogenic and/or natural vectors.

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**ECOLOGICAL IMPACTS OF A NEW SUBSTRATUM, INVASIVE-
OYSTER-REEFS (*CRASSOSTREA GIGAS*, THUNBERG),
ON INTERTIDAL COMMUNITIES, BRITTANY (FRANCE)**

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Oral Presentation

When introduced into France for aquaculture in the mid-sixties, the Pacific oyster, *Crassostrea gigas* (Thunberg), was first confined to oyster-farming sites. Subsequent global warming facilitated the propagation of wild populations the length of the French coastline and *C. gigas* is now considered a well established invasive species. This phenomenon of proliferation has become so important that recently oyster reefs have appeared in sheltered estuaries, on both soft and hard-substrata, such as at our study site, the Bay of Brest, Brittany. Well-known in the United States, oyster reefs of *Crassostrea virginica*, are seen as a valuable habitat that should be protected from overfishing. The situation is however extremely different in France as oyster reefs are not an indigenous habitat, but the result of the proliferation of an invasive species. This study is the first to investigate the impacts of this new substratum on the biocenosis of intertidal habitats in France. Results show that organic and silt composition in the sediment beneath oyster-reefs was not significantly different from bare sites. The oyster-reefs have a positive effect on abundance increasing this by a factor of 30 and concurrently rising the specific richness by a factor of six. Nonetheless, local intertidal community composition is modified by this new substratum as species considered indicators of anoxic conditions increase from 20% to 60% beneath oyster-reefs. Furthermore, species more specific to hard substrata like limpets or mussels are apparent. Therefore, despite a local enhancement of the biodiversity, *C. gigas* can evoke a homogenization of coastal habitats with an impoverishment of its global quality.

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COASTAL SALT MARSH CHANGE INVESTIGATION IN WANGGANG AREA, JIANGSU PROVINCE, CHINA USING LANDSAT TM IMAGERIES

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Oral Presentation

The tidal flats in the coast of Jiangsu Province, China, have a huge geometrical scale with a length of 953.9 km, a width of 3-13 km, which provide the largest continuous coastal salt marsh wetland in Asia. The sediment source of Jiangsu tidal flats was contributed to sediment supply of to the Old Huanghe River. As a result of northward shift of Old Huanghe Estuary in 1855, sediment supply decreased significantly. In recently several decades, coastal erosion appeared in some places. Wanggang area, in the northern part of Jiangsu, fortunately, due to abundant fine sediment supply of the huge radial sand ridge system outside the coast, have a rapidly deposition with a rate of 5-10 cm/a. On account of a need to protect coastline and accelerate deposition, *Spartina anglica* and *Spartina alterniflora* were artificially introduced separately to Jiangsu in 1960s and 1980s. These two kinds of plants fit well and occupy successfully. Nowadays, they have been included into the category of invading species of China because of invasion and affect to original natural wetland. This paper investigated the salt marsh change in Wanggang area, Jiangsu Province using 5 five Landsat TM/ETM images from 1992 to 2003. The results showed the rapidly expansion of *Spartina alterniflora* marsh towards the sea and recession of native *Sueada salsa* marsh and earlier artificial introduced *Spartina anglica* marsh. The results of field works studies also indicated that the primary productivity of *Spartina alterniflora* was tremendously bigger than the other two species. The biological niche of these three plants was slightly overlapped, yet it was not markedly that *Spartina alterniflora* invaded the niche of native *Sueada salsa*, which decreased mainly because of reclamation. In fact *Spartina alterniflora* was a kind of excellent pioneer species to occupy the bare mud flats to produce large areas of new salt marsh.

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**INTERVIEWS FROM PRINCE EDWARD ISLAND, CANADA,
ON BOATER HABITS AND THE POTENTIAL
SPREAD OF INVASIVE SPECIES**

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Poster Presentation

The role of several human-mediated vectors in the dispersal of two aquatic invasive species, the green crab *Carcinus maenas* and the clubbed tunicate *Styela clava*, was investigated using interviews with recreational and commercial boaters in Prince Edward Island. The two species arrived in the southern Gulf of St. Lawrence within the past decade and are likely being spread locally by several natural and human-mediated vectors. Boaters were interviewed to determine how long their boat had been at the present location, the primary use of the boat, use of anchors, sounding equipment or fishing gear, whether any organisms were attached to these items when retrieved, and the fate of those organisms. Bilge water and hull scrapings collected from the vessels were found to contain 47 taxa and 71 taxa, respectively. Boater movements were also examined to predict future sites of spread. These patterns indicate that sites in northeastern Nova Scotia and the southern coast of Prince Edward Island (PEI) are most at risk for the spread of clubbed tunicate by the boating vector, while the green crab will likely spread to sites in southeastern PEI and eastern New Brunswick.

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**EFFECTS OF CLIMATE CHANGE
ON THE RISK OF SHIPPING-MEDIATED INVASIONS
IN THE SOUTHERN GULF OF ST. LAWRENCE**

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Oral Presentation

Potential invaders to the southern Gulf of St. Lawrence, a water body which freezes for several months each year but has the warmest waters north of Virginia in summer, must overcome severe environmental challenges. Most successful invaders are native to northern Europe or northern Asia. If climate change results in warmer winter temperatures, it will likely increase the success rate of new inoculations from other sources. International vessels visit ten commercial ports in the southern Gulf of St. Lawrence. Up to 90% of the incoming vessels are carrying ballast that will be discharged at the ports. Both wild fisheries and aquaculture are major contributors to the economy of the region. More than 15% of Canada's fishing catch, by weight, comes from these highly productive waters, which represent only 1% of Canada's exclusive economic zone, by area. Even under present climate conditions, these industries are being threatened by ongoing invasions. To date, we have documented the establishment of at least 23 nonindigenous species. We used the risk assessment protocol developed by the GloBallast programme of the International Maritime Organization to investigate and compare the opportunities for species invasions under present and predicted climatic conditions at the ten ports. We conducted biological surveys in each port, analyzed the vessel traffic in 2001-2005 and identified other risk factors such as the presence of environmentally sensitive areas. The future climate conditions were predicted for the year 2050.

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**MARINE BIOINVASIONS IN TROPICAL AND
SUBTROPICAL ECOSYSTEMS OF THE SOUTHWEST ATLANTIC:
CURRENT STATUS AND MANAGEMENT PERSPECTIVES**

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Oral Presentation

The extensive Brazilian coastal zone harbors a wide variety of tropical and subtropical marine ecosystems, which have been under threat because of growing industrialization and unplanned land occupation. In recent years, the introduction of exotic species of aquatic microorganisms, plants and animals has raised a strong concern nationwide due to their impact on ecosystem services and economic activities, particularly in the maritime and energy sectors, as well as on the public health system. The aim of this study was to provide a first assessment on the occurrence and distribution of marine exotic species in Brazil, as a contribution to the local implementation of the Convention on Biological Diversity. A comprehensive bibliographic search, including sources from the grey literature, supplemented by interviews and written questionnaires delivered to the scientific community and the private sector, revealed a total of 53 marine exotic species (as for June 2006) belonging to three major population groups: detected (28), established (15), and invasive (10) species. A large number of prospective exotic species could not be assigned to any of these groups due to their cryptogenic nature. Approximately $\frac{1}{3}$ of the validated exotic species pertained to the benthic macrofauna, followed by zooplankton (11%) and macroalgal (9%) representatives. The source area for the majority of the exotic species recorded was the Indo-Pacific ($> \frac{2}{3}$ of introductions). Ballast water and incrustation on commercial vessels and oil platforms are considered the major transport vectors. Most exotic organisms have been recorded in Brazilian coastal ecosystems only in the last 15 years, probably as a combined result of the increasing maritime trade and more intensive regional research on marine bioinvasions. Among management practices presently undertaken by the country to minimize further introductions of aquatic organisms, we highlight the recent implementation of mandatory guidelines for the prevention and control of ballast water discharges.

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MODELING THE ECONOMIC IMPACTS OF THE EUROPEAN GREEN CRAB ON THE U.S. WEST COAST

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Oral Presentation

The European green crab, *Carcinus maenas*, is one of the most widely distributed invasive species in coastal systems. This species has become established on five continents and has produced significant negative ecological and economic impacts in many areas. On the Atlantic coast of North America, green crabs have been established for at least 180 years. On the Pacific coast, green crabs became established in San Francisco Bay in the late 1980s and expanded their range rapidly during the 1990s. To date, there have been no formal review of the ecological impacts of green crabs and no formal attempts to quantify and understand their potential economic impacts. This paper presents a predictive framework for understanding the magnitude and extent of green crab impacts on the West Coast of the U.S. The framework consists of several linked models. We use survival analysis to predict the relative probability of invasion of West Coast sites and ecological impact models to characterize reduction of current shellfish or fish populations. The ecological impact models rely on simple statistical “models” such as logistic regressions to describe the functional relationship between green crab abundance and the dynamics of prey populations. Where data are available, the study also describes changes in benthic communities in response to green crab predation. Finally, descriptors of change in single species populations (native or commercial) or multispecies assemblages are used as input into bioeconomic models with either market or non-market valuation information to quantify the ultimate economic impacts of green crab predation. Estimated economic impacts are largely based on, but not limited to, consequences for shellfisheries. Although we consider broader ecological impacts these impacts are considerably less well understood and rely on limited empirical studies. Valuation of broader ecological impacts is based on valuation of particular ecosystem services affected by green crabs.

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**MODELING INVASIONS BY INVERTEBRATE SPECIES WITH
PELAGIC LARVAE IN ESTUARINE AND COASTAL SYSTEMS:
AN ARGUMENT FOR SHORT GENERATIONAL DISPERSAL DISTANCE**

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Oral Presentation

Estuaries are semi-enclosed water bodies with oscillatory tidal exchange and access to open, essentially boundless coastal waters. Can we make general statements describing the dynamics of invasions in these systems by invertebrate species with pelagic larval forms? The dogma is that larval dispersal is driven by a combination of the duration of the pelagic phase and prevailing physical hydrography. Thus longer larval phases imply ability for more rapid dispersal. Such arguments marginalize the viewpoint that dispersal is a secondary trait of pelagic larvae - the free swimming, primitive larval form evolved primarily to feed in the water column and thereby maximize propagule survival to the subsequent generation. Derived larval forms are typically lecithotrophic with limited duration in the plankton – a scenario de-emphasizing dispersal. Minimum dispersal distances on the order of tens to hundreds of meters per generation will maintain species presence with such events as geological sea level rise and fall. We discuss generational dispersal distance in the context of a recent invasion of the Chesapeake Bay, Virginia, by the oriental predatory marine gastropod *Rapana venosa*. This is a large (up to 170 mm), long-lived predator that matures at 1-2 years, and produces multiple egg masses per year. Egg masses hatch to release free swimming, planktotrophic veliger larvae that typically metamorphose in 3-4 weeks. Although a consideration of larval duration suggests rapid range extension since first observation in the novel environment (1998) this has not been the case in spite of obvious adult population growth (over 13,000 adults collected). We suggest an appropriate model would be gradual increase in local propagule pressure based on adult food resources (here not limiting) to a point where the export of larvae to new environments (local range extension) is sufficient to sustain a gradual progression of an invasion front.

