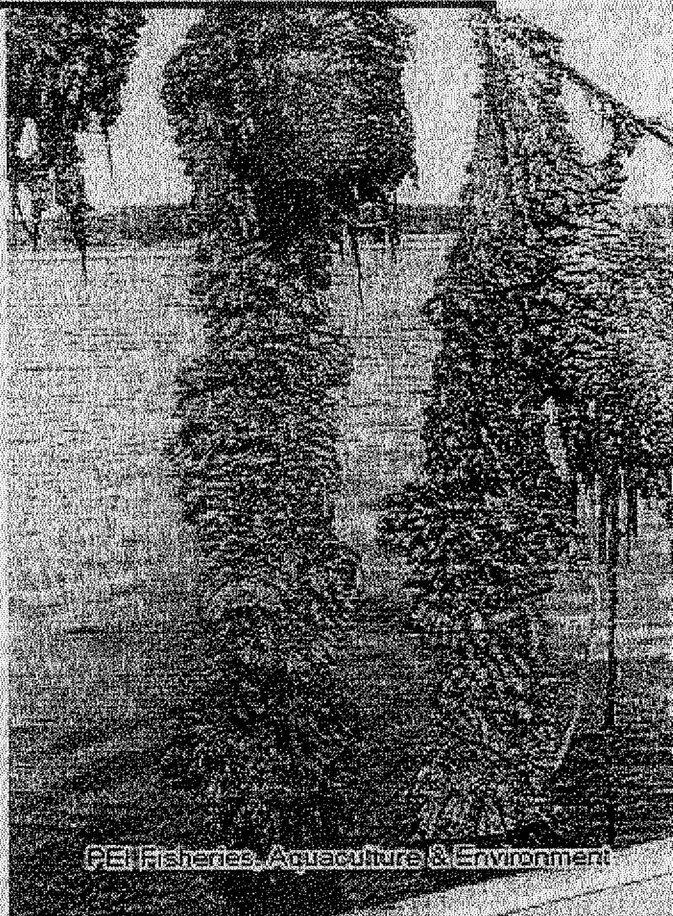
MARINE INVASIVE SPECIES IN THE GULF OF MAINE



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ABSTRACT

Invasive species have become an increasing problem in the Gulf of Maine and around the world. A major mode of transport for these species is the release of ballast water from large shipping vessels. Introduction of non-native species can affect community structure and interactions within the marine community. In order to better understand the process of bioinvasion, it is necessary to determine what exotic species are successful in an area and what characteristics of that area allow for the success of these introduced species. In The Gulf of Maine, the exotic tunicates *Styela clava* and *Ascidiella aspersa* are well established in areas other than the New Hampshire coast. Species such as *Botrylloides violaceous* has become widely dispersed along the entire length of New England, including in New Hampshire. Physical factors like salinity, or ecological pressures such as predation and limited larval dispersal may be the cause of this distribution pattern. Tracking settlement patterns using multiple designs of field recruitment panels showed low recruitment during the winter months, and zero recruitment of these invasive ascidians. A number of different designs for of field monitoring created similarly limited findings. A cube design with horizontal and vertical settlement options was developed to increase the diversity of potential settlers. A stable and successful biomonitoring design will be a critical part of further research into biological invasions. Laboratory tests showed that each of these species had mortality after exposure to salinities of 13ppt and below and survival at 24ppt and above. Future studies should focus on smaller increments of salinity difference to find the threshold of each species.

INTRODUCTION

GLOBAL VIEW OF MARINE INVASIONS

What are introduced species?

An introduced species is an organism that has become established in an area other than its native region. When a species is transplanted to a new area, it may or may not thrive in that area's conditions. Those that thrive may have no natural methods of regulation and therefore have the ability to dominate the community. For a non-native species to become dominant, they must either be competitively dominant over the resident species or have the ability to utilize unused resources in a community that is primarily homogeneous (Berman et. al., 1992). Invading species that do become dominant, especially through the first mechanism, are considered threats to existing habitat and communities because they can out compete native organisms.

How can they effect our environment?

After a species is able to recruit in a new area, it may have several different roles in the community. The marine alga *Caulerpa taxifolia* was one such invader that proved to be very successful in the Mediterranean Sea. It was first recorded in an area of only 1 m^2 in 1984 and by 1993 had spread to encompass 2000 ha, and was thought to have impacted multiple marine invertebrate species whose habitat had been altered (Bellan-Santini et. Al., 1996).

Ecologically, an invading species can cause habitat alteration and changes in community structure (Harris and Tyrrell, 2001, Grosholz et. Al., 2000). Species invasion has altered the alternating climax community typically found at The Isles of Shoals in the Gulf of Maine. It has changed from a cycle of urchin barrens/lush kelp canopy and red algae understory to a community composed mainly of introduced species, *Codium fragile ssp. tomentosoides,* a green alga, *Membranipora membranacea,* a encrusting bryozoan, and *Diplosoma listerianum*, a tunicate (Harris and Tyrrell, 2001). This change was facilitated by over-exploitation of the urchin *Strongylocentrotus droebachiensis*, which essentially removed the grazers that could control these species.

Evolutionarily, an invader may impact the functional morphology of native species, such as the altered morphology of gastropod shells in response to the introduction of the European Green Crab, *Carcinus maenas,* (Seeley, 1986). An invader can also cause hybridization to occur with local species which may or may not cause the loss of native species genotypes (Grosholz et. Al., 2000). In fact, there is lots of opportunity for genetic change when an exotic species becomes established in a new area, thus impacting the evolutionary paths of multiple species.

How do they get here?

There are a number of vectors that allow these species to settle in new areas. Creation of canals, improper disposal of aquaria containing exotic algal and fish species. and intentional introduction for fisheries are some ways that new species appear (Ruiz et. Al., 1997). The main vector, however, is by boating traffic. The transport of non-indigenous species is facilitated by shipping traffic and the ballast water carried in the hulls of large vessels. Empty ships fill their hulls with water for balance and equilibrium until they reach their destination, which may be across the world. The water is released into the sea as its weight is replaced with cargo. This water may be full of larvae that can thrive in this new place (Ruiz et. al., 1997, Cangelosi, 2000, Rigby and Taylor, 2000).

