Maine's Marine Invasion

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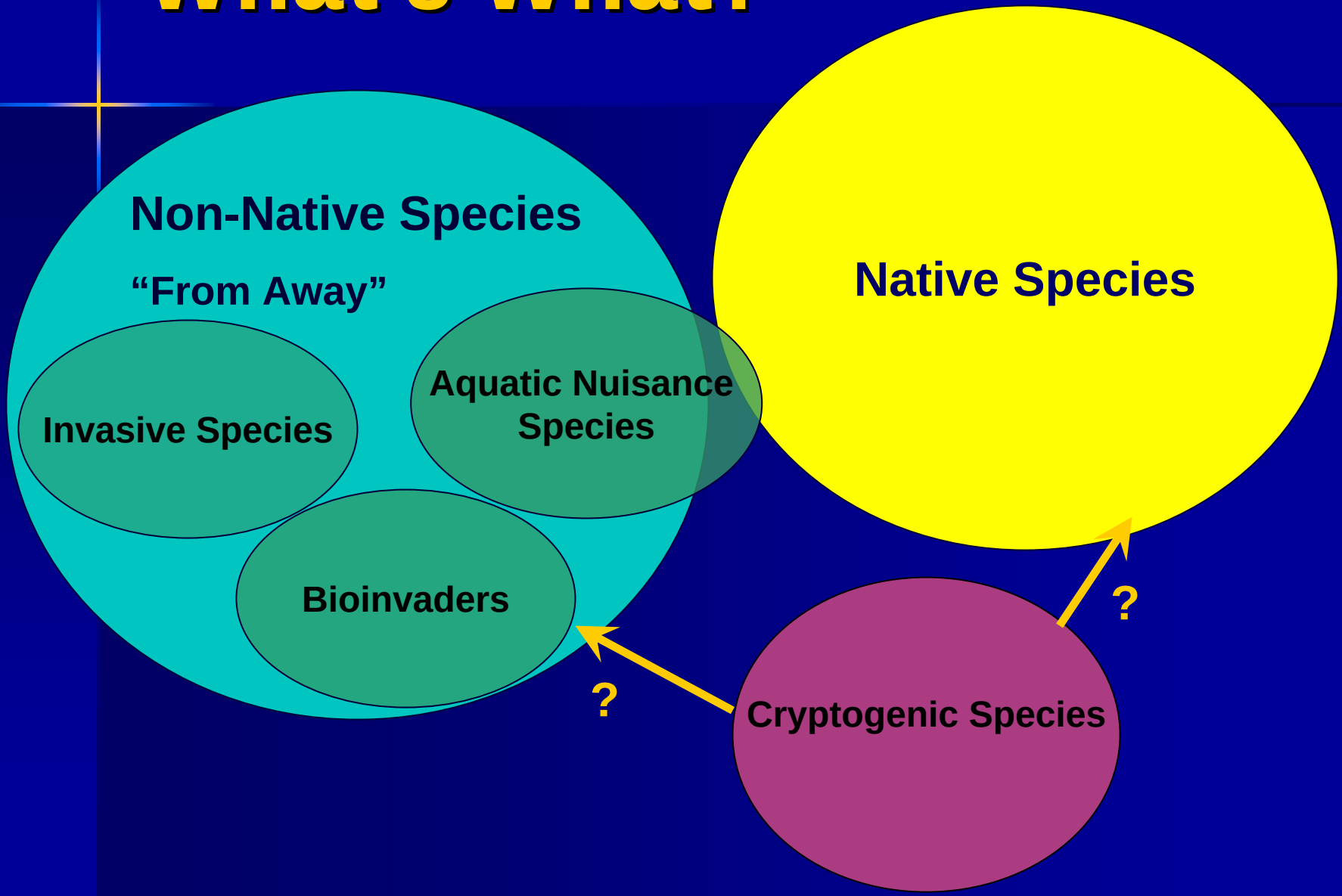
Photo by P. Erickson, Courtesy of MIT Sea Grant

Outline

- What are invasive species?
- What's the extent of the problem of marine invasive species in Maine?
- How do they get here?
- What can I do?

What's What?


Non-Native Species
"From Away"
Invasive Species
Aquatic Nuisance Species
Bioinvaders
Native Species
?
?
Cryptogenic Species

Why is it important to distinguish native from non-native?