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NEW PHYTOPLANKTON SPECIES IN THE BAY OF FUNDY SINCE 1995

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Oral Presentation

A monitoring program was initiated in 1988 to study phytoplankton populations in the Western Isles region of the Bay of Fundy, southwest New Brunswick. Samples are collected weekly from May through October, and monthly during the remaining months for phytoplankton distribution and abundance at five locations – Brandy Cove, Lime Kiln Bay, Deadmans Harbour, the Wolves Islands and mid-Passamaquoddy Bay. The purposes of the study were to: establish baseline data on phytoplankton populations; identify harmful algal species that could potentially cause harm to the salmon aquaculture industry; provide an early warning to the aquaculture industry by sorting and identifying samples soon after collection; and determine patterns and trends in phytoplankton populations. Other purposes of the study were to determine whether there were changing trends in phytoplankton populations or there were additional or new species observed suggesting the introduction of new species. In recent years, the scale of international shipping trade has expanded creating further mechanisms for long-distance transport and in the Bay of Fundy the ports of Saint John and Bayside are experiencing increases in ship traffic and a growth in trade, as are ports in the New England region. A major vector for phytoplankton transport and spread is ships' ballast water and sediments. Since the programme was initiated a number of new species have been observed. In order to allow for determining species indigenous to the Bay of Fundy waters, we have taken a conservative approach and list species that have been observed since 1995. Those new species include the following: (dinoflagellates) *Alexandrium pseudogonyaulax*, *Amphidinium carterae*, *Amphidinium sphenoides*, *Ceratium macroceros*, *Polykrikos schwartzii*, *Preperidinium meuneri*, *Proto-peridinium crassipes*, and *Pyrocystis lunata*, and (diatoms) *Attheya septentrionalis*, *Attheya longicornis*, *Chaetoceros radicans*, *Cylindrotheca gracilis*, *Grammatophora serpentina*, *Lithodesmium undulatum*, *Neodenticula seminae*, *Odontella sinensis*, *Proboscia eumorpha*, *Pseudo-nitzschia subpacific*, *Pseudo-nitzschia fraudulenta*, *Thalassiosira punctigera*, and *Membraneis challengerii*.

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INVASIVE TUNICATE SPECIES IN THE BAY OF FUNDY, EASTERN CANADA

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Poster Presentation

A number of prominent fouling tunicates seem to be increasing in frequency in Atlantic Canada and along the New England coast of the US. Currently, Canadian shellfish industries in the Gulf of St. Lawrence and along the south shore of Nova Scotia have been impacted. In 2006 there were observations that *Didemnum* sp. is spreading through the New England region of the US, has been found on the US portion of Georges Bank and it was confirmed at a number of locations in Maine, including Eastport (L. Harris, University of New Hampshire). Although little research on tunicates has been conducted in the Bay of Fundy, researchers have been informally documenting new species. This level of effort was further supported in 2006 by a Canadian monitoring program to look for *Ciona intestinalis* (vase tunicate), *Botryllus schlosseri* (golden star tunicate), *Botrylloides violaceus* (violet tunicate), *Styela clava* (clubbed tunicate) and *Didemnum* sp. in the Bay of Fundy. Collectors were deployed at 11 monitoring stations in late May/early June; some were retrieved in July and others were left until late October/November. Prior to 2006, the golden star tunicate and the vase tunicate were documented at a number of locations in the Bay of Fundy. Preliminary results from analyses of the collectors retrieved in November indicated that *Didemnum* sp. was detected at Fairhaven, Deer Island indicating that it has recently migrated to the Canadian side of Passamaquoddy Bay. The golden star and vase tunicates were detected at a number of locations, and the European sea squirt, *Asciidiella aspersa* (tentatively identified) was observed at Charlie Cove and Head Harbour, Campbell Island.

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MULTIPLE ASSESSMENTS OF INTRODUCED SEAWEEDS IN THE NORTHWEST ATLANTIC

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Historical, floristic rapid assessment surveys and molecular studies were used to evaluate introduced seaweeds in the Northwest Atlantic. Comparisons from the late 1800s to the early 1900s were documented from Mt. Desert Island and Casco Bay, Maine and showed some early patterns of introduction. Similar studies were conducted in Southern Maine and New Hampshire from the mid 1960s to 2007 and showed some rapid expansion patterns. Rapid assessment studies were conducted during August of 2002, 2004 and 2006 from the Bay of Fundy to Long Island, New York. Molecular evaluations have confirmed several cryptic introduced taxa, including some Asiatic species of *Porphyra*. A synopsis of multiple taxa originating from Asia and Europe is given, including date of introduction, vectors and sources. A few specific case studies are also outlined, including *Neosiphonia harveyi*, *Codium fragile* ssp. *tomentosoides* and *Porphyra yezoensis*.

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**INTO THE PAN, NOT INTO THE WILD:
ADDRESSING LIVE SEAFOOD RELEASES**

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Oral Presentation

Non-native species are introduced into the environment through a variety of vectors including ballast water, the pet trade, the bait industry, and aquaculture. One vector that has not received significant attention is the live and fresh seafood industry. This study surveyed live species purchasable from supermarkets and seafood stores—primarily live fish, shellfish, and other organisms in tanks; live bivalves on ice; and live algae in Boston and New York city. The goal of this study was (1) to determine the potential risks for invasive species introductions via the live seafood trade by non-English speaking populations and (2) to develop an effective non-native species message, outreach materials, and distribution strategy for non-English speaking populations in the northeast United States. Based on the live seafood market study and risk analyses there is much that can be done, in addition to developing outreach materials geared towards the public, that would decrease the chance of future species invasions resulting from mishandling and improper disposal of organisms involved in the live seafood industry. Reaching out to the public is a long-term commitment, especially when cultural or individual behaviors are involved.

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**ADAPTATION CAPACITIES OF AN INVASIVE SPECIES,
THE PACIFIC OYSTER *CRASSOSTREA GIGAS*,
ALONG THE FRENCH MANCHE-ATLANTIC OCEAN COASTS**

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Oral Presentation

The Japanese oyster *Crassostrea gigas* is an important commercial species in France. The large dispersal of larvae during the last decade quickly led to the development of "wild" populations settled mainly on the rocky intertidal zone. Of late, *C. gigas* is considered as an invasive species in Northern Europe. The objective of the project PROGIG (proliferation of the oyster *C. gigas*) is to investigate the potential effects of the invasion of *C. gigas* along the French Manche-Atlantic Ocean coasts. The purpose of this work is to study the genetic variability and to measure some physiological indicators of health and fitness-related traits in populations sampled in three sites located on the Brittany coasts. Allelic frequencies for 6 allozyme loci were homogeneous among sites. In contrast, the genotypes significantly changed in frequency along a vertical gradient in the intertidal zone (30% versus 45%) time of emersion, variations for growth, stress response and energetic contributions were found between different sites on a macrohabitat scale. Reproductive traits and survival were different according to the location in the tidal gradient. To conclude, studies performed to date indicate that selection operates only on a microhabitat scale. Phenotypic plasticity would be the strategic mode enabling *C. gigas* to populate a broad ecological niche.

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INTRASPECIFIC HYBRIDIZATION OF NATIVE AND INTRODUCED SUBSPECIES OF *PHRAGMITES AUSTRALIS* IN NORTH AMERICA

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Oral Presentation

Interspecific hybridization has been identified as leading to the extinction of native floral and faunal gene pools and has also been proven to result in increased aggressiveness in some hybrid forms relative to their parental lineages. While hybridization between native and introduced species can dilute the native gene pool, interbreeding among subspecies is not currently recognized as a serious threat to native species. *Phragmites australis* offers the opportunity to investigate intraspecific hybridization because both native and introduced lineages occur in North America. Introduced *Phragmites* is arguably one of the most successful plant invaders in estuarine systems in North America, but native *Phragmites* populations are declining in the eastern U.S., in part because introduced *Phragmites* has replaced them. Despite range overlaps, hybridization has not been detected between the native and introduced lineages. One hypothesis holds that a phenological barrier precludes cross-pollination between native and introduced populations. However, hybridization should be possible given that native and introduced *Phragmites* strains are classified as subspecies. In a common garden experiment at the University of Rhode Island, we found substantial overlap in the timing of anthesis in paired populations of native and introduced *Phragmites*. Furthermore, in hand pollination studies, 87% of putative intraspecific hybrid crosses produced seed and 62% had rates of seed set of over 50%, a very high success rate for this species. Seeds produced from the crosses are currently being analyzed. Results of microsatellite analyses on putative hybrid seeds are presented and the implications for biological diversity and management of native and introduced *Phragmites* are discussed.

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**THE PACIFIC OYSTER *CRASSOSTREA GIGAS*:
AN INTRODUCED SPECIES FOR AQUACULTURE
IN EUROPEAN WATERS IN THE 1970s BECAME
AN INVASIVE SPECIES IN THE LATE 1990s**

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Oral Presentation

The Pacific oyster *Crassostrea gigas* has been introduced worldwide for aquaculture purposes since the beginning of the last century. In most countries, the species established natural populations to sustain aquaculture production, demonstrating its capacity to adapt to various environmental conditions. This oyster was massively introduced in France in the 1970s following the Portuguese oyster *Crassostrea angulata* mass mortalities resulting from a viral disease and the near shellfish industry collapse. Illegal introductions as early as 1966 in the Marennes Oleron Bay were suspected of being one disease vector correlated to the Portuguese oyster demise. Meanwhile, suitable environmental conditions in French rearing areas along the Atlantic coastline led to large broodstock built up. Wild beds in the mid-1970s were sufficient to sustain regular spat recruitment required to develop a large oyster production. However, several exotic species were introduced concomitantly in spite of several management practices. This emphasized the risk of introducing unwanted organisms and disease agents when transplanting shellfish stocks without a comprehensive risk-assessment approach and fully recognized procedures. Recent published studies demonstrated that *Crassostrea gigas* has taking advantage of warm summers over the last years to expand northwards into new coastal areas. Similar expansion was registered in other European countries including the United Kingdom, Germany, Netherlands and Norway. While oyster population dynamics is clearly related to recruitment success, results underlined the relationship between invasive pattern and recruitment capacity. The species competes for space with other shellfish of commercial interest including the mussel *Mytilus edulis* and the endemic flat oyster *Ostrea edulis*. Competition for space, ecological consequences, conflicts among coastal users and economic impacts are currently under investigation. Colonization of new areas by *Crassostrea gigas* has led to various social and economical consequences: economic development (new spat rearing areas for the shellfish industry), whereas others affect the ecosystem functioning (reduced carrying capacity).

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**DOCUMENTING THE GLOBAL THREAT OF
INVASIVE SPECIES TO MARINE BIODIVERSITY**

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Oral Presentation

Invasive species are widely recognized as a threat to marine biodiversity and the geographic expansion and intensification of this threat through globalization make it imperative to have a global perspective on trends, patterns and risks associated with the movement and distribution of species. To date there have only been limited examinations of the impact and distribution of biological invasions at the global scale. Here we describe a new dataset that for the first time enables worldwide assessments of overall numbers of invasive species, as well as their impact and degree of risk to biodiversity. We have developed a geographically-referenced database of non-native species in marine ecoregions. We have documented information about species' pathways and vectors, and have scored the threat of each species to native biodiversity in the following categories: Ecological Impact, Geographic Scope, Invasive Potential, and Management Difficulty. Our intent is to use the variation in threat between taxa and regions to inform strategies and funding allocations to defend vulnerable habitats from the most harmful invasive species and to better manage the most threatening pathways and transport mechanisms. We will demonstrate how information from our database can be useful to guide policy and conservation decision-making.