Introduced species often do not simply stay in the area where they were dumped. The spread of exotic species along a coastline, for example, is thought to have not originated from one single spot, but rather from a few small areas where they have become established and then thrived and are capable of sending out larvae, thus filling in the gaps between them (Whitlatch and Osman, 2000).

Figure 1. A tanker deballasting, http://invasions.si.edu/NBIC/nbic_mgmt.htm

Regulations governing the dumping of ballast water were first directed towards the Great Lakes in 1990 in response to the zebra muscle invasion. The first marine ballast water management program was created in 1996 when the National Invasive Species Act was enacted, but it could not be mandated in the United States for several years after that (Cangelosi, 2000). Ballast water has become an interesting focus when searching for the source of the organisms dumped into coastal waters. A key to controlling the influx of invasive species is certainly to control the exchange of ballast water (Fig. 1). In one study plankton samples from Japanese ballast water released in Oregon contained 367 taxa. (Carlton and Geller, 1993)Currently, a number of different water treatment plans are being developed for treating ballast water before or after it is pumped in (Rigby and Taylor, 2000). This subject will continue to be an issue as long as ocean-going vessels are used to transport materials.

MONITORING SYSTEM

The northeastern US relies on the Gulf of Maine to supply fish, sea urchins, shellfish and many other marine products. The Gulf of Maine is a complex system where the slightest change can have a significant effect. For instance the introduction of a new species could affect the many other native or commercially valuable species either directly or indirectly. A good example of an invasive species directly affecting a commercially valuable species is the story of *Codium fragile ssp tomentosoides* and *Ostrea edulis*. *O. edulis* was intentionally released in Maine years ago for commercial purposes, but now the invasive *C. fragile ssp. tomentosoides* can lead to the death of the valuable oyster, hence the nickname "oyster thief." C. fragile ssp. *tomentosoides* attaches to the shell of the oyster and during a storm the algae will act as a sail for the oyster and transport it to an area where the oyster will not survive. (MDFA) An early warning monitoring system has the capacity to alert people to what is invading, help in determining how it's invading, and give an idea of how fast it's invading. A warning against an invasion would either help to prevent further invasions, or aid in preparation for the invasion in order to reduce the harmful effects it might have on the Gulf of Maine's fishery.

LABORATORY TESTS

~Study species

There have been a variety of invaders to the northern New England coast in the past few decades, including a number of fouling-community ascidians. These include *Ascidiella aspersa*, which is native to Europe, and *Botrylloides violaceous* and *Styela clava* from the Pacific (MIT Sea Grant). These species were used in lab experiments to determine tolerance to changing salinities. These three species were selected for the lab experimentation because of their varied distributions. The laboratory portion of the project attempts to explain these varied distributions.

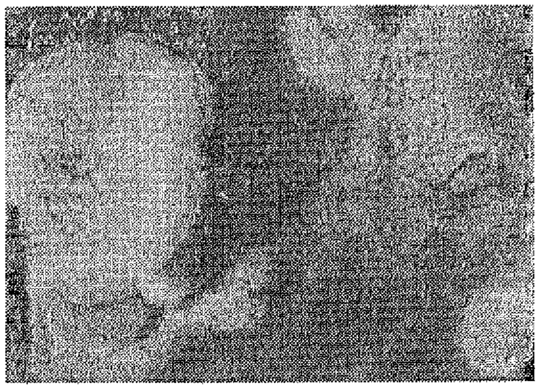

Fig. 2 Botrylloides violaceous

B. violaceous (Fig. 2) is colonial and currently widespread along the east coast. It is a dominant space competitor and is often found as an epifaunal species. Currently it can be found in harbors in Salem and Beverly, MA and as far north as Penobscott Bay,ME intertidally and offshore. (Harris, personal comm.)

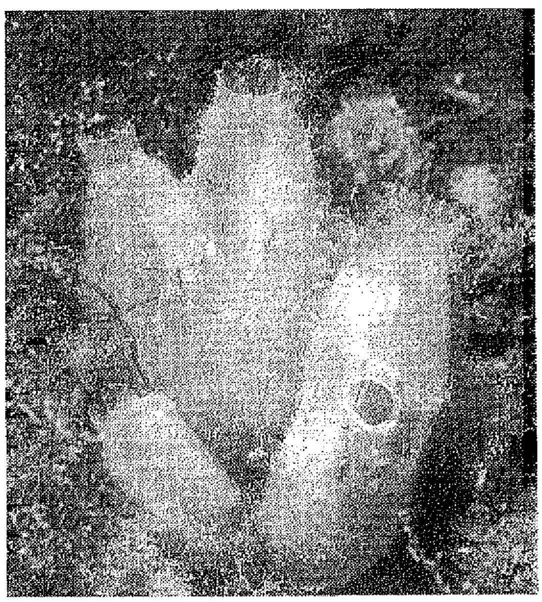

Fig. 3 Ascidiella aspersa

A. aspersa (figure 3) was first observed on the New England coastline in 1991 (MIT Sea Grant, 2002, Whitlatch and Osman, 2000). It is a solitary ascidian with a near-transparent tunic.

It was first found in southern New England and has now become established in Salem, MA, but has failed to be successful on the New Hampshire coastline.

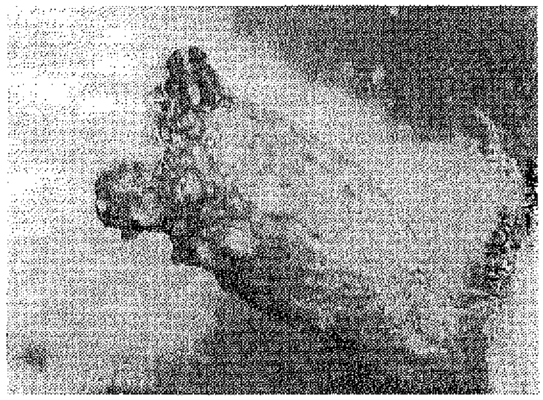

Fig. 4 Styela clava

S. clava (Fig. 4) is a solitary ascidian capable of dominating space in calm, protected areas and creating large fouling assemblages. *Styela* acts as a larval predator, which helps it become spatially dominant. It's population has increased rapidly in Beverly, MA since its introduction in the early 70's, but still has not become established in New Hampshire though its distribution has spread to Maine (Berman et. Al., 1992, Osman and Whitlatch, 2000) and Prince Edward Island.