- Non-natives have few predators, disease, competitors
- Those that can adapt to new conditions therefore free to spread

=Impacts to native ecosystems & human activities

What is the Extent of the Invasion in Maine?

Tracy Hart, Maine Sea Grant

33 non-native species in a preliminary count

Gretchen Lambert, Courtesy of MIT Sea Grant

Marney Pratt, Bowdoin College

Undetermined # of Invasive Species

How do they get here?

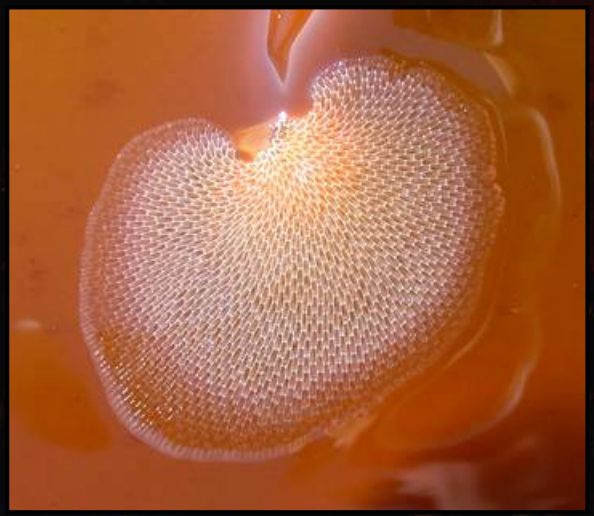
- Shipping
- Non-shipping:
  - Aquaculture
  - Seafood and Bait
  - Public Aquariums
  - Researchers
  - Coastal Restoration Projects
  - Home Aquarium Industries
  - Internet trade
- Intentional Introductions

Ballast Water

- Historically=primary source of introductions
- 5,000-7,000 species/day transported in ballast
- Up to one billion organisms/ship
- Phytoplankton more abundant in coastal ships
- Vessels that travel outside US must exchange ballast before entering US
- Coastal traffic exempt
- Various treatments being explored

Lacy Crust Bryozoan (*Membranipora membranacea*)

- **Source: Ballast water from Europe**
- **Distribution in Maine: Up to Bar Harbor**



Photos by Marney Pratt, Bowdoin College

First seen in GOM in 1987

Within 2 years became the dominant species on kelps

Impacts:
Decreases kelp growth and survival

Rapa Whelk
(Rapana venosa)

- Larvae arrived via ballast water
- Not yet in New England, watch list
- Potential impacts: Preys on barnacles, clams, mussels, oysters.
- Can tolerate large temperature and salinity range.

Photos: U.S. Geological Survey Archives

Ballast & Bait
Ex. European green crab
(Carcinus maenas)

Photo by Marney Pratt, Bowdoin College

- Arrived in ballast
- Exported Maine to West Coast via bait industry
- Abundant throughout Maine coastline
- Impacts: Preys on clams, oysters, crabs, mollusks.
- Eradication failed

Hull Fouling (?)
Ex. Orange/Red Sheath Tunicate
(Botrylloides violaceus)

- Probably introduced via hull fouling
- ME Distribution: up to Penobscot Bay

Impacts:

- Aggressive invader
- Rapid growth
- Smothers sessile animals
- Smothers & blocks light to algae

Photo Courtesy of Larry Harris, UNH

Aquaculture
Ex. Green Fleece

- Probably arrived via oyster aquaculture
- Distribution: entire coastline of eastern U.S. & Nova Scotia

