Vectors

Preventing Aquatic Species Invasions in the Mid-Atlantic

Outcome-Based Actions in Vector Management

Aquatic Invasive Species in the Mid-Atlantic Vector Workshop Findings

Fredrika Moser and Merrill Leffler, editors

Sea Grant Maryland

Mid-Atlantic Panel AIS on Aquatic Invasive Species

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Maryland Sea Grant and the
Mid-Atlantic Panel on Aquatic Invasive Species

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Cover

These photographs suggest various pathways through which non-indigenous species make their way into mid-Atlantic waters, among them, bait usage, ballast water discharge, live seafood trade, ship fouling, and horticulture plants for ponds and aquaria.

Photograph credits, clockwise from upper left: Woman holding fish she caught (bait usage), Jonathan McKnight; ship discharging ballast water, SERC Marine Invasions Research Laboratory; zebra mussels covering a current meter in Lake Michigan, National Oceanic and Atmospheric Administration; seafood storefront and fresh oysters for sale, Pam Fuller, U.S. Geological Survey; recreational boat with ship fouling, Maryland Sea Grant; aquatic horticulture plants, Andy Lazur; and sales list for live market seafood, Pam Fuller, U.S. Geological Survey.

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INTRODUCTION

The plight of our nation's coastal waters has become commonplace in media reports about the environment — excess nutrients, low oxygen, contaminated sediments, and depleted fisheries have often dominated news stories. Only in the last twenty years, however, have we come to understand yet another impact to coastal systems, one that has often had devastating consequences: the introduction of uncontrollable non-native species. Through a network of pathways, diverse arrays of alien species have changed our watersheds: some have disrupted food webs and in many instances have caused irreparable harm. Executive Order 13112 defined alien species as those "whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112, 1999).

Some aquatic species introductions over time have had important social benefits, such as the intentional introduction of the Pacific oyster *Crassostrea gigas* and the accidental introduction of the Manila clam *Venerupis philippinarum*, both now the bases of major shellfish industries in the Pacific Northwest. However, most introductions, the vast majority of which are unintentional, result in few benefits to society. Management efforts to minimize the impacts of established non-native species are costly — rarely do they result in eradication, but frequently they require continuous population control, such as with the sea lamprey in the Great Lakes and *Phragmites* cordgrass on much of the Eastern seaboard. The most cost-effective approach, both ecologically and economically, is to prevent harmful species from being introduced into ecosystems in the first place. The principles of *vector management* provide such an approach — they hold much promise for reducing invasive species introductions and preventing the loss of biodiversity and the economic consequences that often follow (Ruiz and Carlton, 2003).

An integrated program of *prevention through vector management* aims at closing the doors as tightly as possible to harmful non-native species and offers the best prospects against preventing potential new invasions. Executive Order 13112 called for the development of management plans for "identify[ing] pathways by which invasive species are introduced and for minimizing the risk of introductions via those pathways." Towards these ends, the Mid-Atlantic Panel on Aquatic Invasive Species organized a workshop in December 2009 that brought together distinguished scientists and policy leaders from across the country to discuss the research, management, education and public engagement challenges — and opportunities — for developing an action-based vector management framework to prevent new exotic species introductions.

The workshop's aim was to identify outcome-based actions for vector management that Mid-Atlantic states, local governments, NGOs, state and federal legislatures and agencies, the Chesapeake Bay Program, and individuals could effectively pursue.
Participants first discussed two major vectors, (1) maritime shipping and (2) live trade, and the primary pathways through which non-native species make their way into Mid-Atlantic waters, defined broadly as the coastal ocean to fresh water reaches of the region:

- Maritime shipping vector — its major pathways are ballast water (BW) discharges and ship fouling.

- Live trade vector — its major pathways are live bait, aquarium species, aquaculture, live seafood, and aquatic plants.

Based on formal presentations, summaries, and discussions of current knowledge about these vectors and pathways — together with related matters on regulations, education, and public engagement — workshop participants identified significant knowledge gaps and actions required to support a vector management approach to prevent new bioinvasions.

In assessing these gaps, the workshop began by examining progress over the last decade in controlling species introductions via the pathway of ballast water discharges — perhaps the single best example of invasive species vector management. The policy successes in BW management may offer guidelines on applying preventative management principles to the complex issues of reducing bioinvasions from these more diverse pathways.

AIS WORKSHOP AGENDA

In addressing the challenge of bioinvasions from many sources, the Aquatic Invasive Species Mid-Atlantic Regional Workshop 2009 "*Vector Management: A Prevention Solution"* set an agenda (see Appendix) that first called for status reports on our knowledge of major vectors and pathways in Mid-Atlantic waters. While speakers summarized the state of ballast water regulations and technologies for meeting new in-port discharge standards in 2012 (see "Highlights of Presentations on Major Aquatic Vectors in the Mid-Atlantic"), a major focus of the presentations was on other pathways, in particular, ship fouling and pathways that have been grouped under the live trade vector: (1) live bait handling and disposal, (2) aquarium species, (3) aquaculture and live seafood, and (4) aquatic plants. Workshop participants then broke into smaller groups to identify specific gaps in research, management, and education that *at a minimum* needed to be closed if states in the Mid-Atlantic region are to take on a coordinated program of vector management for controlling new aquatic bioinvasions.

The workshop's ballast water presentations noted that twenty years ago the zebra mussel invasion of the Great Lakes exemplified how devastating BW discharges have been as a key pathway for introducing bioinvasive species. These discharges with their diverse assemblages of organisms from foreign ecosystems have led to translocations worldwide of

hundreds of species of microbes, crustaceans, shellfish, many other invertebrates, and fish. While the zebra mussel impacts on Great Lakes ecology catalyzed widespread calls for protective actions and led to federal/state regulations for reducing new bioinvasions via BW discharges, the corresponding impact of bioinvasions in European and Asian coastal waters galvanized international cooperation that led to significant agreements for reducing the impacts of BW discharges from one port into another (For further details refer to International Maritime Organization, http://globallast.imo.org/).