These three invaders, though they are all able to compete well for open space, are controlled by predation and limited larval dispersal and therefore the extent that they can effect native communities is undetermined (Osman and Whitlatch, 2000). They are mainly restricted to harbors and protected bays with little water disturbance where they are able to dominate areas beneath piers and floating docks. Settlement was found to be most successful at sites with little to no current. In their research they also found that newly recruiting larval forms of these organisms are heavily preyed upon by grazers as well as planktivorous fish. These findings are consistent with a number of established local populations, rather than a slow spread from an initial point of introduction (Whitlatch and Osman, 2000). Since the distribution of these invasive organisms is checked by a number of natural factors, they will thrive only in protected areas where predators are absent. These characteristics indicate that these three species will not spread out of control and that native resident tunicates such as *Ciona intestinalis, Molgula manhattensis., and Botryllus schlosseri* will not be competitively excluded by these newly introduced organisms. However, there is evidence that mortality rates of the new arrival species may be lower than in the native species, which gives them an advantage in these areas (Osman and Whitlatch, 2000).

Though protected harbors similar to Beverly and Salem exist on the New Hampshire coast, *A. aspersa.* has not become established locally, while *B. violaceous* has. *S. clava* has not shown to be dominant in local areas either, though it has been found. These excluded species are perhaps regulated by salinity. The coast of New Hampshire is estuarine while the Massachusetts sites are not in proximity to large amounts of freshwater influx. This idea of regulation by salinity has not been previously explored in depth.

OBJECTIVES

- Design and test a stable monitoring system for The Gulf of Maine to detect recruitment patterns for invasive and native primary space occupiers
- Investigate the role of salinity in determining the distribution of invasive species along New Hampshire's seacoast.
- Gather information on the possible role of boat traffic as a vector for species introduction in Portsmouth Harbor.

MATERIALS AND METHODS

MONITORING SYSTEM

The designed early warning system was targeted mainly at invasive sessile invertebrates or algae, more specifically tunicates. Previous studies indicated that tunicates will settle on sanded plexiglass plates. Due to the awesome power the ocean is capable of exerting on anything in or on it, the entire apparatus that would sample for the invasive marine species needed to be able to withstand the power of ocean storms.

Our objectives included sampling the current distribution of invasive species and perhaps catch a species where it had previously never existed. To meet our objectives sanded plexiglass were deployed at several sites in the Gulf of Maine. The invasive tunicates and bryozoans previously found in the sampled areas were *Botrylloides diagensis, Ascidiella aspersa, Styela clava*, and *Diplosoma listerianum*.

A series of frame designs were developed and tested. Two designs were deployed at the same time at each sampling site. The larger design (see Figure 6) held three 20 cm2 plexiglass plates that were sanded and could swivel. The smaller frame held 3 10cm2 plexiglass plates that were also sanded and could swivel. The larger frame was meant to be out sampling for 1 month while the smaller design was meant to be out sampling for 2 weeks. The rate at which most species including tunicates would settle during the fall and winter was not known therefore the two designs catered to the extremes of the possible realities. The larger design out for 1 month was meant to detect species if they settled slowly and in small numbers. While the smaller design out for 2 weeks was meant to detect species that settled quickly and in large numbers. The large and small frame design worked well at our protected marina sites, however half of the proposed study sites were exposed to the open ocean. To moor the large and small frames at the open ocean sites they were attached at the bottom to a cinderblock resting on the ocean floor (depth at these sites was less than 15m) and at the top to a buoy floating at the sea surface. The frame would then reside 2m below the sea surface. Open ocean storms can exert amazing force and proved so when one of the frames was nowhere to be found when we came to collect the plates. One possible explanation for the disappearance is that the cinder block was not heavy enough keep the ocean from dragging the entire apparatus away from the site where it was deployed. Another explanation is that the line used to connect the frame to the cinder block and buoy was not strong enough and broke. A break at either end would explain the result, however it's more likely that the line broke between the cinder block and the frame.

The next design was designed principally for the open ocean sites since the previous designs were lost in the field and thus inadequate. The second design (see Figure 7) was able to be ziptied to a buoy and thus more durable. The most recent design (see Figure 8) was essentially a cube made out of PVC pipe and plexiglass.