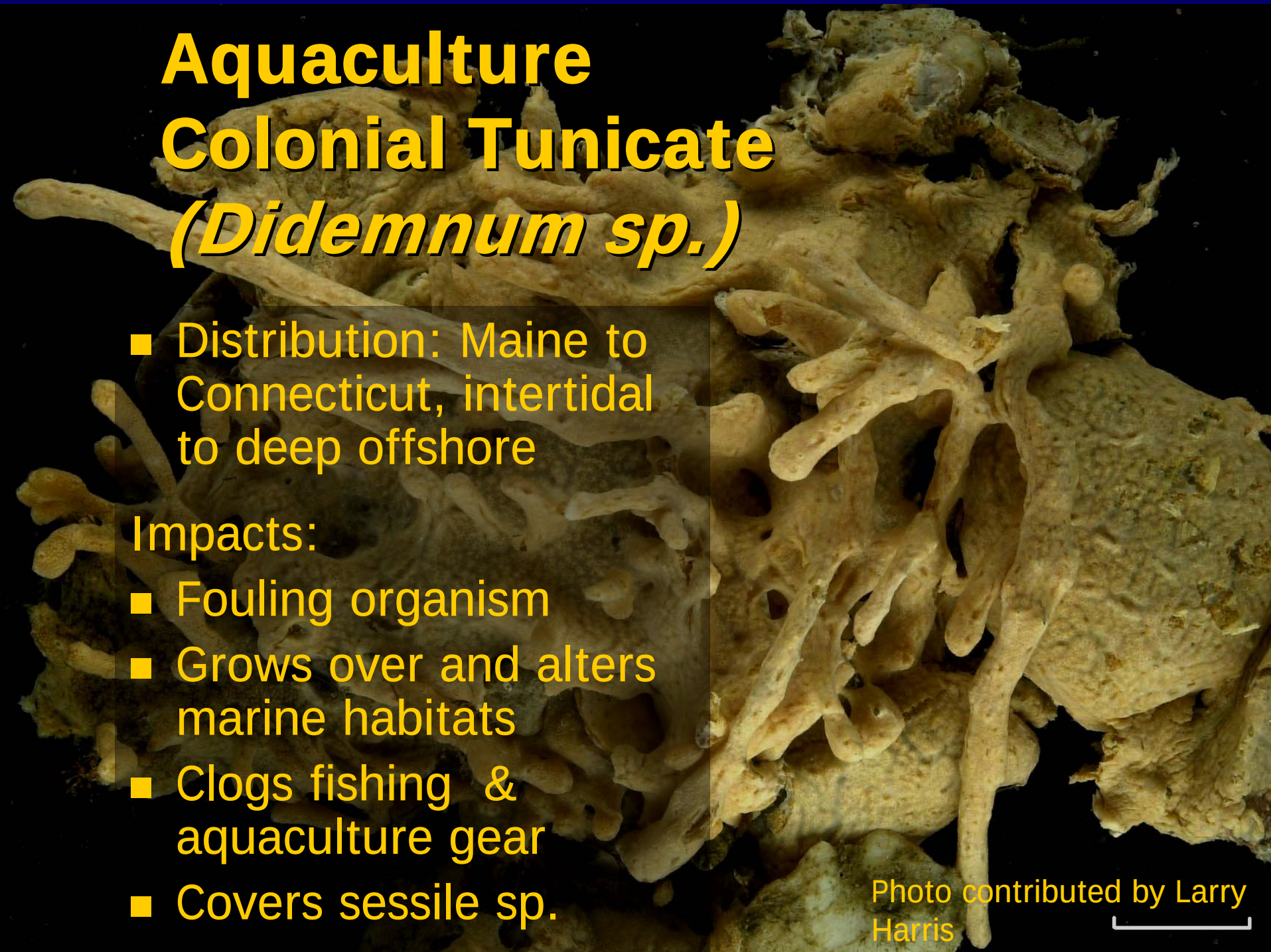
Impacts:

- Smothers oysters
- Outcompetes native kelp and eelgrass
- Dislodges native shellfish
- Chokes beaches (S. New England & Nova Scotia)
- Clogs fishing gear
- Urchins & urchin industry

- Some native predators

Photo Source: MIT Sea Grant College Program

Aquaculture Colonial Tunicate *(Didemnum sp.)*



- Distribution: Maine to Connecticut, intertidal to deep offshore

Impacts:

- Fouling organism
- Grows over and alters marine habitats
- Clogs fishing & aquaculture gear
- Covers sessile sp.

Photo contributed by Larry Harris

What makes one activity riskier than another?

Risk of a successful introduction increases if a dispersal mechanism:

- provides repeated opportunities for an exotic species to be introduced
- transports species capable of surviving in the new environment
- includes numbers high enough to sustain a population

What Can You Do?