Workshop speakers explained that while ballast water discharge protocols now largely center on mid-ocean water exchange, a sometimes-problematic procedure for vessel stability, new onboard treatment technologies in various stages of development will make it possible to shift current regulations from ocean exchange to arrival discharge standards that are aimed at zero live organism release. Development of the international standards for ship discharges have been driven by clear demonstrations of how invasive organisms transported through the BW pathway have severely affected aquatic ecosystems — the Great Lakes, the Chesapeake Bay, the San Francisco Bay, and the Black, Baltic, and Caspian seas — both biologically and economically.

Bioinvasion Alerts in Mid-Atlantic States 2005-2009

Species	*Vector*
Oriental weatherfish*	Aquarium
Chinese mystery snail*	Aquarium
Rusty crayfish*	Bait
Chinese mitten crab*	Ballast/Food
Northern snakehead*	Food
Asian swamp eel*	Food
Asian clam*	Many
Spiny water flea*	Many
Red-bellied pacu	Bait
Rudd	Bait
Asian tiger shrimp	Food
Nile tilapia	Food
Zebra/Quagga mussel	Many

*Established (Pam Fuller, USGS).

Though gaps still exist in ballast water vector management, the continual refining of international BW discharge regulations is a major "success" story in that it demonstrates how scientific understanding of a pathway and its ecosystem threats can provide the rationale and foundation for political will to take effective actions, nationally *and* globally. However, major bio-invasions pathways — that result in the unregulated release of exotic aqua-culture species (molluscs, fish, plants), and aquarium fish and plants into the environment, as well as the improper disposal of non-native live bait and the uncontrolled release of organisms from biofouled vessels — are more fragmented than BW pathways. Prevention of bioinvasions via these pathways is a complex problem that will require a coordinated network of science-based regulation, government inspection and enforcement, and an array of public outreach and education tools. In other words, minimizing introductions of unwanted species from these pathways presents problems equal to, if not more challenging, than current efforts for reducing the hazards from BW discharges.

BIOINVASIONS: MANAGING BY PREVENTION

James Carlton's keynote address on "Vector Science and Policy" highlighted the fundamental goal of vector management: to reduce the transmission, release, and continued dispersal of non-native organisms that pose potential threats to aquatic ecosystems (Figure 1).

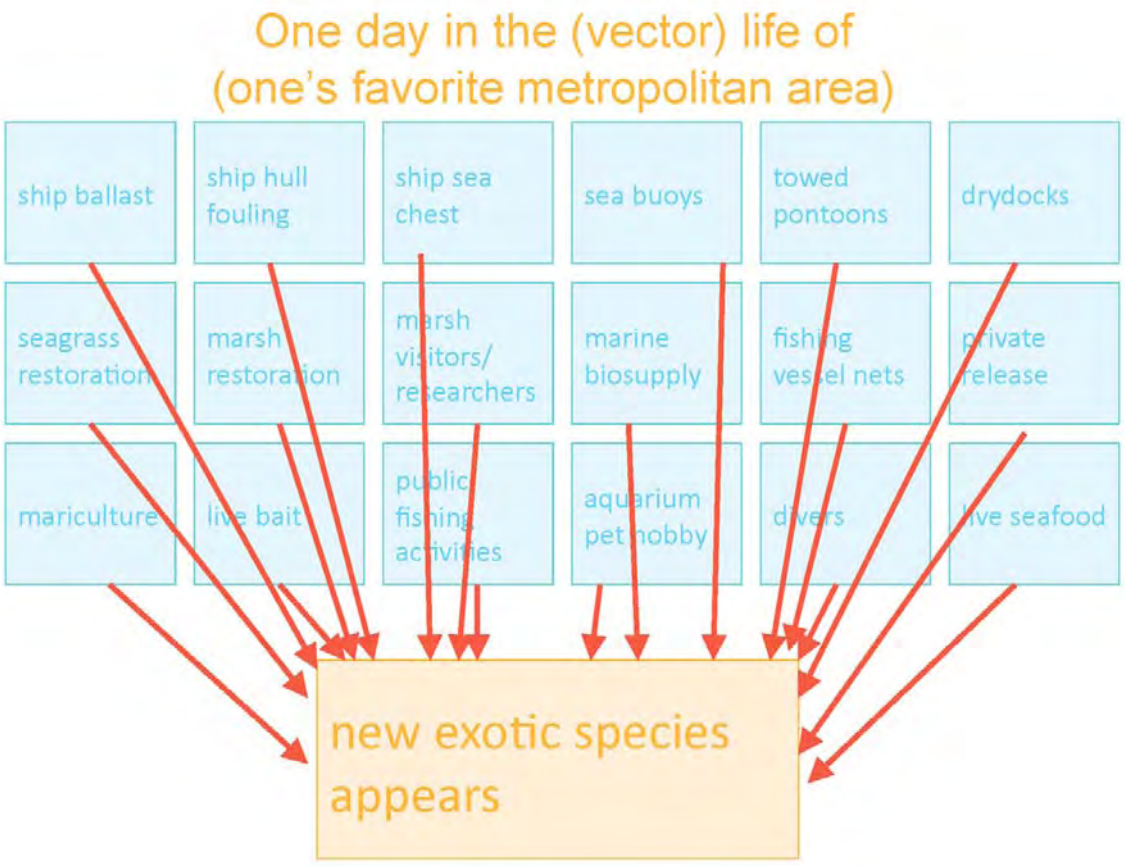

Figure 1. Potential pathways of new exotic species.