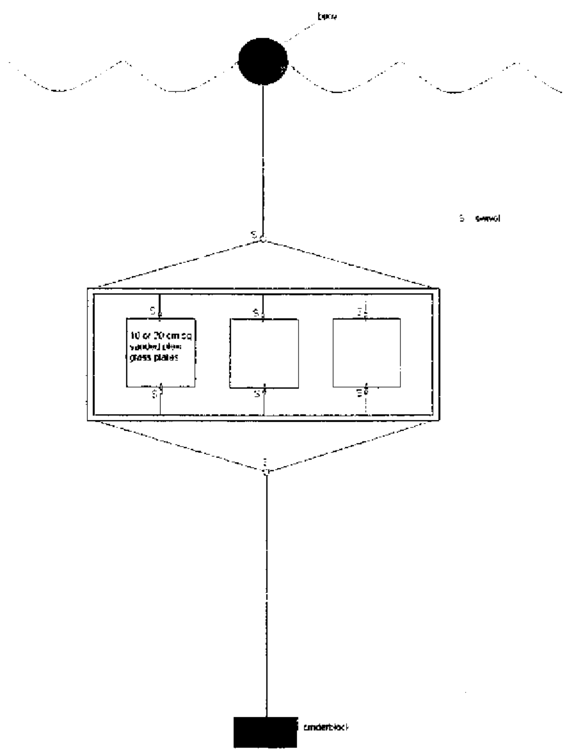

Figure 5- First frame design

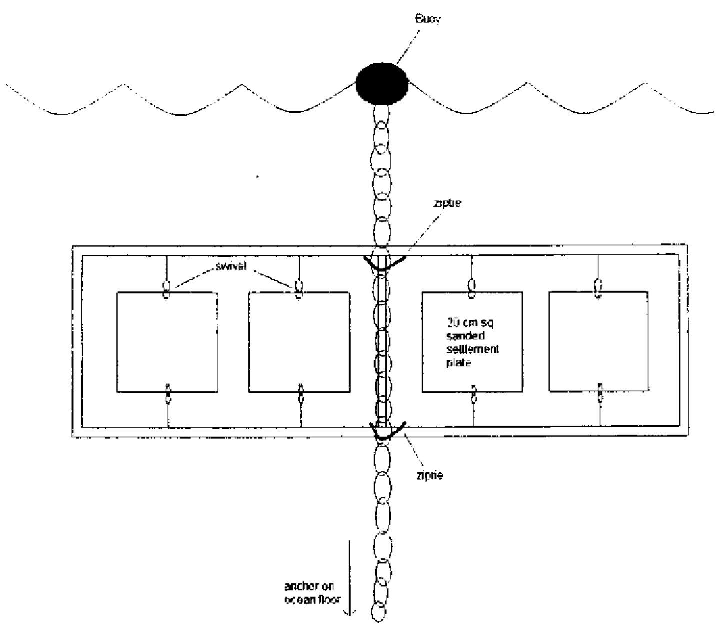

Figure 6- Second frame design

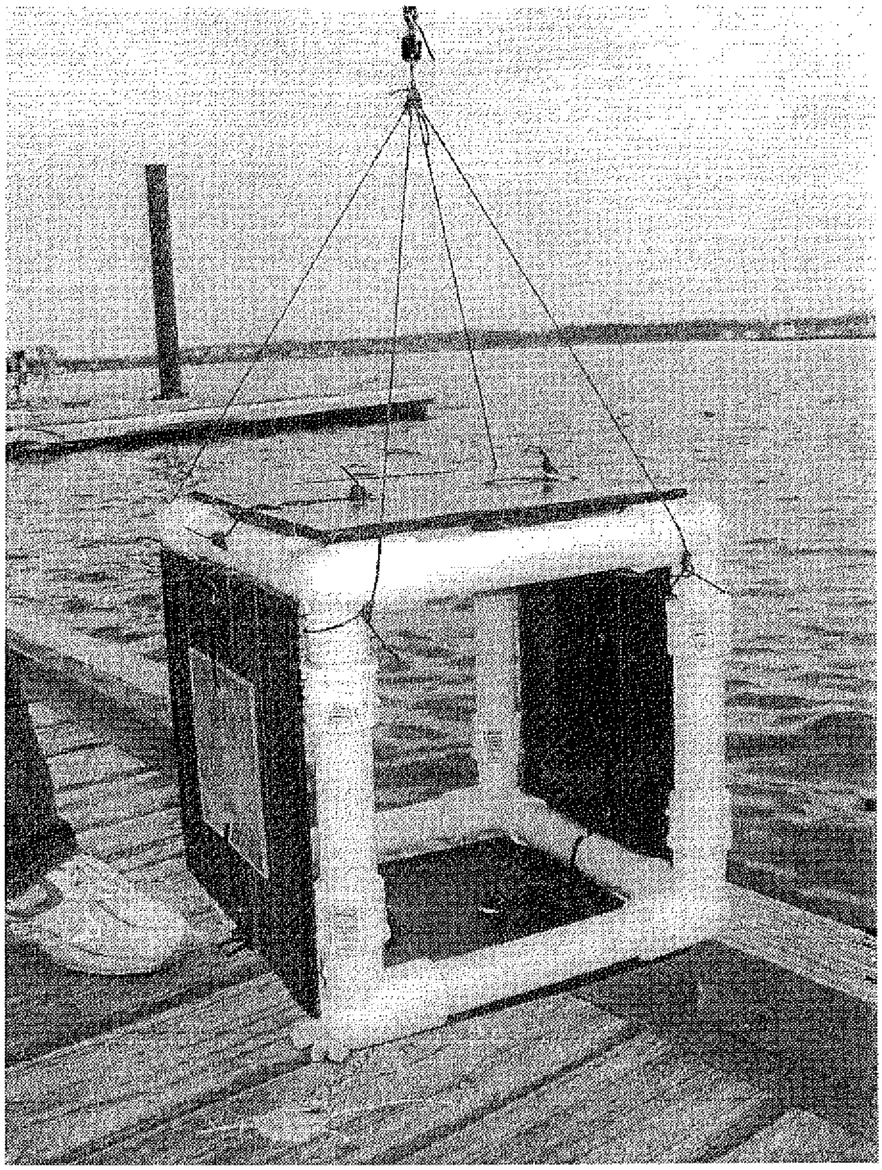

Figure 7 – Cube Design

LAB AND FIELD EXPERIMENTS

To further understand the relationship between river input and species proliferation, the three species were brought from the field into the laboratory for testing. All of the individuals were collected from Hawthorne Cove Marina in Salem, MA. The organisms were handpicked from random spots beneath floating docks and placed in seawater-filled plastic bags for approximately 1.5 hours. They were then transported into a 25 gallon tank filled with 10 ^{0}C seawater (32 –34ppt). The tank had one air stone and an underwater pump to provide a constant current. They were kept in a cold room and were fed live marine rotifers.

There were four salinitiy treatments (0ppt, 13ppt, 23ppt, 32ppt) done in triplicate. At each salinity, individual organisms were placed in a small container with an air stone and left over a period of 12 or 24 hrs. *A. aspersa* received the treatment for only 12 hrs while *B. violaceous* and *S. clava* received the treatment for 24 hrs. After treatments were given the subjects were put in full salinity seawater and left to recover for 24 hours. This allowed the subjects acclimate back to normal seawater and show signs of life. After recovery, subjects were studied under a dissecting microscope for changes in physical form and active pumping of water through the siphons.

A 48 hr transplantation trial was performed using *A. aspersa*, immersing the tunicate in waters that it is not normally found. The northern limit for *A. aspersa* is Salem, MA therefore it was transplanted to Great Bay Marina in Newington,NH as well as to the UNH Coastal Lab in Newcastle, NH. This experiment did not risk introduction of *A. aspersa* to New Hampshire's coastal waters because it has most likely been exposed many times in past years. *A. aspersa* is not absent from New Hampshire's coastal waters because it has no mode of transplantation but because of some environmental factor that prevents the tunicate from surviving.