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**THE ERADICATION OF SNOWFLAKE CORAL
ON THE ISLAND OF KAUAI: 18 MONTHS LATER**

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Oral Presentation

Since October 2005, the Department of Land and Natural Resources has been trying to eradicate a population of the alien Snowflake Coral, *Carijoa riisei*, on the island of Kauai, Hawaii. Snowflake coral has been documented to overgrow and kill black coral in deeper waters of Maui, Hawaii, but has not been found to be widespread on Kauai. Kauai has only two documented populations and one of these is in the Port Allen commercial pier. This pier consists of 738 pilings, which originally had about 60% coverage. The eradication of this population has utilized commercial plastic to cover the pier pilings and smother the coral. Initial treatment has been 100% effective, but subsequent colonies have been found. The final few colonies have proven to be difficult to eliminate and now opens the possibility for an unknown source of colonies elsewhere in the harbor. This project has shown how difficult an established population is to eradicate even in a contained, relatively easy environment to work. This paper will cover the techniques, tools, technology and effort required to eradicate a relatively small population of Snowflake Coral.

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**TRANSFER OF HARMFUL ALGAL BLOOM SPECIES
IN JAPANESE AND KOREAN COASTAL WATERS
THROUGH NATURAL AND HUMAN ASSOCIATED
DISPERSALS REVEALED BY MICROSATELLITES**

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Oral Presentation

We developed polymorphic microsatellite markers in seven harmful algal bloom (HAB) species at present. The number of alleles per locus and the average gene diversity in each species are 2.5-7.4 and 0.52-0.81, respectively, indicating that all these species have highly diversified individuals/populations in intraspecific levels. A significant differentiation was detected among pairwise populations in all three species examined, i.e. *Alexandrium tamarense* (520 individuals in 10 populations), *Heterosigma akashiwo* (248 individuals in 6 populations) and *Cochlodinium polykrikoides* (356 individuals in 9 populations). Isolation by distance was significant in *A. tamarense* and *H. akashiwo*, strongly suggesting the genetic isolation and the restricted gene flow among regional populations has occurred along with Japanese coastal waters. Although a pairwise population of *A. tamarense* is located at a distance of 1,000 km, the result of the exact test implied that the similar genetic structure between these populations has occurred by gene flow through a human-assisted dispersal, because we have hard evidence that *A. tamarense* has been introduced through human activity. In the case of *C. polykrikoides*, population differentiation was strongest between the Sea of Japan populations (4 pop.) and inland Sea populations (5 pop.) and a principal component analysis also showed unambiguously different patterns between these populations, implying that they have different genetic backgrounds. While, the exact test clearly indicated that the Sea of Japan populations have extremely similar genetic structures among 4 populations, suggesting the transfer of *C. polykrikoides* populations by Tsushima Warm Currents from the western parts to the eastern parts along the coastal area of Japan. This may be a typical example of natural dispersal through ocean currents. Establishment of this species at the coastal area and further dispersal to another area, "Biological Invasion", may occur along the Sea of Japan in the near future.

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IDENTIFYING SIMILARITIES: AN APPLICATION FOR THE BALLAST WATER RISK ASSESSMENT

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Poster Presentation

Although several vectors have been identified as responsible by the transfer of marine organisms between geographically separated areas, ballast water discharge from ships is regarded as possibly the most important vector for movements of coastal organisms. The International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted in 2004 and guidelines are under development with the purpose to ensure its uniform application. The draft guidelines for risk assessment have significant flexibility in determining the approach method: environmental matching or species-specific, and aims to apply the regulations in a scientifically robust manner. Environmental matching assumes that the probability of establishment of a harmful species is proportional to the degree of similarity between the donor and recipient port. Although this approach receives critics, since many invasive species has very broad range tolerance (e.g. temperature), it is one, among other risk factors. The major difficulty is to identify which variables are predictive of bioinvasion. Once the parameters are defined, similarities can be calculated through a suite of methods. Several different analyses could be performed for different purposes. This paper took as its basis, a data set developed under the GloBallast Programme, which collated 34 parameters for 357 ports. In data mining it was tested multivariate data analysis divided in two categories, clustering (Ward and k-means) and ordination methods (principal component analysis or PCA and non-metric multidimensional scaling or MDS); and also a neural network algorithm, the Self-Organizing Map, which can be used at the same time both to reduce the amount of data by clustering, and for projecting the data nonlinearly onto a lower dimensional display. The results are presented and analyzed aiming to understand as far as possible this risk factor, and to contribute for a decision support system with mechanisms for assessing all available information relating to source ports.

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**MONETARY ASSESSMENT OF ECONOMIC IMPACTS DUE
TO SPECIES INVASIONS IN MARINE ECOSYSTEMS:
NON-MARKET VALUATION APPLICATIONS
IN DECISION MAKING CONTEXT**

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Oral Presentation

In a democratic system, policy makers should take into account the preferences of the taxpayers belonging to that system. Because we live in a world with scarce resources, one is asked to make the most efficient choice regarding the allocation of these resources. In this context, if policy makers decide to invest on the protection of marine ecosystems against invasive species, less financial resources would be available for other policy areas, for example national public health. On the other hand, such protection provides a wide range of benefits to humans and many are not valued by the current system of market prices. Given that most human activities are priced in one way or other, in some decision contexts, the temptation exists to downplay or ignore these benefits on the basis of non-existence of prices. The simple and simplistic idea here is that a lack of prices is identical to a lack of values. Clearly, this is a slightly biased perspective. As a matter of fact, the micro-economic theory of externalities teaches us that many values cannot be incorporated in conventional market transactions. The question is then how to translate such values into monetary dimensions. This challenging question is addressed in this manuscript. We articulate the discussion as follows. First, we present and discuss the motivations to perform an economic valuation of marine ecosystem quality, in general, and the protection of marine ecosystems against invasive species, in particular. Second, we examine two empirical applications regarding the economic value assessment of the externalities due to marine invasions: one regarding ballast water management programs in the harbour of Rotterdam, the Netherlands; the second, regarding the manila clam management practices in the Lagoon of Venice. Finally, we will provide some conclusions, illustrating the crucial role of this economic information for policy guidance.

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**ASSESSMENT OF BIOLOGICAL POLLUTION
IN AQUATIC ECOSYSTEMS: RATIONALE
AND QUANTITATIVE APPROACH**

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Oral Presentation

Often the impact of alien species (AS) may be interpreted as biological pollution or a decline in ecological quality due to changes in the biological, chemical and physical properties of invaded ecosystems. The literature on the AS impacts continues to expand world-wide, yet there is presently no conventional method to assess and compare these impacts. The aim of this study was to develop a theoretical framework and construct a biopollution assessment method to enable a comparison between different aquatic ecosystems according to the level of biopollution, resulting from the magnitude of the impacts caused by AS. We postulate that AS produce measurable effects on a local community and ecosystem only after attaining a particular level of abundance and only when occupying a sufficiently large area. Using numerous published accounts we analyzed the distribution and abundance ranges of AS and related these ranges with impacts on native community structure, habitat traits and, ecosystem functioning. In each of these three categories we distinguished five levels of impact: 0 - No, 1 – Weak, 2 – Moderate, 3 – Strong and 4 – Massive impact. Finally, we developed a scheme to determine the overall biopollution level according to the abundance/distribution ranges and the level of impacts in each of the three categories. The biopollution index we have devised may be used for assessment and comparison of invasiveness of individual alien species from the same, or different, assessment areas. This study is supported by the European Union FW6 Integrated Project 506675 ALARM “Assessing Large-scale environmental risks with tested methods”.

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MARINE INVADERS IN THE EUROPEAN STRATEGIC RESEARCH PROJECT DAISIE

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Poster Presentation

Much of the biogeographical characteristics of Europe, developed over millions of years of evolutionary separation and specialization, were lost during the last millennium because of human activities. Among the more recent impacts, intentional and unintentional introductions of alien species into European coastal waters resulted in the establishment of self-sustaining populations of species originally from North and South America, South-East Asia, the Indian Ocean and other parts of the World. The manifold changes to the local ecosystems caused by the invasion of alien marine species can be seen as a part of the “global change”. In order to understand the scope and evaluate the consequences of biological invasions the European Commission 6th Framework Programme Strategic Targeted Research Project DAISIE (contract SSPI-CT-2003-511202) (<http://www.daisie.se>) was launched. DAISIE comprises a team of partners from 15 nations and collaborators from additional 9 countries, representing Europe's leading scientists in the field of biological invasions. This paper presents the aim and structure of DAISE with special reference to marine invaders. An essential part of DAISIE is the European Alien Species Database (EASD). The data on aquatic alien species in EASD is made up of national check-lists representing all EU and non-EU European countries, as well as all peri-Mediterranean countries. Authors' rights on the information in EASD are protected via publication of national checklists in the e-journal “Aquatic Invasions”. The Structure of EASD and the vocabulary used to compile and formalize information is discussed. Other components of DAISIE, such as The European Alien Species Expertise Registry, European Invasive Alien Species Accounts and Species Distribution Maps and Spatial Analysis are considered.

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**THE INVASIVE DINOFLAGELLATE *PROROCENTRUM MINIMUM*
(PAVILLARD) SCHILLER IN THE BALTIC SEA:
ENVIRONMENTAL TOLERANCE LIMITS AND
IMPACT ON PHYTOPLANKTON COMMUNITY**

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Poster Presentation

The dinoflagellate *Prorocentrum minimum* is the most successful invasive phytoplankton species in the Baltic Sea. This species was first recorded in the North Sea in 1976 and since that it gradually penetrated into the inner parts of the Baltic. This dinoflagellate shows a wide environmental tolerance range occurring from fully marine to nearly limnic conditions. The lower limit of salinity under which this species was found is 0.7 psu. The abundance of *P. minimum* shows a very high annual variability: in some years the species caused blooms with abundance up to 350×10^6 cells/L, while during other periods it was absent in plankton samples. This dinoflagellate became a common element of summer phytoplankton in the south-western parts of the Baltic Sea (Belt Sea, Arkona Basin), while in the south-eastern waters *P. minimum* appears only in late summer and usually reaches the peak of density in September – October. With saline water inflows, this invasive species penetrates also into the Curonian Lagoon, mainly freshwater body. The present paper summarizes results of the 14 years observations of *P. minimum* abundance in relation to environmental data (water temperature, salinity, nutrients) and its role in the phytoplankton community structure. This study is supported by the European Union FW6 Integrated Project 506675 ALARM “Assessing Large-scale environmental risks with testemethods”.

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USE OF DNA BARCODES FOR DETECTION OF GELATINOUS INVADERS

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Oral Presentation

Introductions of scyphozoan species into coastal and marine ecosystems have come to the attention of the marine bioinvasion community in recent years. Although typically large and relatively robust, scyphozoan jellyfish can be difficult to identify to species using morphological taxonomic approaches. The lack of indistinguishing characters for larval (planulae and ephyrae) and benthic (scyphistomae) stages, as well as the discovery of cryptic species in the group, makes taxonomic identification even more problematical. For the scyphozoa, DNA barcodes (short sequences used for recognition of species) can provide particularly useful and frequently necessary characters for species identification. We present results from study of DNA barcoding of the scyphozoa, one component of a comprehensive barcoding effort for marine zooplankton, the Census of Marine Zooplankton (CMarZ). A portion of the mitochondrial cytochrome oxidase I (mtCOI) gene was sequenced to determine barcodes for 15 scyphozoan species. In addition, a portion of the nuclear large subunit (28S) ribosomal RNA (rRNA) gene was sequenced to provide a phylogenetic context for the species barcoded. MtCOI showed low intraspecific variability (0-0.4%) coupled with high interspecific variability (>14%), demonstrating its usefulness for accurate species recognition. Thus, unknown specimens can be accurately identified using barcodes, if and only if the species' barcode exists in the database. The more conserved 28S rRNA gene, in contrast, resolved phylogenetic relationships for a range of taxonomic levels, from species to class. DNA barcodes are useful tools for recognition and early detection of introductions or invasions of scyphozoan. Implementation of a DNA-based detection system will require a taxonomically and geographic comprehensive genetic database of species barcodes, which can be used to identify introduced species from any region of the world ocean.