That goal is complicated by a number of factors, including:

1. Lack of *scientific predictability* on when and under what conditions non-native organisms are a threat.

2. Lack of a *rigorous system of regulatory controls and enforcement*, nationally and regionally, on the importation of non-native species.

3. Lack of *awareness by citizens* that they may be inadvertently contributing to the spread of invasive organisms.

Because of scientific uncertainties in predicting impacts from problematic non-native species, a precautionary approach may be the most protective measure for preventing their importation or release: when plausible ecosystem risks exist, the burden of proof that a species presents no danger is with the importer or releaser.
Managing by prevention must account for all active vectors that bring non-native organisms into coastal waters with an understanding of *why* a species is transported in the first place, whether accidentally or deliberately; its *geographic path* — where it is coming from and where it is headed; the *way* it is traveling (e.g., canals, roads); and *how* it is transported (e.g., ship). As Carlton emphasized, an integrated prevention program will require regular monitoring, coordination among different agencies, and the ability to interrupt the delivery at various stages, whether by containing non-native species at their source, reducing their transport survival en route, or not allowing their release at the destination.

HIGHLIGHTS OF PRESENTATIONS ON MAJOR AQUATIC VECTORS IN THE MID-ATLANTIC

Developing a vector management framework for actions to prevent new aquatic bioinvasions began with presentations summarizing our current knowledge of bioinvasion pathways, in order to identify gaps in that knowledge. Presentations centered on the pathways of two major vectors: (1) maritime shipping (ballast water discharges and ship fouling pathways) and (2) live trade (bait handling and disposal), aquarium species, aquaculture and live seafood, and aquatic plants.

In addition to the scientific uncertainties that Jim Carlton highlighted in his keynote address, other uncertainties included public outreach and education. While current outreach and education efforts have had some success, a more comprehensive approach is necessary for informing the wide-ranging and quite diverse publics — e.g., boat owners, importers, distributors, retailers, buyers — on how their behavior with regard to non-native organisms can adversely affect the health of aquatic ecosystems that they themselves care for and depend on.

Workshop presentations and discussions relating to education and public outreach noted that while traditional outreach avenues often rely on print media (e.g., brochures, posters, public service announcements, newspapers), broadcast alerts, state regulations (and consequent fines), and more recently the internet, their effectiveness in actually influencing overall behavior has been limited and often not measured in any substantive way. This is in part because few metrics exist to measure outreach effectiveness. Participants agreed that education and outreach must aim at more than “awareness” but at changing behaviors with regard to non-native species and developing sound ways to quantitatively evaluate whether behavior, actions, conduct, and performance have changed.

Maritime Shipping Vector

Ballast Water Discharge Pathway. Discussions of the ballast water pathway highlighted critical lessons about the importance of research. For instance, the Smithsonian Environmental Research Center's (SERC) ballast water studies, and many others, have shown that the density and variety of exotic species in discharges differ based upon ports of origin. The take-home point is that strong research is an essential component for understanding the nuances of a pathway and for developing effective regulations. This is to say that adaptive management is critical. The following are highlights from the BW presentations.

♦ **The Number of Ship Arrivals to U.S. Ports Is *Not* a Good Proxy for Non-native Species "Pressure."** Vessels that do not discharge water are not a threat and those that undergo proper open-ocean exchange pose a reduced threat. However, the shipping route greatly affects the opportunity and ability to carry out proper exchange (i.e., ≥ 200 nautical miles from any land mass). Vessels traveling Pan-American routes (cross-latitude) deliver higher volumes of un-managed or mis-managed ballast water than do transoceanic arrivals (cross-longitude) to the U.S., because of geographic and temporal limitations of the former. Furthermore, un-managed and mis-managed discharge volumes from Pan-American arrivals are by far the greatest on the Gulf of Mexico coast as compared to the East and West coasts of the U.S. These findings are based on ballast water discharge data from 108,354 vessels at East Coast, West Coast, and Gulf ports, submitted to the National Ballast Information Center from Jan 2005 to Dec 31, 2007. — *Whitman Miller*

♦ **Discharge Regulations to Shift from Mid-Ocean Exchange to Ballast Water Disinfection.** The U.S. Coast Guard's proposed ballast water discharge standard regulation would shift the focus of ballast water management from mid-ocean exchange to treatment for reducing the concentration of living organisms. The Coast Guard proposed a two-phased approach. Under Phase 1, beginning in 2012, vessels would be required to meet the ballast water discharge standard. The timeline for meeting the discharge standard would depend both on when a vessel was constructed and its ballast water capacity. This proposed phase 1 standard is the same as that adopted by the International Maritime Organization (IMO; http://www.uscg.mil/hq/cg5 /cg522/cg5224/bwm.asp). Under Phase 2, beginning in 2016 and depending on the outcome of a practicability review, the stringency of the discharge standard would be increased by up to 1000X. The IMO regulations adopted in 2004, and subsequent more stringent standards promulgated by several U.S. states, have significantly spurred research on methods and technologies for evaluating the efficacy of ballast water treatment systems, both for purposes of approval of treatment systems as well as for compliance assessment on board vessels (IMO, 2004). — *Rich Everett*