RESULTS

MONITORING SYSTEM

Settlement from October through April showed a wide variety of patterns. From October through January settlement plates were covered in either diatoms , brown algae, or arborescent red algae. February brought the settlement of a host of new characters such as radiolarians, amphipods, green algae, more diatoms, gastropods, mussels, and copepods. The only invasive specie that settled on our panels was *Membranipora membranacea*. Recovery of plates reached a low during the winter because of harsh weather. The recovery rate of frames was not as low as recovery rate of plates because the swivels that attached the plates to the frame were weak, not the swivel or ziptie attaching the frame to a buoy or floating dock. As more designs have been tested the recovery rate has increased.

LAB AND FIELD EXPERIMENTS

All three organisms tested, *S.clava*, *B.violaceous* and *A.aspersa*, showed very similar responses to the different salinities. The subjects, from all three species, that were placed on the two lower salinities died and the ones at the two higher salinities survived (Table 1).

Organism

Salinity (ppt)	*S.clava*	*B.violaceous*	*A.aspersa*
0	Dead	Dead	Dead
13	Dead	Dead	Dead
23	Alive	Alive	Alive
32	Alive	Alive	Alive
Time (hours)	24	24	12

Table.1: Results from the laboratory salinity experiments. All organisms showed the same results however A. aspersa took less time to die.

Changes in the morphology of the organisms on the low salinities included color, softness, and internal rupturing of the tunic. The *B.violaceous* (Fig 10) subjects (had a very distinct color change from a bright orange to a dark purple and brown color and the consistency changed from a firm rugged texture to soft and "slimy" (Fig. 11) in all six subjects (0 ppt and 13 ppt). The S.clava organisms were harder to observe due to their thick outer layer but some changes were noticeable. Their size had decreased and they had turned to a soft spungy firmness. On the 0 ppt salinity the inner part of their siphon had separated from the outside wall. The most visible results were observed with the A.aspersa due to its transparent nature. On both the 0 ppt and the 13 ppt the siphons retracted to such an extent that they were extremely dense and easily visible by shining light behind them. One *A. aspersa* subjected to 0ppt had its tunic burst as shown in Figure 8.

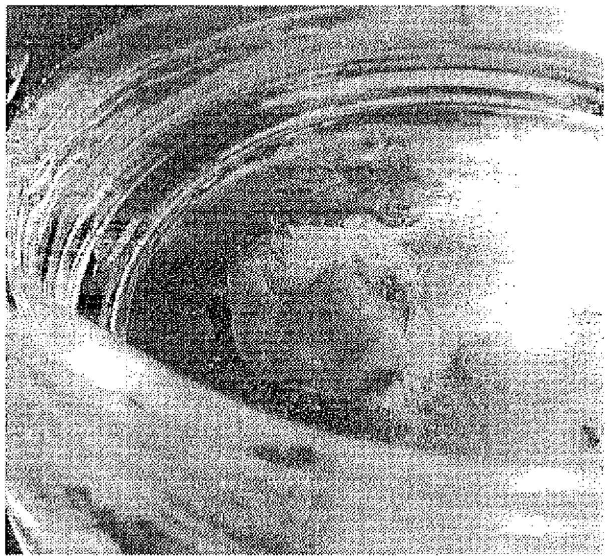

Fig. 8. The collapsed tunic of A. aspersa

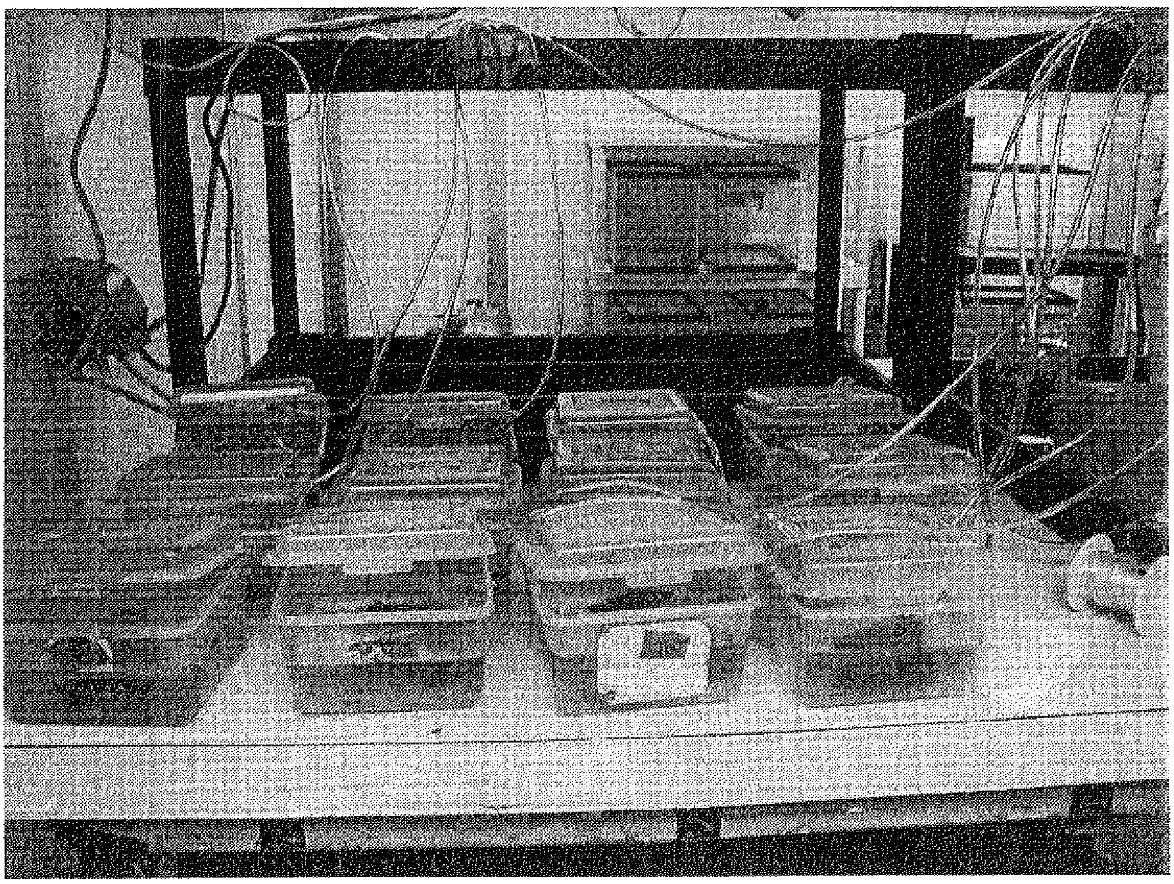

Fig.9. Salinity tests for <u>S. clava.</u> For every salinity concentration (0 ppt, 13 ppt , 23 ppt and 32 ppt) there are three organism in order to make it statistically significant. There is a constant supply of air to each container.