- Discard bait, seafood waste and containers in trash or compost.
- Clean boat away from shore before launching in a new area.
- Avoid buying potential invaders at pet or aquarium shops or the Internet.
- Never release a non-native aquatic pet in or near water.
- Learn more about marine invasive species and how to identify them.
- If you are a diver and would be interested in monitoring, please call Tracy Hart at (207) 833-6521

If you find unusual organisms, check out MIT Sea Grant and MarineID websites. If you find a match, please report to Pete Thayer, Maine Department of Marine Resources (207) 633-9539.

Thank You!

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Websites

http://www.seagrant.umaine.edu/: Maine Sea Grant

http://massbay.mit.edu: MIT Sea Grant Bioinvader Website

www.Marineid.org: Database of Northeast invasive species

http://www.northeastans.org/resources.htm: Northeast Aquatic Nuisance Species Panel

Maine's Marine Invasion
Presentation Notes and Additional Information

Slide 1: Maine's Marine Invasion

Presentation prepared for the Phytoplankton Monitoring Workshop originally scheduled March 12, 2005. Requested goal of the presentation: Provide an overview of invasive species issues in Maine, describe how non-native species get into Maine's coastal waters, and their impacts. I was asked to provide particular emphasis on ballast water as a vector for invasive species introductions because non-native phytoplankton is most likely to arrive via this vector.

Slide 2: Outline of the Talk

This presentation will:
1) Start by going over what invasive species are and some related terms
2) Provide an overview of the problem in Maine. How many invasive and non-native species are there in Maine versus the U.S.?
3) Describe how they get into Maine's coastal waters (prominent vectors and pathways). Then examples of some species that have gotten to Maine via these various pathways.
4) Lastly, suggest some steps that citizens can take to minimize introductions

Slide 3: Making sense of the terms….What is a marine invasive species?

- There are native species; those that have been in Maine waters historically…
- And there are non-native species…those that are "from away", those that weren't in this region historically. Many similar and basically synonymous terms used to describe non-native species. (e.g. Exotic, alien, nonindigenous all emphasize that they are new to this region; another term, "introduced species", emphasizes both non-native status and that these species are introduced by human activities.)
- Not always easy to tell if something is native or non-native. Shipping, for example, has been going on for over 500 years and bringing new species with it, whereas we're lucky if we have species records dating back to the 1800s. In some cases fossil records and genetic studies can help reveal origins, but many species' origins still unclear. These are put in a category called "cryptogenic species". Species of unknown origin.
- Not all non-native species cause problems in their new environment. Many are unable to survive, reproduce, and spread. Some non-native species are even brought in for beneficial aspects (farms, controlling other pests, etc). Therefore, problematic species are a smaller subset of all species that are introduced here. These have been given a number of different names (invasive species, bioinvaders, aquatic nuisance species)

<u>Additional definitions for reference:</u>
Introduced species –Those that arrive to a new place outside their native range. Those that have been transported intentionally or unintentionally by human activities into a region in which they did not occur historically. (Key points=by humans; from away).

Invasive species –introduced species that causes or has the potential to cause economic or environmental harm. Those introduced to an area outside their natural range by human activities and cause or have the potential to cause economic harm or disrupt native ecosystems.

Aquatic Nuisance Species-Most definitions say that has to be non-native/introduced. Many say that must also threaten diversity or abundance of native species, ecological stability, or commercial, agricultural, or recreational activities that depend on such waters.

Cryptogenic species – those whose origins are unknown.

Bioinvaders—Salem Sound coast Watch—species that have been moved beyond their natural limits by human activities. Jim Carlton—introduced species that develop self-sustaining populations.

Slide 4: Why is it important to distinguish native from non-native?
While many species can't survive or reproduce in their new environment, the ones that can pose a significant threat b/c they often don't face the predators, diseases and competition that keep their numbers in check in their native environment. Therefore, if they can adapt, they have the potential to spread unchecked and disrupt native systems and the human activities that depend on these systems. Impacts that can occur:

Ecological impacts of invasive species: outcompete native species for space and resources; dislodge, overgrow, or prey directly on native species; eat their food; block light to plants; spread new diseases; cover habitats to the extent that native species can't settle or survive = Changes in communities, declines in abundance, habitat degradation, ecosystems overrun with few species, less diversity

Socio-economic: Clog fishing gear and aquaculture pens; Foul boats, piers, and other man-made structures; costs for control, research and monitoring.