♦ **Testing and Treatment Technologies.** The testing and evaluation of ballast water treatment systems to prevent the spread of invasive species is challenging and complex but reasonable methods to validate the ability of treatments to meet IMO D2, and proposed USCG Phase 1, discharge standards now exist. However, no current methods or

approaches can verify, with any level of confidence, that treatment systems meet more stringent discharge standards, such as those put forward by several states and proposed as Phase 2 by the USCG. There are now four formal ballast water treatment test facilities around the world, with others in development. Two of the test facilities are located in the U.S.: the Maritime Environmental Resource Center (on the Chesapeake Bay) and the Great Ships Initiative (on Lake Superior). Currently, eight unique treatment systems have been certified as meeting IMO D2 standards by different Administrations (Germany, Korea, Liberia, Malta, Marshall Islands, Norway, Panama, and United Kingdom) and they appear to have the potential to meet USCG Phase I regulations. Treatment approaches include chlorination, deoxygenation, filtration + UV, and ozone. — *Mario Tamburri*

♦ **Federal Regulations of Ballast Water Discharges**. The U.S. Coast Guard and the U.S. EPA have federal oversight of BW management, although states retain authority to "adopt or enforce control measures over aquatic nuisance species." Since December 2009, EPA has been issuing Vessel General Permits under the Clean Water Act; regulations, which covered such discharges as engine effluent and paint coatings, also now require mandatory ballast water exchange and salt-water flushing for ships from outside the EEZ and those in Pacific nearshore voyages (http://cfpub.epa.gov/npdes/home.cfm?program_id=350). EPA does not yet require numeric living organism standards because treatment technologies were not available and economically achievable under the best available technology (BAT) standard. — *Rich Everett*

♦ **Stakeholder Participation in Ballast Water Management and Hull Fouling**: **The Case of California.** In developing protocols for BW and hull fouling management, California used a technical Advisory Group, which includes representatives from all groups that might be affected by regulations: the maritime industry, ports, state agencies, environmental organizations, and research institutions. The Advisory Group ensures rulemaking decisions consider the best available science and concerns of affected stakeholders; it has been critical in designing and funding a successful inception of a regulatory program. The program is funded through fees assessed on the industry on a per voyage basis, which avoids statewide funding issues and improves strong collaboration with industry. Regulations include compulsory ballast water exchange by all ships, reporting requirements, recordkeeping, fouling removal, and hull husbandry reporting. Data management deals with some 10,000 ballast water-reporting forms annually. Vessels that operate within the Pacific Coastal region must exchange ballast water beyond 50 nautical miles. — *Maurya Falkner*

Ship Fouling Pathway. The accumulation of microorganisms, plants, algae, and animals on hulls and especially in niche areas such as sea chests, rudders, bow thrusters, and stern tubes, is often overlooked as a significant pathway for translocating non-native species. Research efforts have been limited on understanding this pathway.

♦ **Ship Biofouling Research**. Some baseline information is available on (1) fouling across vessel types, (2) effects of voyage characteristics on accumulation of fouling organisms, and (3) husbandry practices regarding niche areas, though much work is still

needed. A recent study found that 45% of species introductions are unambiguously linked to ship fouling (Hewitt, C. L. and M. L. Campbell, 2009). Data compiled from 20 studies revealed that nearly a 1000 different species have been recorded within ship fouling communities worldwide; Arthropoda were the highest in numbers, followed by Annelida and Mollusca. — *Ian Davidson*

♦ **Ship Biofouling Regulations.** Currently, few regulations are in place to inhibit bioinvasions through ship fouling although indirect (inadvertent) management actions regarding anti-fouling paint use help prevent biofouling accumulation. In 2007 IMO took up the issue as a work item and in 2008 an international conference focused on ship fouling. Some states have prohibited vessels from conducting underwater hull husbandry, e.g., Maine and Massachusetts. California has language in its law that requires management of hulls. In addition, California regulations include some limited "best management practices" language regarding ship fouling. While there is a Congressional Resolution on hull fouling — U.S. H.R. 3618 Clean Hull Act of 2009 — it is focused on anti-fouling systems in light of the phase out of tributyltin-based anti-fouling paints. Although, this resolution lacks language specific to aquatic invasive species, anti-fouling systems are likely to have implications for AIS transfer. — *Robin Danesi*

♦ **Recreational Boats and Biofouling**. Non-commercial vessels in the Mid-Atlantic may be an important vector for bioinvasive species, though hull fouling among such boats is highly variable and depends on many factors, for example, the number of ocean-going vessels and the frequency and timing of bottom cleaning. Smaller recreational vessels pose additional risks particularly in areas where boats transported by trailers across watersheds can also move invasive species with them. U.S. studies of recreational and fishing vessel biofouling are limited and provide minimal information regarding the effectiveness of cleaning techniques and education and public outreach campaigns (Rothlisberger et al., 2010; Horvath, 2008).

Live Trade Vector

Unregulated or, at best, poorly regulated species imports, sales, and distribution of non-native species have been major factors in coastal bioinvasions of Mid-Atlantic waters. The case of MSX disease (caused by the protist *Haplosporidium nelsoni*) in oysters in the Chesapeake Bay and other East Coast waters — brought in by experiments with the non-native *Crassostrea gigas* in the 1950s — may be among the most notorious and devastating. The National Invasive Species Council (NISC) 2008-2012 National Invasive Species Management Plan (http://www.invasivespecies.gov/) called for developing screening processes that evaluate species moved intentionally in trade. Work on these screening efforts is on-going by the federal agencies of the NISC. Peter Jenkins pointed out that only three countries have pre-import screening systems: Australia, New Zealand, and Israel — why not the United States?

Controlling the diverse pathways in the live trade vector is complicated by numbers of different factors — for example, some species may be intentionally released, some unintentionally, while others such as the Chinese mitten crab may be illegally imported

(see "Education and Public Engagement"). Although limited studies in different parts of the U.S. have provided some insights into the volume and diversity of live trade, very few studies have tried to quantify the relative importance of different live trade vectors. Among the primary pathways are (a) indiscriminate dumping of live bait, containers and packing material; (b) release of live organisms from home aquariums; (c) escape of live seafood products; and (d) escape of non-indigenous plants from backyard ornamental ponds or their deliberate use in habitat restoration. The following summary, based on talks by presenters (primarily Edwin Grosholz, Robert Wiltshire, and Pam Fuller) and follow-up discussions, highlights our current understanding of live trade vectors in the Mid-Atlantic.