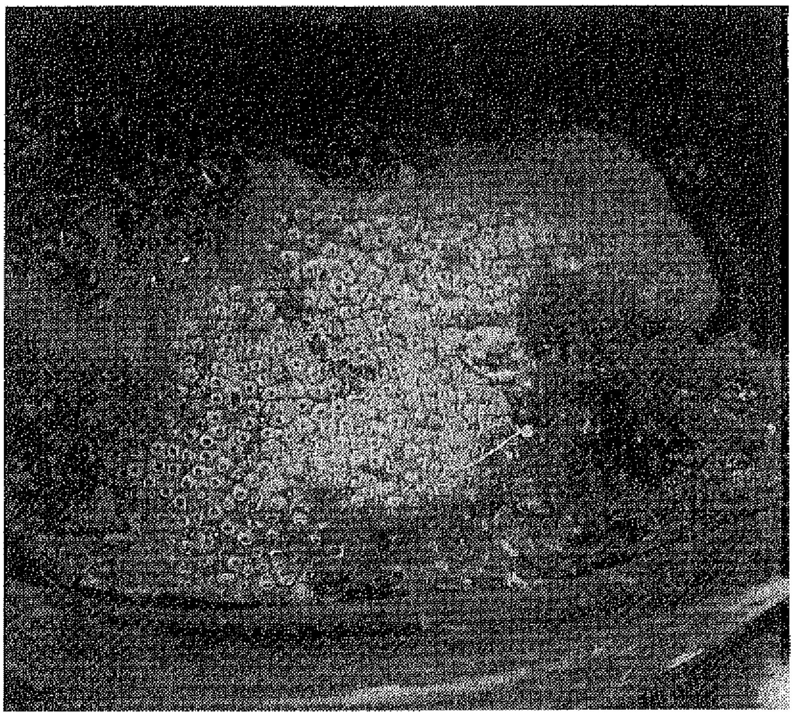

Fig 10. B. violaceous *prior to testing. Its bright orange color is clearly visible and the small siphons are all open*

Fig 11. B. violaceous *after 24 hrs under 13 ppt seawater. The color has faded and siphons have become less distinct as if it is out of focus.*

Boat Traffic in The Gulf of Maine

Each summer thousands of recreational craft travel up and down the east coast of North America. Though boats that come from New Hampshire are all taken out of the water in the fall, boats that come from more southern locations like Long Island Sound stay in the water year round. Boats that are kept in the water year round In the year of 2002, sixteen ships loaded cargo at Portsmouth, NH, thus discharging ballast water into the Piscataqua River. Also in 2002 204 ships unloaded cargo thus collecting Piscataqua River water and transporting it to the location where the tanker will load up with cargo next. The ships coming in and out of Portsmouth Harbor come from all over the world as shown by the list of homeports in appendix B. Ships that were loading and dumping ballast water came from various ports including but not limited to Algeria and the Bahamas.

DISCUSSION

LAB AND FIELD EXPERIMENTS

Although the laboratory procedure did not seem to show any trend between the organisms it did provide valuable information for future studies. By looking at the results obtained, it may be argued that the *A. aspersa* is less resilient to changes in salinity due to the fact that identical results were obtained among all species yet was subject to the treatment for half t he time the other species were.

Many unexpected problems were encountered during the laboratory experiments, which greatly reduced progress of the study. Such problems should be mentioned in order to aid similar future studies. The biggest problem encountered was an inability to measure the health of an organism. Prior to the start of the laboratory procedures, it was decided that the best way to analyze the organisms was to look at the filtering rates. This however proved to be not reliable due to two reasons: first there was no way to measure the filtering rates, and second, the organism would close their intake and excurrent siphons. The filtering rate problem was never solved and still remains as a very important source of information. The method tested to see filtering rate was the inject ink in the water that would, in theory, allow us to visualize water movement. Nevertheless the ink did not keep its consistency and dissolved in the water. No other products were added to the water due to the fact that they could potentially affect the way the organism filters thus affecting the outcome of the experiment.

The second problem, closing the siphons, was caused due to a natural reaction that most filter feeders have when under stress. This problem was solved by allowing the organisms to sit in full strength seawater over a period of 24 hr thus allowing them to open again. Although this solution seemed to work, it carried some problems. The most important aspect was that the organism could not be looked at immediately after testing. Studying the subjects immediately after they had been taken out of their respective salinities could have provide valuable information on how quick does the organism readjust to its normal salinity over time. Other ways used to check for responsiveness from the subjects during the experiments was by gently tapping on them with a laboratory probe. This would some times make the creature close its siphons even tighter or even open them allowing the observer to determine how quickly they respond (the longer they take the less healthy they are).

For future studies several aspects should be addressed prior to the laboratory practices. The first and most important is the above mention filtering rates and overall health of the organism. It is imperative that a reliable system is found to address this problem. With this resolved more tests may be carried out and thus further understanding of organisms may be possible.

GENERAL DISCUSSION

To answer the questions associated with the patchy local distributions of invasive species, lab tests exposing local tunicates to varied salinities and field tests of a recruitment panel design were performed. Not all of the questions were answered, but further research in each of these areas will increase the information available to invasive species research.

Lab tests showed fatality under 13ppt and no effect at or above 24ppt for each of the species observed. These results show a threshold salinity that creates a physical and distribution boundaries. Further research should focus at the 13ppt-24ppt range to find the pinpointed salinity below which each species cannot survive for an extended amount of time. The duration of exposure to these salinities should also be controlled to discover if some are capable of longer periods at these lowered salinities.

The many settlement panel designs attempted to create an optimal environment for the settlement of a diverse group of species. The final cube design incorporated different angles and a semi-protected inner environment that was not available on the earlier frames. Analysis of the settlement accumulated on this frame was not available at the time of publication; however, ongoing observations through the summer months of this and the other frame designs would be useful in comparing the effectiveness of this shape. Further investigations into the summer would also allow the panels to be exposed to increased larval densities in the water column, which would show the effectiveness of the plate design. The proposed monitoring designs should be, if built and maintained properly, an effective method of gaining insight to the amount of invasive organisms currently recruiting into the Gulf of Maine.