What this means in real terms….Approximately 400 of the 958 species that are listed as threatened or endangered under the Endangered Species Act are considered to be at risk primarily because of competition with and predation by nonindigenous species (TNC 1996, Wilcove et al. 1998). The U.S. spends $137 billion to deal with invasive species each year (Pimentel 2000).

→ Therefore important to distinguish native from non-native species so that can direct research, monitoring, inventory, and management efforts toward species that are most likely to cause harm.

Slide 5: What is the Extent of the Invasion in Maine?
We don't really know! Partly because of the difficulty of monitoring expansive marine systems and partly because of difficulty already mentioned of distinguishing native from non-native species.

But, prominent invasive species scientist, Jim Carlton, from Williams College and Mystic Seaport in Connecticut, took a stab at quantifying Maine's non-native species for a forum on marine invasives that was sponsored May 2004 by the Casco Bay Estuary Project and

Maine Sea Grant. In his preliminary count, 33 species in Maine were considered non-native. He did not distinguish which of these are considered invasive/ bioinvaders.

How does this compare to the U.S. as a whole? Maine has just a small subset of what could become invasive. Approximately 50,000 nonindigenous (non-native) species are estimated to have been introduced to the United States (USBC 1998). Since the arrival of the first European settlers, at least 400 exotic marine and estuarine species have become established in North America (Ruiz et al. 1997) and a subset of these has caused significant economic and ecological damage (e.g., Ropes 1968; Kimmerer et al. 1994).

Slide 6: How do they get here?

I. Shipping: Species are introduced by shipping in two ways:

a) ballast water—which is seawater that is pumped into an empty or unfilled ship to provide stability at sea. Organisms pumped in with it. Pumped out to make room for new cargo when arrives at destination port. Species from one area released to a new area;

b) Species can also attach to ship hulls and hitchhike a ride to a new area. Called hull fouling organisms.

Historically shipping has been the primary means of aquatic introductions (Ruiz et al. 2000). [New England ports, however, receive relatively little ballast water (Smith et al. 1999), so non-shipping pathways for exotic marine introductions may be important in this region (Weigle et. al).]

II. Non-Shipping: Non-shipping pathways include:

a) Aquaculture: Aquaculture products can be nonnative (e.g. oyster species grown in Maine, *Ostrea edulis*) and can also carry hitchikers (such as bonamia oyster disease). While past introductions have occurred via this vector, today DMR regulates aquaculture industries to minimize the entry of diseases, parasites, or other potentially dangerous organisms.

b) Seafood and bait industries: shellfish can carry organism on their shells. Live seafood can be imported from other areas and be released. Species used as bait can also pose a risk if introduced and packing materials for this bait can carry hitchikers.

c) Public aquariums: Public aquariums collect non-local species or buy them from marine biological suppliers. They are located next to a water body in most cases (Weigle et al), therefore increasing risk of accidental escapes. Ex. A public aquarium in Monaco introduced the Australian seaweed Caulerpa taxifolia (Vahl) C. Agardh into the Mediterranean Sea in 1984, and the alga now carpets large expanses of the sea bottom in the western Mediterranean (Wiedenmann et al. 2001).

d) Scientists and Researchers: buy non-native species from marine biological suppliers. According to Weigle et. al. study, universities, colleges, private research institutions, and biological research suppliers acknowledged importing live marine organisms.

e) Restoration: privately or publicly funded coastal wetland restoration projects may pose another important mechanism for marine invasions (Weigle et al). Historically, landscapers and restorers have selected plants for ornamental and functional reasons (Newcomb 1989), and the geographic origins of the plants have been of little concern.

Many nurseries now sell coastal plants specifically for restoration purposes and advertise shipment to anywhere in the United States.
f) Home Aquarium industries: Pet and aquarium shops import non-native species. The species or the water they are contained in (which may carry hitchhikers) can be released accidentally, or on purpose when a pet owner wants to let their pet "go free!"
g) Internet trade—greatly increasing the rate and quantity of non-native species bought, sold, and transported around the world. Limited regulation.