Live Bait Pathways. Non-native species bait fish and many species of invertebrates are sold live as bait, thus becoming potentially strong vectors in themselves and in the associated organisms that tag along. A study by Cohen et al. (2001) found that bait boxes of marine worms from the State of Maine contained up to 24 other species. Similarly, Yarish et al. (2009) reported on live bait worms packaged with seaweed sold in Long Island Sound — they identified "14 species of macroalgae, two species of harmful microalgae and 23 different categories of invertebrates," thus confirming that "bait worm packaging can be a vector for non-native species." In another example, in a two-year period, 66,000 *Namalycastis abiuma* — seven-foot "nuclear worms" — were imported from Vietnam; in Maryland, the Department of Natural Resources listed the species as a potential invasive (J. McKnight, pers. comm., 2009). Currently there are only limited federal requirements for screening new species imports, and inspections and enforcement of current regulations are spotty (www.aphis.usda.gov/import_export/animals/animal_import/marine_import_fish.shtml).

Aquaria Pathways: Import, Wholesale, Retail, and Home. Only a few studies have assessed impacts of live organism vectors — for example, a survey of importers and distributors in a coastal Massachusetts region by Weigle et al. (2005) found that nearly all responding distributors (i.e., pet stores, seafood markets) tend to discharge *untreated* holding waters — these discharges may harbor a host of exotic organisms that "hitchhike" on fish and shellfish — into local waters. Chang et al. (2009) investigated the number of fish species for sale in the San Francisco Bay area and Sacramento aquarium stores by surveying fish taxa and approximate sales volume in both large (big box) and small aquarium/pet stores: of more than 850 species sold by stores, 27 had the potential to survive if released — of these, six are already established in the Bay-Delta.

Aquaculture and Live Seafood Pathways. Expanding markets for live seafood — non-native fish, shellfish species, and crustaceans — have increased the possibilities of bioinvasions not only of imported species but their associated fauna in water and materials used for holding and cleaning the seafood. For example, the movement of abalone stocks from South Africa to California into mariculture plants introduced, through open outflow pipes into the adjacent rocky intertidal zone, a parasitic polychaete *Terebrasabella heterouncinata* that shut down production and impacted facilities for several years, costing millions of dollars. Chapman et al. (2003) found 24 species of live non-indigenous bivalves for sale in Northwest grocery stores — 11 of the 24 species have established themselves (some through vectors other than the live

seafood trade) and other species could well become established or introduce new microorganisms. Even with fresh or even frozen seafood, a danger exists for pathogen, or disease, introductions, e.g., virus in frozen herring.

Aquatic Plant Pathways. While aquatic horticulture is the fastest growing segment of the plant industry — with an estimated 16 million backyard ponds alone — regulations designed to protect waterways are limited. There are many examples of intentional translocations of non-native plants that have become aggressively invasive and costly to contain, among them, hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhornia crassipes*), Brazilian elodea (*Egeria densa)*, and Eurasian watermilfoil (*Myriophyllum spicatum).* The U.S. is the leading consumer of aquatic horticulture plants, with its largest sources from Indonesia, Philippines, and the South Pacific.

The status reports on the maritime and live trade pathways of non-native species introductions set the groundwork for workshop participants to discuss outcome-based actions essential for developing a framework of vector management policy.

FRAMEWORK FOR VECTOR MANAGEMENT OF AQUATIC INVASIVE SPECIES

A management plan for preventing new aquatic bioinvasions must begin with knowledge about vectors and the non-native species coming into the Mid-Atlantic region, scientific assessments about their potential to establish wild populations and their potential to have ecological, economic, or other impacts, and priority actions to prevent the release of those species identified as potentially dangerous. While regulations resulting from the negative assessment of an individual non-native species' invasive risk may be costly, time-consuming, and disruptive to business, over the long term, ecological and economic costs are likely to be much higher than if the release of invasive species were prevented in the first place. Further, a prevention management approach can take less costly alternative approaches to regulatory listing of the hundreds of organisms and their "hitchhikers" that come into U.S. waters. Alternatives include the "coarse screen" approach advocated by some environmental organizations (Jenkins, 2007) or creating "species of concern" lists (McKnight, pers. comm., 2009) that provide a starting point for prevention through outreach and education before invoking regulatory limitations.

Despite limited resources, major opportunities exist to coordinate across states in the Mid-Atlantic region and bring together multiple stakeholders, thus increasing the number of vested interests and helping to instill buy-in and responsibility for invasive species issues — California's actions in policy-making and funding for ballast water management are a model.

To address the gaps in our knowledge of the (1) maritime shipping vector — specifically, ship fouling pathways — and (2) live trade vector — namely, bait, aquaria fish, live seafood, and aquatic plants pathways — the workshop identified five knowledge needs/actions that cut across all of these:

1. Assessment of the diversity of all non-indigenous species imported into the Mid-Atlantic region through the comprehensive sampling of all active vectors in the region to estimate the species pool.

2. Determination of potentially dangerous species, using such tools as species black-and-white lists, species of concern lists, and/or comprehensive risk assessments.

3. Priority actions to halt importations or releases, e.g., biological screening.

4. Education and outreach actions to address risks posed by the intentional and unintentional release of non-native species.