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INVADING ECOSYSTEM ENGINEER DRAMATICALLY ALTERS BENTHIC COMMUNITIES IN AND OUT OF MARINE RESERVES

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Oral Presentation

Invasive species, especially those that are ecosystem engineers can affect the species composition of a community through creating and modifying habitat. The introduced oyster, *Crassostrea gigas*, a large bodied, long lived animal that attaches to hard substrata, has invaded the rocky intertidal zone of the Pacific Northwest of North America. When in high abundance, this species can cover > 70-90% of available space on the shore. We compared the species composition (richness and abundance) of the community overgrown by oysters (by directly observing the species composition on the underside of shells removed from the rock) to the community that presently uses the oyster shell as habitat for oysters found in and out of marine reserves. We found that the communities overgrown by oysters significantly differed than those found on oysters both in species composition and in the relative abundance of dominant species. We found significant declines in macroalgae and some species of barnacles (e.g., *Chthamalus*) and significant increases in limpets and other species of barnacles (*Balanus*). In addition, we found significant differences between the communities found on oysters inside and outside of matched reserve sites. Thus this invasion is having a differential impact on marine reserves, which also have higher densities of this invader.

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**MULTIPLE EPIBIONT UTILIZATION OF THE INTRODUCED
PERIWINKLE *LITTORINA LITTOREA* IN THE GULF OF MAINE**

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Poster Presentation

Multiple epibiont species utilize the shell of the introduced periwinkle snail *Littorina littorea* within the Gulf of Maine. Calcareous encrusting algae and the boring sponge *Cliona* sp., which commonly co-occur on *Littorina littorea*, have the potential to differentially impact the snail's fitness and survival through competing bioconstructive and bioerosive processes. This presents a unique opportunity to investigate the use of an abundant but non-native basibiont by multiple native epibiont species. To determine the prevalence, co-occurrence, and environmental patterns of snail shell use by the two epibionts, nineteen intertidal cobble fields from southern Maine to mid-Massachusetts were extensively surveyed. Shell usage by epibionts was found to vary with location, intertidal habitat, and shell length. General patterns of *Cliona* and calcareous algal coverage and co-occurrence on *Littorina littorea* will be presented. The ramifications of this species association, both for the epibionts and their substrate periwinkle snails, need to be examined further.

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PRIORITIES FOR MARINE BIOSECURITY RESEARCH

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Oral Presentation

In the marine environment our understanding of biosecurity risks and how to address them is growing but is still limited. There are so many gaps that we need to know what the most important research is that addresses the biggest risks. We also need to know how best to spend our limited funds. We may get sick of hearing it but setting priorities is critical. So where should we focus our effort? What is the science that will make the biggest difference? Who should decide? New Zealand has been developing a Biosecurity Science Strategy and trying to answer some of these questions. There are challenges -- how to priorities between different types of research or between research in different systems (terrestrial vs marine), how to decide what research will have the biggest long-term benefit, and how to get people to agree what the priorities are! In developing the science strategy we used five criteria - strategic value, benefit-cost, practicality, technical feasibility, and acceptability to priorities research across the biosecurity system. Not surprisingly the short answer is 'prevention is better than cure' - in particular we need research that helps us better predict and prevent risks, research to 'secure the border' including dealing with biofouling, and research to better understand the behavior of the groups we need to help address biosecurity risks. This presentation will outline the other priorities identified in the biosecurity science strategy and what this might mean in an international context.

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POLLUTION DECREASES NATIVE DIVERSITY AND INCREASES INVADER DOMINANCE

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Oral Presentation

Anthropogenic disturbance has traditionally been considered one of the dominant factors determining the establishment and dominance of introduced exotic species. Yet few experimental studies have attempted to address whether anthropogenic disturbance can facilitate the establishment and spread of invasive marine pests. A manipulative experiment was conducted to determine the effect that metal (Cu) pollution exposure had on the diversity and invasibility of developing hard substrate assemblages – with particular emphasis on the timing and duration of pollution events. The experiment was repeated at four locations in two harbours. Increasing pollution loads consistently decreased native species diversity at all study sites by between 33% and 50%. In contrast, there was no significant change in the numbers of nonindigenous species (NIS) in response to pollution exposure. Percent cover was used as a measure of competitive dominance, with increased pollution leading to increases in NIS dominance at all sites by between 6% and 29%. At three of the four study sites, this increase in NIS dominance resulted in dramatic community shifts where assemblages that had previously been dominated by natives changed to become either extensively dominated by NIS or equally covered by native and NIS alike. No single native or NIS was repeatedly responsible for the observed changes in native species diversity or NIS dominance at all sites. Rather, the observed effects of pollution were driven by a diverse range of taxa and species at each site. These findings have important implications for our understanding of how pollution mediated disturbances can help facilitate the establishment and spread of introduced exotic species within native recipient communities.

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**AQUATIC INVADERS: A NATIONAL PARTNERSHIP
TO UTILIZE FREE CHOICE LEARNING
TO REDUCE INTRODUCTION AND SPREAD
OF AQUATIC INVASIVE SPECIES**

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Poster Presentation

The “Aquatic Invaders” program is the result of a partnership comprised of national, regional, state and private agencies involved in aquatic invasive species research, outreach, and education. Funded through the National Sea Grant College Program, the comprehensive package or “tool kit” has been tested at Association of Zoo and Aquarium (AZA)-accredited institutes nationwide in 2006 and a final version will be distributed to more than 200 AZA sites in 2007. Educators at these facilities have the potential to reach millions of visitors each year; however they need interactive and entertaining programs for diverse audiences of all ages and interests. Thus, “Aquatic Invaders” engages audiences for about 20 minutes with fun interaction. By illustrating common behaviors, the program also arms them with knowledge to help them avoid contributing to the introduction and spread of invasive species. The kit contains props and background material for educators to present the short program, as well as information to develop longer programs about the invasive species problem. The national message focuses on the concept of invasive species as a threat to natural ecosystems, as well as the identification of distinct “pathways” by which the general public may unknowingly introduce these species or encourage their spread. Yet the program is flexible, thus facilitating regionally relevant messages regarding pathways or species that are of particular concern. The project has included evaluation processes throughout, including input from regional Aquatic Nuisance Species Task Force panels, demonstrations at the National Marine Educators Association and the Association of Zoo & Aquarium national meetings and beta-testing at eight accredited sites. The project evaluation is being coordinated with a large, National Science Foundation-funded project to evaluate the educational experience at Association of Zoo and Aquarium sites.

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**INVASIVE POLYCHAETES (*ANNELIDA*, *SPIONIDAE*)
IN THE ATLANTIC AND PACIFIC OCEANS**

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Oral Presentation

Lists of alien marine invertebrate species all over the world usually include polychaetous worms (*Annelida*, *Polychaeta*). Natural polychaete invasions caused by the global warming should be distinguished from intentional and non-intentional transportations mediated by means of the human activity. *Spionid polychaetes* are among the most common invaders since many of them live in estuaries and intertidal zone, produce numerous viable pelagic larvae and are associated with the commercial oyster and shrimp industry, i.e. possess all features characteristic for invasive species. Correspondingly, spionids are frequently dispersed outward from their native regions by means of the aquaculture, ballast water and hull fouling of ocean-going vessels. Examples of those non-intentional transportations in the Atlantic and Pacific Oceans are summarized. Attention is drawn to the fact that increasing interest in bioinvasions has been accompanied by decline in studies on the taxonomy of marine invertebrates, including polychaetes. Faunas of native polychaete species are poorly known for many Pacific and Atlantic countries, creating problem in recognizing alien species. Studies on larval development, molecular analyses and website databases are discussed as elements of a general strategy in such a recognizing.

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**INTERSPECIFIC COMPETITION BETWEEN
FOUR INVASIVE SPECIES IN BRUDENELL RIVER,
PRINCE EDWARD ISLAND, CANADA**

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Oral Presentation

Over the past several years the Brudenell River, in Prince Edward Island, has had four aquatic invasive species introduced. *Styela clava* (clubbed tunicate) was first identified in the late 1990's, becoming well established in the river system by 2002. Subsequently, in 2004, *Ciona intestinalis* (vase tunicate) was identified, followed by *Botrylloides violaceus* (violet tunicate) and *Botryllus schlosseri* (golden star tunicate) in 2005. With the identification of several tunicate species in the same river system within a short period of time it was important to determine the extent of interspecific competition between tunicates. Using a series of collector plates under three separate deployment and collection regimes this study determined (1) the recruitment period and magnitude of recruitment for each species (2) changes in tunicate species and abundance through the field season and (3) the effect of tunicate recruitment order on interspecific competition between species. Final results show recruitment of *C. intestinalis* starting the first week of June ($\bar{x} \pm = 34/100 \text{ cm}^2$, $n = 9$) and steadily increasing in abundance until the first week of September ($\bar{x} \pm = 9172/100 \text{ cm}^2$, $n=9$) with recruitment ending the second week of December. *S. clava* started recruiting the last week of June ($\bar{x} \pm = < 1/100 \text{ cm}^2$, $n = 9$), reaching a maximum of $96/100 \text{ cm}^2$ the first week of September with recruitment ending the second week of October. *Botryllus schlosseri* and *B. violaceus* recruitment was not observed. Throughout the field season *C. intestinalis* consistently was the dominant species and recently settled *S. clava* rarely survived to maturity on the collector plates. The order of tunicate recruitment did not have any effect on interspecific competition because the reproduction and recruitment of *C. intestinalis* far surpassed that of the other species throughout the season. The *C. intestinalis* species has proven itself to be highly resilient with extremely high recruitment levels and growth.

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**PREDICTIONS IN AN INVADED WORLD - PART II:
USING NICHE MODELS TO PREDICT DISTRIBUTIONS
OF MARINE/ESTUARINE SPECIES AT THE ESTUARY SCALE**

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Oral Presentation

To better understand the potential geographical distributions of nonindigenous species (NIS), we are evaluating the ability of niche models to predict the presence of existing native and NIS species within individual estuaries based on landscape characteristics. One model being evaluated is nonparametric multiplicative regression (NPMR), an approach that inherently incorporates interactions among environmental factors which are likely to occur over large environmental/latitudinal gradients. From the 219 estuaries in California, Oregon, and Washington, a subset of 28 estuaries were selected for model development based on the criterion that at least 100 species had been reported in the estuary in the regional database Pacific Coast Ecosystem Information System (PCEIS). The presence or absence of nine native, nine NIS, and two cryptogenic benthic species within each estuary was then determined based on available distributions in PCEIS. A set of 13 quantitative landscape characteristics for each estuary was extracted for each of the 28 estuaries or its watershed from PCEIS, and estuarine-scale models developed for the 20 species. Preliminary results indicate NPMR can reasonably predict the regional distribution of these species, though its sensitivity to incorrectly stating a species is absent from an estuary needs to be evaluated. Most species were modeled using two to three landscape variables. Similar to the habitat scale, latitude was the most frequently included variable, being selected in 11 species' models. At the estuary scale, however, mean air temperature was included as frequently, with five instances where both latitude and mean air temperature were included in the same model. An unexpected result was that the ratio of estuarine area to watershed area was included in eight models. Looking at the overall ability to predict distributions at the estuary scale, these results indicated that NPMR will predict equally well for both native and nonindigenous species.