** In a recent study in Massachusetts (Weigle et. al) no single non-shipping vector stood out as presenting a primary risk. Each evidenced characteristics or handling practices at different points in the importation process that could facilitate introductions.
** Respondents in all groups reported they discharged tank water used to hold nonlocal species directly into a local water body (versus disposal through a municipal drainage line). The aquatic ornamentals stores and public aquarium respondents treated or filtered the tank water before releasing it.

h) Intentional introductions:
Some species are introduced intentionally to serve a human purpose—food or products, to control another species, management purpose (autumn olive (erosion) purple loosestrife) or pleasure (song birds). There are recent examples of intentional introductions on both coasts (e.g. the Chinese mitten crab (Eriocheir sinensis) in the San Francisco Bay Delta region of California, the snakehead fish, Family Channidae, in Maryland, Virginia, and now the Upper Great Lakes, and the Asian swamp eel (Monopterus albus) in Florida).

Some introductions have been beneficial. Species introduced as food crops (e.g., corn, wheat, and rice) and as livestock (e.g., cattle and poultry) now provide more than 98% of the US food system, at a value of approximately $800 billion per year (USBC 1998).

Slide 7: More on ballast water

[Note: I was asked to say a bit more about ballast water specifically for this presentation to the Phytoplankton Monitors because it is the primary means by which non-native phytoplankton species are introduced.]

- With over 5,000 species being transported around the world on a daily basis, ballast water discharges are recognized as a serious problem threatening global biological diversity, including renewable resources, and human health worldwide (Carlton 2001; Vitousek et al. 1997). (Another source said 7,000)
- A single ship can carry up to a billion individual organisms in its ballast water including exotic phytoplankton species.
- Analysis of shipping patterns in New England suggest that 25% undergo ballast water exchange—bulk carriers and tankers exchange the most volume. (Pederson, Ballast Water Exchange Zones Workshop, p. 3-4)
- Domestic discharges (ships from other parts of US) are likely to have higher concentrations of phytoplankton that are more likely to survive (Pederson, Ballast

Water Exchange Zones Workshop, p. 4). Coastal traffic is a greater risk for introductions of nonindigenous phytoplankton.

- Management strategies: mid-ocean exchange. If release out to sea in deep water, often can't survive or make it to nearshore areas. Not always possible due to weather and safety issues (Ballast Water Exchange, 2003, Pederson). Treatment before release.
- Voluntary submission of ballast water reporting forms is low
- Authorities: USCG has authority under the Nonindigenous ANS Prevention and Control Act of 1990 and the National Invasive Species Act (reauthorized) of 1996 to propose rules if voluntary guidelines not met.
- The final rule, which became effective July 28, 2004 requires all vessels operating outside the US EEZ to exchange ballast water mid-ocean, retain it onboard, or use a USCG approved alternative technology to treat. Must have ballast water management plan.
- New ruling as of April 2005 prohibits all ships from dumping ballast water in U.S. waters without a permit. No exceptions.

Slide 8: Ballast Water brings the Lacy Crust Bryozoan (*Membranipora membranacea)*

Now examples of species that have been introduced via the various vectors.

This is the Lacy Crust Bryozoan (source for most of this information is a lecture by Marney Pratt, Bowdoin College)
1. How introduced? Ballast water from Europe (Berman et al. 1992)
2. First seen at Isle of Shoals in 1987. Within 2 years became the dominant species on kelps (Berman et al. 1992). Species you will see almost everywhere in Maine
3. Distribution in Maine: Up to Bar Harbor

Impacts: Encrusts on kelps. Decreases growth and survival (Lambert et al. 1992, Scheibling at al. 1999, Chapman 1999). Encrustation led to increased drag on the blade and reduced flexibility in storm surge. Contributed to decline.

Kelp is a vital GOM habitat, therefore Membranipora could potentially contribute to a vast shift in coastal marine habitat. As kelp beds were devastated, replaced by Codium. Now also found on non-kelp substrates. (from Megan Tyrrell/Larry Harris presentation at the May 2004 Maine Marine Invasions forum)

Unusual in that it has some native predators (sea slugs). Many invasive species do not have predators.

Slide 9: And the Rapa Whelk *(Rapana venosa)?*

Not yet in New England but on watch list.