5. Enforcement action.

While states in the Mid-Atlantic region have tackled elements of these needs, a cohesive program of interstate vector management prevention does not exist — such a program will benefit greatly from coordination across the region on a suite of collective efforts to successfully combat aquatic bioinvasions. Workshop participants organized such efforts into a rigorous framework that includes (1) research, (2) management, (3) education and public engagement, and (4) regulation and enforcement. In the Outcome-Based Priority Actions section that follows, this framework serves as the basis for detailing regional needs for preventing the introduction of non-native aquatic species through maritime and live trade vectors.

OUTCOME-BASED PRIORITY ACTIONS FOR SPECIFIC AIS PATHWAYS

Workshop participants detailed specific research, management, and education/public engagement actions for major AIS pathways in the Mid-Atlantic. States in the region have undertaken various actions already, for example, Maryland DNR conducted a social research study on bait usage in order to determine the potential ecological problems that different baits could pose (Kilian et al., 2010). A key challenge for vector management of aquatic species will be coordinating work already done in the Mid-Atlantic, leveraging region-wide studies, and undertaking outreach and education initiatives that are linked directly to biological and social science research studies of vector management.

Maritime Shipping Vector

Ship Fouling

In general, fouling from commercial maritime ships, commercial fishing vessels, and recreational boats present related problems, though at widely diverse scales and often with uniquely different research, management, and education/outreach needs.

Research Priorities and Information Needs

- Identify those who control the funding for commercial shipping companies that enter Mid-Atlantic waters and evaluate a California-style buy-in by shipping companies regarding control of non-indigenous species released from ships.

- Sample biofouling on a range of vessels entering the Mid-Atlantic region to determine patterns of propagule delivery to the region.

- Determine the frequencies of dry dock, cleaning, coating for commercial vessels — and their ports of origin — in order to assess operational and maintenance practices that may influence the risks of introduction among ships. (One example is California's hull husbandry reporting form — http://www.slc.ca.gov/Spec_Pub/MFD/BallastWater/Documents/HullFormAgentsLetter_2009.pdf.)

- Determine movement of recreational vessels in the Mid-Atlantic in order to develop a matrix of recommendations to minimize the spread and impacts of non-native, fouling-transferred organisms.

- Expand and support efforts to conduct cost-benefit studies for the timing of cleaning in relation to vessel performance and fuel efficiency.

- Inventory regulations for recreational and commercial vessel cleaning and identify regulatory gaps.

Management and Regulation

- Develop a "vision" of shared goals among AIS regional task forces, which can be used to work with Sea Grant programs, state and federal agencies, NGOs, and other important stakeholders, including shipping companies and recreational boaters, for successful coordination between commercial ships and recreational vessels.

- Investigate the efficacy of fees for a more robust system of boat inspections — compare with other states on the East Coast such as Connecticut and Massachusetts, which have boating inspection requirements.

Education/Outreach

- Foster an ethic of recreational boat cleaning based on boater activity within and across state borders.

- Determine the effectiveness of current outreach efforts on invasive species at public boat ramps.

Live Trade Vector

Bait

Research Priorities and Information Needs

- Inventory and conduct gap and inconsistency analyses of state regulations in the Mid-Atlantic.
- Conduct comprehensive surveys on the bait trade, e.g., wholesalers, sellers, purchasers.
- Assess socioeconomic effects of the bait industry, e.g., sales volume and distribution.
- Determine species that have caused ecological problems and those with potential to do so.
- Evaluate threats of hitchhiker organisms — associated species in dunnage, pathogens, parasites, potential diseases — on non-native baits.
- Assess low-cost abiotic packaging materials and their availability.
- Conduct social research on bait usage and disposal.

Management and Regulation

- Develop a state-based "white list" for bait; use species already established.
- Develop regulations for bait packaging, employing a stakeholder approach.
- Develop disease testing and standards to ensure bait species are not carrying diseases.
- Establish unambiguous bait disposal protocols at point of sale.

Education/Outreach

- Identify and differentiate target audiences, e.g., wholesalers, retailers, fishers, associations, press/media, law enforcement, cultural groups, tournament fishers, spokespeople who are "superstars" in the fishing world.
- Prioritize outlets, e.g., weekly fishing columns, recreational bulletins, fishing reports, charter operators, and programs and publications for children.
- Develop "species of concern" lists for baits in the Mid-Atlantic for voluntary action by fishers.

- Encourage use of artificial, biodegradable baits when feasible.

- Determine the effectiveness of outreach and management efforts on invasive species associated with bait shipments.

Aquaculture, Aquatic Horticulture, Aquaria

Research Priorities and Information Needs

- Inventory and conduct gap and inconsistency analyses of state regulations in the Mid-Atlantic.

- Determine non-native species imported to region, sources, volume.

- Assemble biological data, e.g., temperature tolerances, diseases.

- Determine potential diseases, parasites, and pathogens in order to develop screening methods.

- Inventory pond aquaria in the region and related information, e.g., how many in flood prone area, disposal knowledge by owners.

- Determine economic value to the states of income from these industries.

Management and Regulation

- Develop appropriate best management practices.

- Establish disposal protocols at point of sale.

Education/Outreach

- Identify and differentiate target audiences, e.g., wholesalers, retailers, fishers, associations, press/media, law enforcement, cultural groups.

- Develop "species of concern" lists for voluntary action by industry and consumers.

- Prioritize outlets for preventing intentional and unintentional releases.

CONCLUSIONS

This workshop, developed and supported by the Mid-Atlantic Panel on Aquatic Invasive Species and Maryland Sea Grant, has produced a vector management framework of outcome-based actions that aims at preventing new bioinvasions in the region's coastal waters. Focusing on pathways of two major vectors, priority actions have been identified, some of which are achievable in the short term, while others will take longer. By setting

realistic end-points and measurable outcomes, states in the Mid-Atlantic have an opportunity to initiate a program of preventative vector management of AIS across the region. The next steps are now a matter for the Mid-Atlantic Panel of the AIS Taskforce to take up — by combining limited resources among taskforce states and bringing in multiple stakeholders, it will be possible to demonstrate how scientific knowledge and political will can interrupt the seemingly wholesale invasion of our waters by non-native species.