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**THE MEDITERRANEAN SEA IS A BIOINVASION HOTSPOT:
TEMPORAL, SPATIAL AND ECOLOGICAL PATTERNS**

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Oral Presentation

The Mediterranean Sea is a hotspot of marine bioinvasions. I analyzed existing datasets for temporal, spatial and ecological patterns of fish, decapod crustaceans and molluscan invasions in the Mediterranean. Most species (65-95%) originate from tropical areas, mainly from the Indo-Pacific. The highest number of aliens occurs in the eastern basin, most probably due to its proximity to the Suez Canal, and the more favorable conditions in the Levant basin for tropical species. The recent Eastern Mediterranean climatic transient phenomenon may have contributed to an accelerated westward spread of Red Sea species. In fish, the average number of invaders per decade in the second half of the 20th century was 3.6 greater than in the first half, in crustaceans it was 1.7 greater, and in mollusks 5.2, indicating an accelerated invasion (and detection?) rate. Most species that invaded until the 1950s are already considered established. Nonetheless, the number of studies on ecological impacts of these invasions is alarmingly low. Analysis of biological characteristics revealed that the majority of fish invaders in the Mediterranean are spawning, shallow water, benthic carnivores, which make sense ecologically. With the expected increase in human population, in trade, and in global warming, and with the expected expansion of its prime invasion vector, the Suez Canal, the arrival and establishment of more invaders is certain. The future of the Mediterranean seems therefore grim and it calls for extensive research on impacts and management needs.

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**ESTABLISHED POPULATION OF THE
NORTH AMERICAN HARRIS MUD CRAB,
RHITHROPANOPEUS HARRISII, IN THE PANAMA CANAL**

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Poster Presentation

Rhithropanopeus harrisi (Gould 1841) is a small estuarine crab native to the east coast of North America with a distribution ranging from the St. Lawrence Estuary in Canada to Veracruz, Mexico. This species has invaded both the West Coast of the United States and several European countries since the late 1800s. *Rhithropanopeus harrisi* has a broad tolerance to range of salinities and temperatures which probably contributes to its success as an invader. In 1969, five specimens of *R. harrisi* were recorded from Panama but subsequent reports suggest it was not established. Now, we report the first evidence of an established, reproducing population of *R. harrisi* in the Panama Canal. The crab's entire distribution in Panama remains to be determined and potential changes in its ecology pending Panama's Canal expansion plans need to be evaluated.

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**THE EFFICACY OF BALLAST WATER EXCHANGE FOR PREVENTING THE SPREAD
OF NONINDIGENOUS SPECIES AMONG THE FRESHWATER AND
ESTUARINE PORTS OF THE UNITED STATES AND EUROPE**

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Oral Presentation

The Great Lakes and estuaries of the United States share an invasion threat from the North Sea and Baltic Sea via the ballast water operations of commercial ships. Currently, the most common method for reducing the number of viable propagules within a ballasted or non-ballasted ship's tanks is open-ocean ballast water exchange (BWE) or saltwater flushing. To test the efficacy of these treatments, we conducted controlled experiments (n=67) that measured mortality rates due to the osmotic shock experienced by organisms during BWE, simulating flow-through (F-T) and empty-refill (E-R) protocols. We focused especially on larval and adult crustaceans based on their high abundance within the ballast tanks of commercial ships from freshwater and estuarine ports. Source organisms were obtained from habitats adjacent to ports of the Baltic Sea, North Sea, Great Lakes, Chesapeake Bay, and San Francisco Bay. Animals from freshwater or oligohaline habitats (0-2 ppt) experienced the highest mortality, where greater than 90% of all individuals died in flow-through (87% of cases) and empty-refill (93% of cases) treatments. The effectiveness of both treatment types decreased against animals from low salinity (2-5 ppt, 36% F-T and 46% E-R cases) and mesohaline habitats (5-20 ppt, 44% F-T and 56% E-R cases). Overall, empty-refill treatments required less exposure time to cause significant mortality than flow-through treatments in 40% of cases across all salinity categories. Invertebrates that exhibited significant survivorship included mysid shrimps, amphipods, isopods, and decapod zoea. Wide physiological tolerances have contributed to the ability of species from these taxonomic groups to invade freshwater and estuarine habitats. Although BWE is not a complete barrier against all estuarine species, it clearly has strong effects and provides a useful management tool, particularly for low salinity organisms.

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**RISK ASSESSMENT OF AN INVADER:
RAPANA VENOSA IN THE NORTHERN ADRIATIC SEA**

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Oral Presentation

Rapana venosa (Valenciennes, 1846) is a successful alien invasive species. This predatory gastropod has been increasing its biogeographical range moving from the native East Asian seas towards Europe and America having been transported via ship ballast water and associated with aquaculture stocks of bivalves. The whelk is considered internationally a serious menace to bivalve fishery, being preferentially acclimated in estuarine/brackish water coastal regions where intensive bivalve harvesting usually takes place. The first findings of *R. venosa* in the Northern Adriatic Sea occurred in the 1970s when few specimens were collected on the shores of the town of Ravenna; since then the introduced population has been growing undisturbed, being able to colonize the whole Northern Adriatic coasts of Italy. The present paper reports the results of monitoring campaigns in the Northern Adriatic from 2001 to 2004. Different aspects of the population ecology of *R. venosa*, such as distribution, density, biometry, shell morphology, habitat requirement, reproduction, and food preferences have been investigated. Maximum population densities ($>5000 \text{ ind} \cdot 10 \text{ km}^{-2}$) were reported along the coast of Cesenatico (middle Northern Adriatic Italian shore). The large reproductive potential suggests a high propagule supply in an area subjected both to intense shipping and aquaculture activities that would increase the risk of further spreading. On the other hand, prey availability/preference results obtained by foraging experiments, predator density and bivalve harvesting methods, suggest a low risk of impact to the local bivalve fishery. Taking the above into consideration, the Italian shores of the Northern Adriatic would provide optimal ecological conditions for *Rapana venosa*, and are thus an undesirable “nursery” in the Mediterranean.

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DNA BARCODING: AN EMERGING STANDARD FOR SPECIES IDENTIFICATION BY NON-TAXONOMISTS

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Oral Presentation

DNA barcoding is a technique for assigning biological specimens to known species using a short diagnostic gene sequence from a standardized position in the genome. For most animal groups, the 648 base-pair mitochondrial “Folmer” region of the cytochrome c oxidase I gene (COI) is proving highly effective as a barcode region. Once the barcode region of a species has been delimited by using well-identified voucher specimens, the barcode sequence can be used as a proxy for morphological keys. This allows non-taxonomists to identify organisms, even juveniles, larvae, and damaged specimens that can often confound experts. Barcode data are also being used by an increasing number of taxonomists as an independent line of evidence for testing and refining species delimitations. Barcode sequences can be installed on microarrays, allowing the presence or absence of hundreds to thousands of species in a mixture to be determined. This approach could prove highly effective in testing ballast water and hull scrapings for the presence of known or suspected invasives. The Consortium for the Barcode of Life (CBOL) is an international initiative that promotes the development of DNA barcoding as a global standard for species identification. CBOL has more than 140 Member Organizations (primarily natural history museums, biodiversity research institutes, and government agencies) from more than 40 countries. This network of collaborating institutions has already launched barcoding initiatives that are building reference libraries of barcode sequences for agricultural pests, disease vectors, fish, birds, and other economically important groups. The Census of Marine Life and CBOL are working closely to develop barcodes for marine plankton and other groups. CBOL is seeking partners with interests in invasive species, with the goal of launching pilot projects to test the utility of barcoding in this critical area.

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**COORDINATING BALLAST WATER REPORTING
BETWEEN FEDERAL AND STATE PROGRAMS:
A PILOT PROJECT ON THE LOWER COLUMBIA RIVER**

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Poster Presentation

Biological invasions are a significant driver of biological change and biodiversity loss in coastal ecosystems. One of the primary vectors for transferring aquatic nonindigenous species (ANS) around the world is through ballast water aboard commercial vessels. As ship size and speed increases in response to growing global commerce, the likelihood of transporting viable ANS across oceans and between regions also increases. In response to this growing threat, ballast water management (reporting, exchange, and/or treatment) regulations have been implemented at international, federal and state levels. Within the Lower Columbia River, federal and state legislation requires that all arriving commercial vessels submit a ballast water report containing details on the vessel, voyage and ballast water practices. These data are concurrently collected by the National Ballast Information Clearinghouse (NBIC) and the State, creating a duplication of effort. We implemented a collaborative federal/state ballast water reporting project to reduce duplicative data entry and increase data quality. By working in collaboration with the already developed and standardized federal data management program, Oregon and other states can invest their resources into increasing data quality by: seeking missing forms, ground-truthing and correcting errors via follow-up interviews, and informing ship captains and agents of federal and state ballast water management requirements. Conversely, follow-up and instruction carried out at the state level may have a positive effect on federal reporting compliance and enhance overall data quality. Additionally, as data quality and efficiency increases, resources can be spent on the analysis and dissemination of results which will provide the information required for more effective ballast water management and ANS prevention.

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THE ALLOMETRY OF INVASIVE CRAB-NATIVE PREY SIZE INTERACTIONS AT DIFFERENT TEMPERATURES: A PREDICTOR OF INVASION SUCCESS?

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Oral Presentation

Size matters when crab predators attempt to subjugate armored molluscan prey. Understanding the scaling of these size relationships and their species or environmental-specificity may help predict the impact of introduced crabs on native molluscs as the invaders' ranges expand. First, does either predator or prey gain a disproportionate advantage from an increase in body size? Second, does the scaling relationship differ for different species of introduced predators with respect to a common prey? Third, will water temperature alter the scaling relationships for either predator species? An excellent system to test these questions can be found in the western north Atlantic where the European green crab *Carcinus maenas* and the Asian shore crab *Hemigrapsus sanguineus* encounter a wide-ranging native snail *Littorina obtusata*. We tested the size scaling of snail vulnerability to crushing by these two crab predators in feeding trails in each of two water temperatures characteristic of summer conditions in the southern (16 °C) and northern (10 °C) Gulf of Maine (GoM). By increasing the sizes of snails presented, we determined the maximum size snail that could be crushed by a given size crab (i.e., the critical size of vulnerability) over a range of crab sizes for each species. Our results demonstrated that the slope of the log relationship of critical snail size versus crab carapace width differed for the two invaders. As size increased, *L. obtusata* was at a greater disadvantage in confrontations with the more recent invader *H. sanguineus* than with the earlier invader *C. maenas*. In addition, while crushing performance of *H. sanguineus* was similar in both temperatures, performance of *C. maenas* declined in the colder temperature. These data suggest that the Asian shore crab will be a more effective predator on *L. obtusata* than *C. maenas* as it expands northward.