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APPENDIX A : MATERIALS

MONITORING SYSTEM

- 3/4 '' PVC TUBING AND FITTINGS
- PLEXIGLASS
- PLEXIGLASS CUTTER
- PLIERS
- NYLON ROPE
- ZIPTIES
- PVC GLUE
- BOX CUTTER
- SAW
- SWIVELS OF VARIOUS FORMS
- DUCT TAPE*

LAB EXPERIMENTS

- 1 LITER PLASTIC BOXES*
- AIR STONES
- TUBING
- MARINE ROTIFERS
- SEAWATER*
- 25 GALLON WATER TANK*
- DISSECTING MICROSCOPE*
- DIGITAL CAMERA*

* - used under both parts

APPENDIX B :

Portsmouth, NH Shipping records for the year of 2002

Date	Name of Vessel	Home Port	Cargo	unload	load
Jan-02	Ionia	Greece	Salt	unload	
Jan-02	Barge-KTC-115	USA	Kerosine	unload	
Jan-02	Roy Maersk	Denmark	Oil	unload	
Jan-02	Barge -Island 0	USA	Gas	unload	
Jan-02	Sichem Caribbean	Singapore	Tallow		load
Jan-02	Ceilo Di Londra	Libya	Oil	unload	
Jan-02	Uranus	Marshall Islands	Oil	unload	
Jan-02	Maria Green	Netherlands	Cable		load
Jan-02	CSL Atlas	Bahamas	Gypsum	unload	
Jan-02	Rickmeyers Seoul	Panama	General Cargo		load
Jan-02	Roy Maersk	Denmark	Oil	unload	
Jan-02	Chios Charity	Greece	Salt	unload	
Jan-02	Br. Alexandra	USA	Cement	unload	
Jan-02	Irving Canada	Barbados	Gas	unload	
Jan-02	Irving Canada	Barbados	Oil	unload	
Jan-02	Helios	Norway	Propane	unload	
Jan-02	Navios Pioneer	Panama	Coal	unload	
Jan-02	CSL Atlas	Bahamas	Gypsum	unload	
Jan-02	Wellington Kent	Canada	2 Oil	unload	
Jan-02	Irene	Greece	Salt	unload	
Jan-02	Barge - Cape Cod	USA	Oil	unload	
Jan-02	Pindar	Bahamas	Oil	unload	
Jan-02	The Monseigneur	USA	Kerosine, 2 Oil	unload	
Jan-02	Wellington Kent	Canada	Gas	unload	
Jan-02	Ceilo Di Londra	Libya	Oil	unload	
Feb-02	Nejma	Bahamas	Propane	unload	
Feb-02	Irving Eskimo	Canada	Oil	unload	
Feb-02	Beth B.	Panama	Salt	unload	
Feb-02	Lovely Lady	Malta	Gas	unload	
Feb-02	TOKI	Nassua	Salt	unload	
Feb-02	Irving Eskimo	Canada	Oil	unload	
Feb-02	Moon Sapphire	Libya	Oil	unload	
Feb-02	Gypsum Centennial	Bermuda	Coal	unload	
Feb-02	Wellington Kent	Canada	Oil	unload	
Feb-02	Thelassa Desgagnes	Canada	Asphalt	unload	
Feb-02	Azalea	Malta	Salt	unload	

Feb-02	CSL Atlas	Bahamas	Gypsum	unload	
Feb-02	Wellington Kent	Canada	Oil	unload	
Feb-02	Captain Michalis	Greece	Salt	unload	
Feb-02	Roy Maersk	Norway	Gas	unload	
Mar-02	Uranus	Marshall Islands	Gas	unload	
Mar-02	Ceilo Di Londra	Libya	Oil	unload	
Mar-02	Havis	Norway	LPG	unload	
Mar-02	Barge-KTC-115	USA	Kerosine	unload	
Mar-02	Barge - PENN	USA	Asphalt	unload	
Mar-02	Irving Eskimo	Canada	Oil	unload	
Mar-02	Chembulk Singapore	Libya	Caustic	unload	
Mar-02	Navios Pioneer	Panama	Coal	unload	
Mar-02	Irving Canada	Canada	Diesel	unload	
Mar-02	Alice Oldendorff	Libya	Gypsum	unload	
Mar-02	Thelassa Desgagnes	Canada	Asphalt	unload	
Mar-02	Barge-RTC-120	USA	Oil	unload	
Mar-02	Barge- B-240	USA	Gas	unload	
Mar-02	Irving Eskimo	Canada	2 Oil	unload	
Mar-02	Navios Pioneer	Panama	Coal	unload	
Mar-02	Kurzeme	Libya	LPG	unload	
Mar-02	Clipper Skagen	Norway	LPG	unload	
Mar-02	Nordscott	Bahamas	Diesel	unload	
Mar-02	Barge-B-125	USA	Gas	unload	
Apr-02	Alice Oldendorff	Libya	Gypsum	unload	
Apr-02	Barge Bulkmaster	USA	Coal	unload	
Apr-02	Barge - PENN-410	USA	Asphalt	unload	
Apr-02	Irving Canada	Canada	Oil	unload	
Apr-02	Irving Canada	Canada	Oil	unload	
Apr-02	Br. Alexandra	USA	Cement	unload	
Apr-02	Ambassador	Vanuatu	Gypsum	unload	
Apr-02	Barge-B-120	USA	Oil	unload	
Apr-02	Alice Oldendorff	Libya	Gypsum	unload	
Apr-02	Barge - PENN-410	USA	Asphalt	unload	
Apr-02	Uranus	Marshall Islands	Oil	unload	
Apr-02	Wave Sentinel	Britain	Cable		load
Apr-02	Nejma	Bahamas	LPG	unload	
May-02	Barge-B-120	USA	Gas	unload	
May-02	Akedemik Semenov	Cyprus	Tallow		load
May-02	New Rive	USA	Diesel	unload	
May-02	Antwerpen	Canada	Coal	unload	
May-02	Maersk Rochester	Denmark	Oil	unload	
May-02	Barge Ironmaster	USA	Coal	unload	
May-02	Dock Express 20	Netherlands	Cable		load
May-02	Dock Express 20	Netherlands	Cable		load