REFERENCES

Chang, A.L., J.D. Grossman, T.S. Spezio, H.W. Weiskel, J.C. Blum, J.W. Burt, et al. 2009. Tackling aquatic invasions: risks and opportunities for the aquarium fish industry. Biological Invasions 11:773-785.

Chapman, J.W., T.W. Miller, and E.V. Coan. 2003. Live seafood species as recipes for invasion. Conservation Biology 17:1386-1395.

Cohen, A.N., A. Weinstein, M.A. Emmett, W. Lau, and J.T. Carlton. 2001. Investigations into the introduction of non-indigenous marine organisms via the cross-continental trade in marine baitworms. Report for the U.S. Fish and Wildlife Service, 29 pp.

Executive Order. 1999. Executive Order 13112: Invasive Species. Federal Register: Feb 8, 1999, 64 number 25.

Hewitt, C.L. and M. L. Campbell. 2009. Assessment of relative contribution of vectors to the introduction and translocation of marine invasive species. Report for the Department of Agriculture, Fisheries and Forestry, 45.

Horvath, T. 2008. Economically viable strategy for prevention of invasive species introduction: Case study of Otsego Lake, New York. Aquatic Invasions 3(1):3-9.

IMO. 2004. International convention for the control and management of ships' ballast water and sediments. IMO Convention, February 13, 2004.

Jenkins, P.T. 2007. Broken screens: The regulation of live animal imports in the United States. Report for the Defenders of Wildlife, 58 pp.

Kilian, J.V., R. J. Klauda, S. Widman, M. Kashiwagi, R. Bourquin, S. Weglein, et al. 2010. A study of the sale, use, and release of live bait in Maryland: A call for stricter regulations, better education, and enhanced monitoring to reduce the threat of invasive species introductions. Draft Report, 21 pp.

McKnight, J. 2009. MD Department of Natural Resources. Personal communication.

Rothlisberger, J.D., W.L. Chadderton, J. McNulty, and D.M. Lodge. 2010. Aquatic invasive species transport via trailered boats: What is being moved, who is moving it, and what can be done. Fisheries 35 (3):121–132.

Ruiz, G.M. and J.T. Carlton. 2003. Invasion vectors: A conceptual framework for management. Pages 459-498 in G.M. Ruiz and J.T. Carlton (Eds.), Invasive species: vectors and management strategies. Washington D. C.: Island Press.

Weigle, S.M., L.D. Smith, J.T. Carlton, and J. Pederson. 2005. Assessing the risk of introducing exotic species via the live marine species trade. Conservation Biology 10(1):213-223.
Yarish, C., R. Whitlatch, G. Kraemerz, and S. Lin. 2009. Multi-component evaluation to minimize the spread of aquatic invasive seaweeds, harmful algal bloom microalgae, and invertebrates via the live bait vector in Long Island Sound. Report for the Department of Ecology and Evolutionary Biology, University of Connecticut, 24 pp.

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Safra Altman, NOAA/OAR, Planning, Policy and Evaluation, Silver Spring, MD
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Fredrika Moser, Maryland Sea Grant, UMCES, College Park, MD
Greg Ruiz, Smithsonian Environmental Research Center, Edgewater, MD
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Mario Tamburri, Alliance for Coastal Technologies, UMCES, Solomons, MD

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APPENDICES

WORKSHOP AGENDA

The workshop goal is to develop a 5-point framework for priority action and the key steps towards effective implementation for aquatic invasive species vector management in the mid-Atlantic region. A Maryland Sea Grant publication will highlight workshop findings and detail the action framework. The publication will be targeted for the Mid-Atlantic Panel on Aquatic Nuisance Species and the states and District of Columbia that it represents, the regional Chesapeake Bay program and the national Aquatic Nuisance Species Task Force.

Registration and Continental Breakfast – *Admiral Ballroom, 5th Floor*
7:30 a.m. – 8:15 a.m.

Opening Remarks

8:15 Mid-Atlantic Panel on Aquatic Invasive Species – Jonathan McKnight, Chair
Maryland Sea Grant – Fredrika Moser, Ph.D.

8:30 Mr. John Vasina, Maryland Port Administration

Keynote Address

9:00 Vector Heterogeneity, Integrated Vector Management (IVM) and the Vector Early Warning System (VEWS) – James Carlton, Ph.D., Williams College

Defining the Vectors — State of Knowledge – Fredrika Moser, PhD., moderator

9:30 Commercial Shipping and Invasion Opportunity in North America – Whitman Miller, Ph.D., Smithsonian Environmental Research Center

9:45 International and National Ballast Water Management – Rich Everett, Ph.D., U.S. Coast Guard and Robin Danesi, U. S. Environmental Protection Agency

10:05 From Paper to Policy - Implementing California's Marine Invasive Species Act – Maurya Falkner, California State Lands Commission

10:20 Implementing Ballast Water Regulations: Treatment Systems and Enforcement – Mario Tamburri, Ph.D., Chesapeake Biological Laboratory

10:35 – 10:50 Coffee Break

Vector Management – State of Knowledge – Jonathan McKnight, MD DNR, moderator

10:50 Hull Fouling as a Vector of Marine Nonindigenous Species – Ian Davidson, Ph.D., Portland State University