[Information here and on slide is from U.S. Geological survey website http://cars.er.usgs.gov/Nonindigenous_Species/Rapa_whelk/rapa_whelk.html]

- Native to Sea of Japan. Arrived in ballast waters.
- Potential impacts: preys on barnacles, clams, mussels, oysters. Indication of how destructive this species can be: There is a bounty for live and dead rapa whelks is paid by Virginia Institute of Marine Science.
- Species has tolerance for large temperature and salinity range. Found in sand and mud.

Slide 10: Ballast & Bait
Ex. European green crab (Carcinus maenas)

[Primary Source: Robin Hadlock Seeley, Cornell University presentation at the May 5, 2005 Marine Invasions Forum and other sources]

Arrived in dry ballast 1817 from Europe (Salem Sound Coast Watch identification cards).
Expansion of Carcinus on Maine coast 1893 -1951 starting in southern Maine and heading up the coast to Downeast Maine (Robin Hadlock Seeley presentation at the Maine Marine Invasion Forum, May 5, 2004)
Exported from Maine to West Coast through bait industry—in packing materials (a seaweed known as wormweed) used to pack bait worms
Distribution throughout Maine. Dominant nearshore organism.
Predator on small invertebrates (Seeley). Preys on oysters, crabs, mollusks, snails.

Impacts: Blamed for collapse of Maine soft-shell clam industry. Drop in Maine soft-shell clam landings in 1950s attributed to green crab (Seeley). Competes with native species for food.
Both the green crab (Carcinus maenas) and the alga Codium fragile (Suringar) Hariot subspecies tomentosoides (van Goor) Silva were likely transported to the west coast of the United States in seaweed used to pack shipments of bait worms (Lau 1995).

[limited information about green crabs presented here because Elizabeth Stephenson, UMaine will follow with a presentation on green crabs and Asian shore crabs]

Slide 11: Hull Fouling (?) Ex. Orange/Red Sheath Tunicate
(Botrylloides violaceus)

- Orange or Red Sheath Tunicate. A sea squirt, Native to Asia
- Vector: Contradictory information. According to Salem Sound Coast Watch species identification cards, this species probably arrived in U.S. in 1970's via ship fouling. Larry Harris of UNH, however, says that no one knows how this species arrived (email March 2005).
- Current distribution up to Penobscot Bay in protected areas (it is in shallow, warmer, backwater areas between islands) rather than out on coast in colder, high energy environments (Tyrrell/Harris presentation)

- Considered an aggressive invader. Its rapid growth results in other sessile animals and algae being smothered, blocks light to the algae and can kill filter feeders by overgrowth (Tyrrell/Harris)
- Habitat preference: subtidal (occasionally in intertidal), attached to submerged structures, algae, slow moving or sessile organisms (Salem Sound Coast Watch identification card)

Slide 12: Aquaculture Ex. Green Fleece (Codium fragile ssp. tomentosoides)

- Considered one of the most invasive seaweeds in the world (Trowbridge 1998).
- Green alga, native to Japan, likely brought to Boothbay Harbor via oyster aquaculture in 1960s (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).
- Hitchhiker on oyster shells. It was first documented in the GOM in 1964 in Boothbay Harbor (Salem Sound Coast Watch identification card). In the early 1960s, *Codium* was introduced to southern Massachusetts attached to the shells of transplanted oysters from Long Island Sound (source: Tyrrell, 2005, GOM Habitat Primer)
- Has many descriptive names (oyster thief, deadman's fingers, green fleece)
- Can be found in the intertidal zone down to 15 m depth. (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).
- Very abundant in Nova Scotia and southern New England. Fast spreader/high densities—

Impacts:

- Clogs beaches in S. New England.
- Can dislodge mussels, oysters, clams, native algae, etc. Commonly called Oyster thief b/c the extra drag created by Codium can result in shellfish being ripped up from the seafloor during storms (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).
- Smothers oysters (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).
- Can open the door for other invasives, e.g. Neosophonia (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).
- It attaches to hard surfaces ranging from rock, to shells, to ship hulls (Salem Sound Coast Watch Invasive Species Identification card).
- "The rapid growth of this species and its ability to regenerate from broken fragments assist it in outcompeting native eelgrass and kelp beds, the primary shelter for many finfish and invertebrates" (Salem Sound Coast Watch Invasive Species Identification card).
- "Codium now occupies many habitats that were previously kelp beds, which also may have negative consequences for the urchin fishery as it is a less preferred food than kelp and urchins have reduced growth rates on it as compared to kelp" (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).