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THE INTERNET AS A DISPERSAL MECHANISM FOR LIVE MARINE SPECIES

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Poster Presentation

In recent decades, global trade has grown exponentially; handling of live organisms has improved; express-shipping services have become ubiquitous; and the Internet has evolved as a major tool for commerce. Together these changes may increase the risk of biological invasions because consumers can now purchase live marine organisms directly, receive them quickly, and handle and dispose of them with little regulatory oversight. To assess the role of the Internet in moving live marine species, we: (1) identified which industries involved in the live marine species trade used the Internet to sell species directly to consumers, and (2) surveyed the taxonomic diversity and geographic origins of species sold over the Internet in 20 retail operations each in the seafood industry and marine ornamentals business. Our results showed that marine ornamentals and seafood companies made extensive use of the Internet to sell live marine organisms directly to consumers; whereas, bait suppliers, saltmarsh plant nurseries, and marine biological suppliers did not. Marine ornamentals businesses cumulatively sold a tremendous diversity of live marine organisms over the Internet (>1400 species); typically used scientific nomenclature to identify at least some species; and imported > 85% of their product from the tropics. In contrast, seafood businesses collectively sold far fewer live or fresh species (128); rarely used scientific names; and drew organisms mainly from temperate regions. Our results suggest that Internet sales will increase the risk of biological invasions in U.S. waters. To mitigate this threat, we recommend better reporting of the taxonomic identity, condition, and geographic origin of species sold over the internet and increased educational initiatives directed at the consumer to encourage safe handling practices and awareness of marine bioinvasions.

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**ALTERNATIVES TO MITOCHONDRIAL MARKERS
FOR PHYLOGENETICS AND POPULATION
GENETICS IN *DIDEMNUM* SP.**

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Poster Presentation

Previous studies of population genetics or phylogenetics of invasive ascidians have used the mitochondrial genes cytochrome b and COI or the ribosomal gene 18S. Attempts to isolate these genes from the invasive *Didemnum* sp. have primarily amplified bacterial genes. Using DNA preparations consisting of non-feeding larvae to remove potential contamination from adult guts has not alleviated the problem of DNA contamination. Here we present a method utilizing random clones of cDNA libraries for identifying potential marker genes in *Didemnum* sp., discuss advantages and disadvantages of the method, and present preliminary results.

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DEVELOPMENT OF MOLECULAR PROBES FOR BETTER MANAGEMENT OF INVASIVE TUNICATE SPECIES

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Oral Presentation

Tunicate species are highly invasive and create costly fouling problems to the aquaculture industry in Prince Edward Island. There are currently four invasive tunicate species present in waters throughout Prince Edward Island: *Ciona intestinalis*, *Styela clava*, *Botrylloides violaceus*, and *Botryllus schlosseri*. *Ciona intestinalis* fouling is presently causing major problems to mussel aquaculture in Eastern Prince Edward Island where *Ciona* comprises up to 75% of the weight of mussel socks in some areas. Current monitoring practices for the presence of eggs and larval forms of these species in water samples involve time consuming and costly recruitment studies as well as inaccurate histological identifications. In this study, molecular probes will be developed in an attempt to facilitate the rapid analysis of samples for invasive tunicate monitoring by polymerase chain reaction (PCR). Primers will be developed for 18S rDNA sequences specific to tunicate species. Through efficient detection methods and careful monitoring, it is hoped that further invasions of these tunicate species throughout Prince Edward Island waters can be prevented or managed.

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**NEGATIVE IMPACTS OF THE INVASIVE SEA URCHIN
CENTOSTEPHANUS RODGERSII ON COMMERCIALY
FISHED ABALONE (*HALIOTIS RUBRA*)**

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Oral Presentation

Incursion of the long spined sea urchin *C. rodgersii* into Tasmanian (Australia) waters in the late 1960s and its subsequent establishment at high densities raises several questions about potential interactions between the sea urchin and another large herbivore on rocky reefs, namely the black-lipped abalone (*Haliotis rubra*) which supports the State's most valuable fishery (ca. US\$95M p.a.). Surveys show a negative relationship between densities of *C. rodgersii* and *H. rubra* at several spatial scales, suggesting negative interactions. We used manipulative experiments to examine competitive interactions between these species and the effects on behavior and growth. Our results showed that experimental removals of *H. rubra* had no detectable effects on *C. rodgersii* behavior, movement and growth and there is no evidence that fishing abalone contributed to their invasion success. In contrast, introduction of *C. rodgersii* to experimental areas containing abalone resulted in *H. rubra* dispersing from the area and seeking shelter in cryptic microhabitats that would greatly reduce the likelihood of their detection by fishers. Other experiments showed that abalone grow more slowly in the presence of the sea urchin at densities, often encountered in nature. Abalone would not move into small bare patches created by overgrazing by *C. rodgersii*, irrespective of whether the sea urchins were present or not, suggesting that lack of food, shelter and/or residual chemicals of the sea urchins deterred occupation of these patches. The overall picture from the combination of methods suggests that management options for the *H. rubra* fishery are limited to complete removal of *C. rodgersii* and regrowth of barrens areas.

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**NAVIGATING FROM PAPER TO IMPLEMENTATION:
CALIFORNIA'S PERFORMANCE STANDARDS
FOR BALLAST WATER TREATMENT**

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Oral Presentation

California's Marine Invasive Species Act of 2003 (the Act) directed the California State Lands Commission (CSLC) to recommend performance standards for the treatment of ballast water, in consultation with the State Water Resources Control Board and an advisory panel. As prescribed by the Act, the CSLC strove to consider economic achievability and technological feasibility, while also protecting beneficial uses of affected waters. However, robust information on these topics was limited, presenting a central challenge for the selection of a specific set of standards. For example, only a limited number of prototype treatment technologies had been tested on a very small range of vessel types, under limited environmental conditions. An inconsistent variety of analytical methodologies had been used to evaluate systems, making cross comparisons problematic. Also, a biological threshold at which standards might be considered protective is not known. Despite these difficulties, the CSLC provided recommendations to the California State Legislature in January of 2006. By the fall of that year the Coastal Ecosystems Protection Act of 2006 was passed, adopting the standards recommended by the CSLC. While the standards are intended to push technologies towards management options that are significantly more effective than ballast water exchange, their implementation presents formidable challenges for the CSLC. Protocols that will most appropriately evaluate the efficacy of systems must be selected. A process and/or infrastructure must be instituted to approve and track the shipboard performance of treatment systems for a large number of vessels: over 670 discharged in California during 2005. CSLC must also determine if technologies will be available meet the standards by the earliest implementation date of 2009. This presentation will provide background on the selection of standards, and will discuss the hurdles and strategies planned by the CSLC as it moves towards implementation.

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**MODELING BIOLOGICAL UNCERTAINTY
RELATED TO THE CONTROL OF SPECIES
INTRODUCTIONS VIA BALLAST WATER**

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Oral Presentation

Dense and diverse assemblages of organisms are continuously being transferred within and among ocean basins and estuaries through commercial ship ballast water operations. Reducing the quantity, quality and frequency of organism discharges by performing mid-ocean ballast water exchange or other treatment can decrease invasion risk. However, decisions regarding the management of ballast water are complicated by uncertainties related to invasion biology, performance of treatment options, and shipping industry behavior. Empirical evidence has shown that the concentration, composition and survival of organisms in ballast tanks vary significantly among vessel types and voyage routes. This variability, which directly affects the selection of suitable treatment options to reduce invasion risk, however, is not well understood. Here, the importance of biological uncertainty in the management of ballast water is evaluated through the application of a comprehensive decision-analysis framework—the Ballast Water Discharge and Decision Support Model—to 2004 international ship arrivals in two distinct port environments: the Delaware Bay Port System and the Port of Miami. The model is run in GAMS, a high-level modeling system for mathematical programming and optimization. Data on discharged ballast water volume, source locations, and uptake dates from the National Ballast Information Clearinghouse (NBIC) are incorporated into the model on an individual tank basis. A set of treatment options that represents the current ballast water efficiency-cost technology frontier is identified. Ranges of initial concentration and growth rates of ballast-water-entrained populations are extrapolated from the literature, and the use of satellite images to aid the estimation of initial concentrations is explored. Current and alternative policies are evaluated. Our results further the understanding of current limitations and costs that uncertainties impart to the management of ballast water and shed light on scientific and policy efforts needed to reduce ballast water-mediated introductions.

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**NATIVE GASTROPODS AND INTRODUCED CRABS:
SHELL MORPHOLOGY AND RESISTANCE TO PREDATION
IN THE NEW ENGLAND ROCKY INTERTIDAL ZONE**

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Oral Presentation

When invaders are generalist predators their impacts on native communities can be a major restructuring force. Less than two decades after its discovery in New Jersey, the Asian crab, *Hemigrapsus sanguineus*, rapidly expanded its range and density to include the majority of the New England coastline. This new voracious predator joins an earlier invader, the European shore crab *Carcinus maenas*, in many intertidal locations as far north as mid-Maine, and in areas further south it largely replaces the older exotic crab from its rocky intertidal habitat. What remains poorly understood is how this new invader may modify local communities, especially considering its impact on native prey, such as the rough periwinkle snail, *Littorina saxatilis*, an important intertidal herbivore. I investigated the vulnerability of these snails to shell-breaking predators by examining their morphology and crab-induced scarring history. Sampling was conducted in four regions ranging from the Rhode Island/Connecticut border to the northern Maine/Canadian border. Snails differed significantly in shell shape between several of these regions. The far northern snails had significantly thinner shells than those found further south and thus were more vulnerable to crab predation. Crab-induced shell scarring frequency also varied significantly among these regions. Scarring produces a significantly thicker shell in these snails; in laboratory investigations many crabs took longer to handle scarred individuals than unscarred conspecifics. Studies on the variable morphology of this native gastropod coupled with predation studies provide a greater understanding of the ecological and evolutionary consequences of the arrival of novel predators in an ecosystem.

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**AQUATIC INVASIVE SPECIES (AIS)
IN THE STRAIT OF GEORGIA,
BRITISH COLUMBIA, CANADA**

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Oral Presentation

Within British Columbia, the Strait of Georgia (SoG) is especially susceptible to potential aquatic invasive species (AIS). Potential AIS vectors include commercial shipping, recreational boating, and aquaculture, each of which has transported nonindigenous species to the area in the past. In order to fully characterize the AIS composition and distribution within the SoG, two large-scale monitoring programs recently have been initiated by the Canadian Department of Fisheries and Oceans (DFO), one to monitor intertidal habitats and the other to characterize subtidal AIS. Twenty-four beaches were sampled as part of the intertidal survey while two types of settlement plates (tiles and tunicate collectors) were deployed at nine locations throughout the SoG. Both surveys characterized the presence of native and non-native species and each has identified several AIS. To date, of the more than 200 species encountered in our intertidal survey we have identified one Cnidaria, seven Polychaeta, eight Mollusca, two Crustacea, two Bryozoa and three Ascideacea that are nonindigenous. Similarly, of the more than 50 species encountered during our subtidal survey we have detected one Porifera, two Algae, one Mollusca, three Bryozoa and three Ascideacea species that are nonindigenous. Observed distribution patterns seem to be related to species' life history characteristics, their environmental tolerances and known or presumed vectors of introduction and will be discussed. For example, intertidal height is important for nonindigenous bivalve species. Further, these results suggest this area's vulnerability to invasion potentially parallels other significantly AIS-modified freshwater-brackish water environments such as San Francisco Bay, and may explain the greater occurrence of AIS in the SoG relative to other parts of BC.