11:10 Invaders for Sale: The Potential for New Invasions via Live Organisms in Aquarium, Aquascape, Seafood, Aquaculture and Bait Trades – Edwin Grosholz, Ph.D., University of California, Davis

11:40 Wildlife Importation: Broken Screens – The Regulation of Live Animal Imports into the United States – Peter Jenkins, Defenders of Wildlife

12:00 – 1:15 Lunch – Idea Incubator – *Stone Room, Admiral Fell Inn*

Vector Management – Priorities for Actions

Working Groups:

1:15 Panel Presentations: Facilitator – Greg Ruiz, Ph.D., Smithsonian Environmental Research Center

Five-minute presentations with time for questions and discussion

Live trade in the Mid-Atlantic Area; A View from the NAS Database – Pam Fuller, Ph.D., U.S. Geological Survey, FL

Overview of State Invasive Species Policy Tools – Read Porter, JD, Environmental Law Institute, DC

Changing Human Behavior to Reduce AIS Transport Risk – Robert Wiltshire, Center for Aquatic Nuisance Species, MT

2:00 Working Group Ship Fouling Vector – Facilitators – Greg Ruiz and Ian Davidson

2:00 Working Group Live Trade Vectors – Facilitators – Ted Grosholz and Pam Fuller

3:30 – 4:00 Break (Meeting summarizers meet to synthesize "The Way Forward")

4:00 – 4:30 "The Way Forward" – Jim Carlton and Working Group Facilitators

Select and summarize 5 priority areas for action and list steps towards implementation. Summarize a 5-point framework for priority action and the steps towards implementation. Group questions and open discussion.

5:00 Closing Remarks and Thanks to Participants – Fredrika Moser

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PRIORITY AREAS: A FRAMEWORK

AIS Vector Workshop
December 2, 2009 Admiral Fell Inn, Baltimore

Introduction

This is a summary of the ideas generated during the presentations and more fully developed during the afternoon work groups. The work sessions were tasked with identifying priority areas for short and long term action in research, management and education/public engagement for several vectors. Workshop participants identified vectors of interest through a pre-workshop online survey and during the presentations and panel discussions held prior to the work groups. The vectors were: Ship fouling; bait trade; and aquaculture/aquatic horticulture/aquarium trade. The results of the survey are presented on the workshop web site: www.mdsg.umd.edu/vectorworkshop/outcomes/

The table below was developed by Jim Carlton and the work session facilitators and presented to the workshop in a plenary discussion "the way forward" that followed the work session.

PRIORITY ACTION	**OPPORTUNITIES: STEPS TOWARD IMPLEMENTATION** (Near-term vs. long-term steps to be parsed out) (Federal vs. state-based to be parsed out) How do we fund all of these? Fee, tax, existing funding
Prevention: Identify new invasions to facilitate *Early Detection / Rapid Response*	* **Monitoring:** institute mandatory monitoring programs, focused on sites of high inoculation probability based upon knowledge of vectors (*HIP* sites: "smart searches")
Prevention of Introduction of Species via High-Risk Intentional Commercial Importations / Bait Trade	* Establish pre-import, pre-use screening programs * Stronger **Enforcement**
Prevention of Public-Mediated Movement of Species (intentional importations, intentional transplantations, accidental translocations):	* **Education I:** Import the fields of social marketing and sales marketing to assist development of best strategies: increase public awareness, but direct outreach with consistent messages crafted to be audience-specific is required to change behavior; *peer-to-peer sharing* is key; evaluate efficacy of programs focused on whether change was generated * **Education II:** Increase cultural and ethnic sensitivity in public outreach * **Education III:** Insure in-reach (agency staffer education and buy-in) as well as out-reach
Coordination: Increase power of limited resources by combining the resources of multiple stakeholders:	* Increase number of vested stakeholders to increase a sense of ownership (including responsibility) in invasive species issues * Elevate vector management on ANS Task Force agenda, including continuing inter-regional sharing of strategies

Regulation: Aggressively patch holes in invasive species management x vector:	Seek potentially low-hanging fruits for "best management practices" and shared goals across all vectors: * **Ballast:** Increase understanding of efficacy of ballast water exchange in coastal systems * **Fouling: General:** Increase understanding of potential role of ship-fouling (commercial and private, including stochastic vessel movements, but recognizing a vast range of vessel species and movement patterns), including research and understanding of cleaning, maintenance, and design practices for niche-area fouling on ships; increase regulatory grasp of, if not oversight and authority over, frequency of ship-maintenance. Outreach to funding agencies about importance of evolving advanced cleaning technologies and implementing their application. * **Private Illegal:** Increase understanding of role of illegal / blackmarket movements (political will) * **Vector Blitz:** Assess range of vectors one time one place – case study? * **Live Trade: General:** Increase monitoring of live trade species by increasing genetic fingerprinting of traded stocks; seriously expand production of "white lists" (focused on preventing trade of species of high potential ecological or disease impact [disease screening protocols]; increase regulatory oversight of waste-water discharge; point of sale information about what we are buying; disposal protocols across broad menu of organisms; mechanism for reporting by vets of disease or other incidents with pets; * **Live Trade: Bait:** Biological inventory of species in the trade and sale volumes (including value of industry to a particular state); a social inventory of bait use trade and use (including wholesalers, retailers, tournament activity, *et al.*); inventory of mid-Atlantic states regulation; replacement of live dunnage to ship bait with abiotic dunnage; strategies to reduce associated organisms ("hitchhikers"); inventory of trade species that are likely to be disease, parasite, and pathogen agents; develop protocols for bait disposal (to be distributed at point-of-sale); increase bait-tracking across mid-Atlantic states by implementing a uniform receipt program proving point-of-sale from approved vendor bait station ("bait certification program"); source of bait and others; emphasize native species as bait.