- Increases maintenance labor for aquaculturists and reduces productivity of cultured species (Salem Sound Coast Watch identification card).

Note:

- Consumed by a sea slug, Placida dendritica, and by green urchins, but urchins prefer kelp over Codium (Tyrrell/Harris presentation at the Maine Marine Invasive Species Forum, Portland, ME 2004).

Slide 13: Aquaculture ex. Colonial Tunicate *(Didemnum sp.)*

A North Sea species (according to Gretchen Lambert. Info from Larry Harris, email March 2005).

Distribution: Now covers large area of the continental shelf off New England (e.g. George's Bank) (Salem Sound Coast Watch identification card).

First collected in New England in 1993 in Damariscotta River on shell/gravel bottom (Salem Sound Coast Watch). Also found on dock pilings in Walpole Maine since 1988 (Salem Sound CW) and reports of growing densities in Boothbay Harbor (Jon Lewis, DMR) & Easport. Reports of species in Maine going back 30 years, but remained relatively undiscovered until rapid assessment in 2000 (Tyrrell/Harris presentation).

It occurs from the intertidal zone to very deep water offshore. Can cover a variety of substrates, including shell hash, gravel, flat rock, pilings, ropes, overgrows a huge variety of sessile invertebrates and algae. (Tyrrell/Harris presentation, May 5, 2004).
Impacts: Alters marine habitats and threatens to interefre with fishing, aquaculture, and other activities (Salem Sound Coast Watch); aggressively grows over bivalves and may smother them or interfere with their growth. (Salem Sound Coast Watch); may overgrow aquaculture structures slowing shellfish growth or decreasing flushing of cages.

Biggest fears are re: its colonization of gravel pavements on George's Bank, a very productive fishing ground. Whether it will affect recruitment of valuable finfish or shellfish sp. remains uncertain but could have large ecological and economic impacts (Tyrrell/Harris presentation, May 5, 2004).

Predation: In the US Atlantic coast, the common periwinkle, Littorina littorea, has been been observed eating it. However, this sea squirt's ability to colonize a huge variety of substrate types in a wide variety of environmental conditions imply that strong top-down control by predators will be unlikely.(Tyrrell/Harris presentation)

According to Page Valentine's web page, various reports of predators in New Zealand include: seastars, urchins, chitons, in the US Atlantic coast, intertidal zone, the common periwinkle, Littorina littorea, has been been observed eating it.

Control: Eradication extremely difficult. Limited distribution while adapting to GOM. Once adapted rapidly expanded range. Once established and expanding, a species is a different beast; the potential for control is poor and impact great.

Slide 14: What makes one activity riskier than another?

Eradication usually impossible once established=need for prevention and early detection. Therefore need to determine which human activities are of greatest risk.

The risk of a successful introduction is likely to increase, if:
a dispersal mechanism provides repeated opportunities for the introduction of exotic species or their gametes into the local environment (Ruesink et al. 1995; Ruiz et al. 2000), transports exotic species capable of surviving in the local environment (Tucker & Richardson 1995; Smith et al. 1999), and includes sufficient numbers of the exotic species to sustain a population (Mack et al. 2000).

Therefore, need to reduce number of times species introduced, and # of individuals introduced and pay attention to which activities most likely to introduce species that can survive here….

This information provides a way to think about which behavior are risky and way to prioritize outreach efforts.

Slide 14: What Can You Do?

Discard bait, seafood waste and containers in trash or compost.

Clean boat away from shore before launching in a new area.

Avoid buying potential invaders at pet or aquarium shops or the Internet.

Never release a non-native aquatic pet in or near water.

Learn more about marine invasive species and how to identify them.

If you are a diver and would be interested in monitoring, please call Tracy Hart at (207) 833-6521

If you find unusual organisms, check out MIT Sea Grant and MarineID websites. If you find a match, please report to Pete Thayer, Maine Department of Marine Resources (207) 633-9539.

Slide 15: Thank you!

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