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**PARASITE RELEASE AND BIOTIC RESISTANCE
IN INTRODUCED POPULATIONS OF THE
SAIL-FIN MOLLY, *POECILIA LATIPINNA***

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Oral Presentation

Introduced species often escape the parasites they encounter in their native range. However, they generally encounter novel parasites in the new region. The extent to which they are released from these natural enemies and encounter biotic resistance in their introduced ranges will influence their demographic success. To examine the role of parasites and biotic resistance (parasitism and predation) in populations of the introduced sail-fin molly, *Poecilia latipinna*, I compared population size structure and parasitism in native and introduced molly populations. I also conducted field experiments to assess the interactions between a native killifish (*Fundulus parvipinnis*) and the introduced molly. Introduced mollies were larger and were infected with fewer parasites compared to native populations. Growth rates of introduced mollies were similar in the presence and absence of killifish. However, surprisingly, native killifish grew better in the presence of female sail-fin mollies, presumably because they were able to eat live-born mollies. One parasite, the trematode, *Euhaplorchis californiensis*, was common in both the native and introduced fish species. However, metacercarial intensities were two orders of magnitude greater in the native killifish. I present a hypothetical scenario for how this parasite could mediate interactions between the two fish species to benefit the invader.

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**PHYSICAL FACTORS MEDIATE EFFECTS OF GRAZING
BY A NONINDIGENOUS SNAIL SPECIES ON SALTMARSH
CORDGRASS, *SPARTINA ALTERNIFLORA*,
IN NORTHEASTERN US SALT MARSHES**

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Poster Presentation

In salt marshes of the southeastern United States, grazing by a common Littorinid snail has been demonstrated to cause substantial declines in the biomass of saltmarsh cordgrass, *Spartina alterniflora*. In the northeastern United States, a similarly ubiquitous but nonindigenous Littorinid snail may also negatively affect production of this key marsh-building plant species. We manipulated densities of the herbivorous gastropod *Littorina littorea*, at two sites to investigate the effect of its grazing on plant production and sediment accumulation. The effect of the snail manipulation differed between study sites. The site with longer inundation periods, lower elevation and poor drainage due to smaller sediment grain size had lower aboveground biomass, indicating *S. alterniflora* was physically stressed. Sediment accumulation rates were three times lower at this site which was likely due to the lower plant biomass. At this site with physically stressful conditions, plots where *L. littorea* was excluded for four months had higher end of season plant biomass as compared to all of the other treatments. Similarly, stocking snails at twice their normal density led to lower end of season biomass as compared to snail exclusion treatments. At the site where physical conditions were less stressful, snail manipulations had no effect on end of season biomass or stem density. The deleterious effect of grazing by this highly abundant nonindigenous snail species is only apparent where *S. alterniflora* has diminished production capacity due to stressful physical conditions. Accelerating anthropogenic impacts, such as sea level rise, will further stress salt marsh plants such as *S. alterniflora*, leaving them increasingly susceptible to herbivory. Together these stresses, along with eutrophication, signify trying conditions for northeastern US marshes in the near future.

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**ESTABLISHMENT OF THE COLONIAL ASCIDIAN *DIDEMNUM* SP.
ON GRAVEL HABITATS OF NORTHERN GEORGES BANK –
EFFECTS ON BENTHIC FAUNA AND A PROBABLE SOURCE
FOR FURTHER INFESTATION OF THE BANK**

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Poster Presentation

The colonial ascidian *Didemnum* sp. has since 2003 become well established on the gravel habitats of northern Georges Bank, a major fishing ground off the northeastern United States. Gravel provides a stable substrate, and seasonal water temperatures (4-17 °C) are well within the species' tolerances. *Didemnum* sp. has infested two adjacent gravel areas totaling 88 sq mi in water depths of 45 to 65 m. One area is open to fishing, and the other has been closed since 1994. The ascidian has persisted on the gravel habitats despite the periodic disturbance of some colonies by bottom fishing activities. At some sites, the tunicate covers 75 percent or more of the gravel. The species can spread through the transport of colony fragments and by sexual reproduction. Our studies of benthic assemblages on this part of the bank began in 1994 using video and photo surveys and biological dredge samples. Annual surveys from 2003 to 2006 investigated the extent of the tunicate infestation and collected samples for comparing benthic assemblages in colonized and unaffected areas.

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**DETECTION OF NONINDIGENOUS MARINE INVERTEBRATES
IN A MEDITERRANEAN INDUSTRIAL PORT USING
DNA ASSISTED IDENTIFICATION TECHNIQUES**

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Oral Presentation

The introduction of nonindigenous species (NIS) into the Mediterranean Sea has been ongoing since the 15th century. As a hub of steadily increasing commercial shipping, and encircled by major ports, it is very susceptible to the introduction of ship-borne organisms. Ballast water discharges and hull fouling are recognized as major vectors of nonindigenous species, and consequently commercial ports are often the point of inoculation. Moreover, the extent to which invertebrate NIS have invaded the Mediterranean is not entirely known. To minimize these species' invading potential and their spread into neighboring coastal areas, discovering them as early as possible in their progression is essential, but often hindered through their difficult identification and the problem posed by morphologically hard to distinguish cryptic invaders. In this study we target the industrial port of Marseille (France), one of the largest international ports in the western Mediterranean, to test the applicability of DNA assisted identification techniques (DNA barcoding and DNA taxonomy) coupled with morphological methods, to enable the detection of potential marine invaders. In the first stage, we focus on discovering locally unknown species and/or cryptic invaders. In a second stage, by extending the sampling to occurrences of these species in their home range, phylogenetic methods will be applied to reconstitute their origin and progression. These techniques will subsequently be taken further by applying them not only to invertebrate communities in ports, but also to ballast water, characterizing its biotic contents by using similar molecular techniques, greatly facilitating the identification of otherwise taxonomically hard to determine larval stages. This project is part of the European Union Marie-Curie Research Training Network HOTSPOTS, aiming at understanding and conserving Earth's biodiversity hotspots.

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PRACTICAL ASPECTS OF BALLAST WATER MANAGEMENT

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Oral Presentation

Ships' ballast water (BW) is known to be an important vector for the introduction of non-native species to aquatic environments around the globe. To minimize the risk of further introductions, the member states of the International Maritime Organization (IMO) have agreed on a new convention on ballast water and ballast water tank sediments. This convention is planned to go into force as soon as 2009. Furthermore, a number of national, regional and local regulations have been put into place already. Many of the latter regulations ask the ships to perform ballast water exchange, and some regulations allow for ballast water treatment with approved technologies. This paper gives a short overview on the current regulations and focuses on practical aspects of ballast water management onboard ships. This includes technical aspects of ballast water exchange and aspects of the ship board tests during Type Approval Testing according to Regulation G8 of the new BW convention. Furthermore, experiences are presented that were gained during 6 months of operation of a ballast water treatment system on a commercial vessel.

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**POPULATIONS OF THE INTRODUCED ALGA, *UNDARIA PINNATIFIDA*,
SUFFERING DIFFERENT ANTHROPOGENIC PRESSURES
DISPLAY DISSIMILAR GENETIC PROPERTIES**

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Oral Presentation

Populations of invaders often need to develop specific adaptations to grow and spread in their newly colonized environment. The maintenance of populations can also be favored by human activities which allow recurrent introduction of migrants and thus may prevent local adaptation. Hence, non-native species that proliferate in habitats suffering from increasing anthropogenic pressures provide an interesting model. The worldwide invasive Asian alga *Undaria pinnatifida* which colonizes a large spectrum of coastal (un-)impacted habitats in Brittany (France) is thus a well-appropriated model. We used mtDNA and nuclear microsatellite markers to gain insights into settlement and dispersal for this annual species. Populations of three habitats (729 individuals from farms, marinas, and rocky-habitats) have been surveyed over two years to avoid 'snapshot' effects and to better understand population dynamics. The following questions were addressed: do populations from different habitats share similar genetic properties (genetic diversity)? And what is the level of gene exchange between habitats? Populations from different habitats display great differences of diversity and inter-annual changes. The lowest genetic diversity was found in crops and associated with a significant inter-annual genetic variability due to cultural practices. Populations from marinas presented a greater genetic diversity associated with temporal instability but a strong heterozygote deficiency due to autogamy in one place and to Wahlund effect in the other one. A very different situation was observed in populations from rocky habitats which appear to be stable over time and spatially closed. Even if human's activities promoted the initial settlement, these populations nowadays seem to be self-sufficient. Altogether, these results associated with large self-assignment rates within each habitat suggested that this invasive alga has a potential for local adaptation. This work highlights the need for long-term surveys and studies of divergence among habitats for adaptive traits.

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**OUTREACH TO REDUCE THE LIKELIHOOD OF FUTURE INTRODUCTIONS
OF THE GREEN ALGA, *CAULERPA TAXIFOLIA*, VIA AQUARIUM RELEASES**

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Oral Presentation

Although it may never be possible to accurately quantify the number of exotic species that have or will become established in coastal waters as a result of accidental or purposeful aquarium releases, invasion biologists agree that this is an important dispersal vector for marine organisms (e.g. green macroalga *Caulerpa taxifolia* – aquarium strain, Pacific red lionfish *Pterois volitans*). “Aquarium dumping” is also an area where outreach can have a huge impact if materials are created that change human behaviors, leading to fewer releases into coastal waters. We are currently funded by NFWS/National Caulerpa Management Plan to create “Don’t release” materials designed to educate retailers and aquarium hobbyists about the problems with releasing unwanted organisms into local waterways as well as alternatives to release. To this end, we have developed an animated public service announcement as well as print and web materials. These are currently being distributed to aquarium hobby groups via MACNA (Marine Aquarium Conference for North America) national meetings, local interest groups, the internet, and mass mailings. We were also charged with creating a Caulerpa identification key for aquarium hobbyists, customs agents, and retailers. We will describe these products as well as evaluation of the effectiveness of our materials to date. We will also describe additional outreach plans to prevent future invasions of Caulerpa and other non-native species via aquarium releases.

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**PRELIMINARY INVESTIGATIONS ON THE MOLLUSCAN
BIODIVERSITY SAMPLED DURING THE BIOLOGICAL
PORT SURVEY OF MOMBASA, KENYA**

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Oral Presentation

Port of Mombasa was surveyed in August 2004 for the presence of introduced marine species and to establish baseline information on biota. Sampling was at berths with high traffic and high volumes of ballast water discharge including sites adjacent to heavily used berths, tug docks, slipways and a dry dock. Sampling was undertaken at 31 sites in and around the mouth of the Port. More than 700 different specimens of flora and fauna were sorted out and preserved in 1032 sample containers. Samples were collected using 0.5m² quadrats on wharf pylons, taking mud samples and dinoflagellates cysts, towing nets to sample plankton, taking large "grab" samples of mud to look for polychaetes (worms) and molluscs (shells). The most common taxa encountered during the survey were polychaetes, sipunculids, sponges, oyster shells, ascidians, barnacles, solitary corals, hydrozoans, crabs, algae and fishes. The molluscan families identified in the port survey were; Acroporidae, Anomiidae, Anthemiphyllidae, Arcidae, Balanidae, Cardiidae, Cassidae, Cymatiidae, Cypraeidae, Chamidae, Littorinidae, Littorinidae, Oystreida, Mysidacea. The study aimed at inventorying species in our port thus through constant monitoring be able to identify invasive species as knowledge is lacking of any introduced species and to input on draft guidelines for management practices.

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THE STRATEGIES OF AQUATIC INVASIVE ALIEN SPECIES (IAS) IN CHINA

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Oral Presentation

China has a lot of endemic aquatic species and ecosystems supporting development of aquaculture in China. About 129 aquatic invasive alien species (IAS) were introduced into China from other countries or regions by the way of aquaculture species introduction and other methods. Now some aquatic alien species have become a serious environmental issue and damage local aquatic ecosystems and impact endemic species throughout the China. A representative region is Yunnan Province, China where about 34 fish species were introduced, and now seriously threaten endemic fish. There are not concrete laws and regulations on aquatic alien invasive species in China, only principles prescribed by law. According to the “Law of Fishery, China”, Article 1: Import and export of aquatic seeding, must be approved by the Fisheries Agency, State Department or fisheries agency of the provincial government. “Law of Marine Environment Protection, China”, Article 25: Introduction of marine Fauna and Flora species, should implement a scientific assessment, and avoid damage to the marine ecosystem.

This paper describes China’s management and regulatory system, the status of China’s aquatic alien invasive species, a brief description of the species, and the impact of aquatic alien species. The key “channel” or vector of aquatic alien invasive species in China is aquaculture species introduction. Other vectors include pets for personal use or through commodity and transportation facilities. As species introductions gain more attention on economic value, neglect of the impact on ecology increases and the process is not well managed. These cause many aquatic alien invasive species to be released to natural surroundings and generate ecological and environment disaster. To address these problems, the discussion suggests some strategies, including: (1) consummate law and regulations on IAS, (2) set up institution on risk evaluations, (3) strengthen animal and plant inspection, (4) distinguish key management authority and responsibility, (5) develop international cooperation, (6) promote research input and enhance capability building, and (7) advance education and public awareness.

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**A NEW INVASION OF AN OLD INVADER: *BATILLARIA ATTRAMENTARIA*
IN SAN FRANCISCO BAY, CALIFORNIA USA**

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Oral Presentation

Few data exist describing founder populations in marine systems. New invasions can shed light on founder processes, but are frequently not detected. In July 2005, we discovered the first known population of *Batillaria attramentaria*, a mud snail native to Japan, in a small marina in San Francisco Bay, California. The invader's limited spatial extent, a low parasitism rate (2.31%) and a modal size class of 10-15 mm suggest that this invasion occurred within the last several years. This discovery offers an opportunity to investigate early invasion dynamics of a species that has been part of West Coast mudflat communities for decades. Previous population genetic analyses indicate that all other West Coast introductions of this snail have been traced to a single prefecture in Japan, while its most common parasites (two genetically distinct cryptic species of the trematode *Cercaria batillariae*), were likely introduced as a larval infection with introduced snail hosts or as eggs dispersed in migratory shorebirds. We expect genetic analyses to confirm the origin of the snail and identify which cryptic parasite species is in the San Francisco Bay population, permitting insight into possible vectors. If *Batillaria* expands its range in the Bay, it could have impacts similar to its effects elsewhere on the West Coast, including the introduction of a novel parasite, competition with the native mud snail *Cerithidea californica*, and alterations to the benthic habitat with the addition of hard shell substratum. This study also includes an eradication effort. During five days in the summer of 2006, 69,259 snails were removed by hand from an eradication area covering 539 m², which represents a majority of the colonized area. The results from this population characterization and eradication effort will further our understanding of founder populations of invasive species and advance our knowledge about eradication efforts in soft sediments.

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**POTENTIAL RISKS OF THE INTRODUCTION
OF NONINDIGEOUS *PENEAUS VANNAMEI*
FOR AQUACULTURE PRACTICES IN ERITREA**

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Poster Presentation

The Seawater Foundation along with Seaphire International began an initially successful seawater farming project in Eritrea, the “Seawater Farms Eritrea” in 1999. The project was mainly based on, among other things, the culture of *Peneaus vannamei*, a shrimp species valued for its tolerance to variations in salinity, temperature, pH and oxygen levels that render it best-suited for farming. However, the project has faced a major setback after few years of operation due to the outbreak of viral diseases that caused massive juvenile mortality. Given the speed with which shrimp diseases have spread in many different countries, including Eritrea, it seems eminently sensible for concerned authorities to be troubled by imports of nonindigenous species, with potentially negative consequences such as entry of foreign shrimp diseases and damage to mangrove and coastal ecosystems caused by irresponsible aquaculture practices. It has been widely documented that viruses imported with *P. vannamei* spread to other species such as *P. monodon* in many countries. The concern is also related to some degree to the imported species being potentially invasive. The introduction of invasive nonindigenous species is a leading cause of biodiversity change globally, particularly in aquatic ecosystems. Although, the Eritrean Fisheries Legal Notice states that “No person shall import any live fish or other aquatic organisms into Eritrea except pursuant to a license issued under these regulations”, it does not clearly stipulate the safety nets in the importation and commercial farming of fish or other aquatic organisms. In the absence of regulatory mechanisms, it is tempting for aquaculture and other industries to take advantage the situation and avoid the mitigation of externalities in the introduction of exotic species.

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**FACTORS INFLUENCING INVADER SUCCESS
IN COASTAL ECOSYSTEMS: A 20 YEAR
RETROSPECTIVE LOOK AT STUDIES
OF SOUTHERN NEW ENGLAND NON-NATIVE ASCIDIANS**

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Oral Presentation

At least five non-native ascidian species have successfully invaded southern New England during the past 30 yrs and have become permanent and often dominant members of shallow subtidal epifaunal assemblages. Studies since 1987 have found that: (a) adult non-native ascidians transplanted to sites where they are rare or absent survive and grow at rates similar to sites where they are abundant, (b) they tend to reach their highest abundances in harbors frequently impacted by human activities, (c) there is an inverse relationship between local biodiversity of the resident community and the ability of these species to invade, (d) ascidian recruitment is not strongly inhibited by any single epifaunal species, (e) ascidian recruits are commonly preyed on by several species of small gastropods and when these predators are abundant enough they can eliminate ascidian recruitment and drive ascidian invaders to near or complete local extinction, (f) juvenile ascidian life stages of solitary species are preyed on by cunners, (g) long-term warming of seawater is facilitating the abundance of non-native ascidians, while reducing the abundance of resident species, (h) non-native ascidians can react more rapidly to small-scale disturbances than resident species. Collectively, these results suggest at least four potential contributors to the invader success: (1) environmental constraints or limits which influence where populations can successfully establish themselves, (2) life-history constraints that influence larval transport and distribution, (3) how the resident epifaunal community interacts with the invaders, and (4) differences between resident and introduced ascidians in their vulnerability to predators or physical disturbances.

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MUDDYING THE WATERS: FACTORS COMPLICATING OUTREACH AND COMMUNICATION ABOUT INVASIVE SPECIES

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Oral Presentation

Traditional outreach and communication to the public about invasive species have typically been top-down, predicated on the assumption that information from scientists and other experts, once disseminated to the public, will lead to behavioral changes. Culturally sensitive and linguistically appropriate components are missing from nearly all nearly all efforts to prevent and manage invasive species in the United States. Efforts to directly – and suitably – engage important constituencies involved in the importation, use, and potential release of living organisms have largely been absent from the past two decades of intensive regional and national outreach programs. Pamphlets, brochures, and posters translated from English into other languages are exceptions that have arisen in recent years. But almost always, these are direct translations, missing a fundamental sociological element: making the content also culturally appropriate. Data from two case studies – the Chinese Mitten Crab (*Eriocheir sinensis*) in California and the Australian Redclaw Crayfish (*Cherax quadricarinatus*) in Jamaica – speak strongly to the importance of culturally appropriate content, as well as other factors, in outreach and communication efforts on invasive species. Cultural traditions, worldviews, and religious beliefs and practices, are a few of the factors that must be taken into consideration, especially if we are to prevent further marginalization of already disenfranchised communities, and promote democratic and equitable participation in the management of invasive species, as well as the prevention of future introductions.

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**GREAT BALLS OF BRYOS: NOVEL SUBSTRATE
ON THE MUD FLATS IN SAN FRANCISCO BAY**

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Oral Presentation

The Atlantic bryozoan *Schizoporella variabilis* forms free-living balls on the mudflats in South San Francisco Bay. Previously unreported from the Bay, these bryoliths exist in two morphologies, generally correlated with tidal height: (1) fluted and open in the intertidal zone and (2) dense and compact in the subtidal. The balls range from golf ball to football size and form fairly dense patches over a significant portion of the South Bay. While *S. variabilis* is known to form multiple layers over objects such as plastic debris in its native range, extensive aggregations like those in San Francisco Bay have not been reported. In the bay, bryoliths appear to form around bivalve shells, adding new layers as they are turned, presumably by currents or via bioturbation. More than two dozen species of algae and invertebrates have been found living on and in the bryoliths. These associated organisms include many non-native fouling organisms that require hard substrate and thus would not normally live on the mudflat. Several free living forms, including the Asian clam, *Venerupis philippinarum*, and the polychaete *Marphysa sanguinea*, also inhabit the bryoliths. In addition, the bryoliths appear to serve as a “nursery” for the Atlantic oyster drill *Urosalpinx cinera*; we have found numerous eggs, tiny juveniles, and shells of drilled bivalves in the interstices of the bryozoan balls.

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**STUDY IN GEOGRAPHIC DISTRIBUTION OF MICROALGAE
ALEXANDRIUM TAMARENSE AND *ALEXANDRIUM MINUTUM*
BASED ON INTERNAL TRANSCRIBED SPACER SEQUENCES ANALYSIS**

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Oral Presentation

Alexandrium tamarense and *Alexandrium minutum* are two species of *Alexandrium* genus. Both of them could produce neurotoxins responsible for paralytic shellfish poisoning (PSP). Outbreak of *A. tamarense* and *A. minutum* blooms lead to serious economic impacts on the local marine fisheries, public health and the aquatic environment. It has been found that *A. tamarense* and *A. minutum* could form algal blooms in many coastal regions and their distribution ranges are still expanding around the world. Evidences have shown that blooms of *A. tamarense* occurred only in the temperate waters of North America, Europe and Japan until 1970. But by 1990, they had been well documented throughout the Southern Hemisphere, in South Africa, Australia, India and Thailand. Some investigations have proved that *A. tamarense* and *A. minutum* are typically spread via ballast water. So, in order to understand their spreading trend, it is very important to identify the geographic origin of *A. tamarense* and *A. minutum* through a rapid and reliable method. Because of the genetic diversity of different genera and species, molecular tools are very useful for their phylogenetic studies. We believe that microalgae strains belong to the same species while an origin from different sea areas should have different phylogenetic status. So the highly variable genetic regions of rDNA could be used for identifying the geographic origin of *A. tamarense* and *A. minutum*. In this study, the Internal Transcribed Spacer (ITS) regions including 5.8s rDNA were selected as targets for polymerase chain reaction (PCR) amplification. The ITS fragments from six *A. tamarense* strains and one *A. minutum* strain that all were isolated from China sea area were sequenced successfully. With other ITS sequences of ten *A. tamarense* strains and nine *A. minutum* strains chosen from GenBank, the phylogenetic tree by Maximum Likelihood method was constructed through DNAMAN software and their geographic distribution were analyzed. In the phylogenetic tree of *A. tamarense*, all the species divided into three different geographic clades: tropical Asian, western European, and temperate Asian clades. In the phylogenetic tree of *A. minutum*, all the species divided into two different geographic clades: tropical Asian and Mediterranean sea clades. These kinds of division are totally consistent with the geographic information of *Alexandrium* strains. The results indicate that it is feasible to identify the geographic origin of *A. tamarense* and *A. minutum* through ITS sequences analysis.

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