May-02	Nordscott	Bahamas	Oil	unload	
May-02	Chios sea	Panama	scrap		load
May-02	Barge Ironmaster	USA	Coal	unload	
May-02	Barge-KTC-155	USA	Oil	unload	
May-02	Minverva Julie	Malta	Gas	unload	
May-02	Barge Bridgeport	USA	Coal	unload	
May-02	Barge - PENN 400	USA	Asphalt	unload	
May-02	Jo Cedar	Netherlands	Caustic	unload	
May-02	Barge Ironmaster	USA	Coal	unload	
May-02	Barge - PENN 400	USA	Asphalt	unload	
May-02	neptune	Marshall Islands	Oil	unload	
May-02	CSL Atlas	Bahamas	Gypsum	unload	
May-02	Barge -Island 60	USA	Gas	unload	
May-02	Ambassador	Vanuatu	Gypsum	unload	
Jun-02	Barge-B-120	USA	Oil	unload	
Jun-02	Barge - PENN-410	USA	Asphalt	unload	
Jun-02	Barge - PENN 400	USA	Asphalt	unload	
Jun-02	Barge Somerset	USA	Coal	unload	
Jun-02	Irving Canada	Canada	Gas	unload	
Jun-02	neptune	Marshall Islands	Oil	unload	
Jun-02	Navios Pioneer	Panama	Coal	unload	
Jun-02	Irving Eskimo	Canada	Gas	unload	
Jun-02	Barge-B-130	USA	Gas	unload	
Jun-02	Barge-B-125	USA	Gas	unload	
Jun-02	Barge - PENN 400	USA	Asphalt	unload	
Jun-02	Alice Oldendorff	Libya	Gypsum	unload	
Jun-02	Barge - PENN 400	USA	Asphalt	unload	
Jul-02	C.S. Baron	Netherlands	Cable		load
Jul-02	Sichem Mediteranean	Singapore	Tallow		load
Jul-02	Balder	Norway	Salt	unload	
Jul-02	CSL Atlas	Bahamas	Gypsum	unload	
Jul-02	Barge-KTC-155	USA	Oil	unload	
Jul-02	Irving Canada	Barbados	Oil	unload	
Jul-02	Ambassador	Vanuatu	Gypsum	unload	
Jul-02	Havis	Norway	LPG	unload	
Jul-02	Ambassador	Barbados	Salt	unload	
Jul-02	Barge -Island 60	USA	Gas	unload	
Jul-02	Irving Canada	Canada	Diesel	unload	
Jul-02	Barge Penn 400	USA	Asphalt	unload	
Jul-02	Jo-Miro-D	Italy	Caustic	unload	
Jul-02	Barge - PENN 400	USA	Asphalt	unload	
Jul-02	Ambassador	Barbados	Salt	unload	
Jul-02	Wellington Kent	Canada	Gas	unload	
Jul-02	NOAA Ronald Brown	USA	none	unload	

Jul-02	Navios Pioneer	Panama	Coal	unload	
Aug-02	C.S. Baron	Netherlands	Cable		load-
Aug-02	Irving Canada	Canada	Diesel	unload	
Aug-02	Barge Patomac	USA	Asphalt	unload	
Aug-02	Irving Canada	Canada	2 Oil	unload	
Aug-02	Barge B 55	USA	Gas	unload	
Aug-02	Nordscott	Bahamas	Gas	unload	
Aug-02	CSL Atlas	Bahamas	Gypsum	unload	
Aug-02	Barge Bridgeport	USA	Coal	unload	
Aug-02	Barge Patomac	USA	Asphalt	unload	
Aug-02	Barge Adalaide	USA	Cement	unload	
Aug-02	Four Etoiles	Bahamas	Oil	unload	
Aug-02	Lodestar Queen	Panama	Tallow		load
Aug-02	Barge - PENN 400	USA	Asphalt	unload	
Aug-02	Irving Eskimo	Canada	Oil	unload	
Aug-02	Barkald	Norway	Coal	unload	
Aug-02	Asphalt Star	Greece	Asphalt	unload	
Aug-02	Thelassa Desgagnes	Canada	Asphalt	unload	
Aug-02	Swan	Cyprus	Salt	unload	
Sep-02	Navios Pioneer	Panama	Coal	unload	
Sep-02	Irving Canada	Canada	Oil	unload	
Sep-02	Ambassador	vanuatu	Gypsum	unload	
Sep-02	Wellington Kent	Bahamas	Oil	unload	
Sep-02	Barge-KTC-71	USA	Oil	unload	
Sep-02	Sunniva	Panama	Caustic	unload	
Sep-02	Barge - PENN-410	USA	Asphalt	unload	
Sep-02	Navios Pioneer	Panama	Coal	unload	
Sep-02	Havis	Norway	LPG	unload	
Sep-02	Pioneer	vanuatu	Gypsum	unload	
Sep-02	Maersk Rochester	Norway	Oil	unload	
Oct-02	Barge-B-175	USA	Oil	unload	
Oct-02	Maersk Rochester	Norway	Oil	unload	
Oct-02	Maersk Rochester	Norway	Oil	unload	
Oct-02	Viking Lady	Libya	Oil	unload	
Oct-02	Barge Gulfstream	USA	Asphalt	unload	
Oct-02	Nordeuropa	Denmark	Gas	unload	
Oct-02	Elver	Greece	Salt	unload	
Oct-02	Maersk Rochester	Norway	Oil	unload	
Oct-02	Evros	Greece	Gas	unload	
Oct-02	Navios Pioneer	Panama	Coal	unload	
Oct-02	Barge - PENN-410	USA	Asphalt	unload	
Oct-02	Panam Flota	Panama	Tallow		load
Oct-02	Barge Penn 460	USA	Oil	unload	
Oct-02	USNS Zeus	USA	Cable	unload	

Oct-02	Eleoussa	Malta	scrap		load
Oct-02	Cielo di Selerno	Libya	Kerosine	unload	
Oct-02	Wellington Kent	Bahamas	Diesel	unload	
Oct-02	Barge B 55	USA	Gas	unload	
Nov-02	Pioneer	vanuatu	Gypsum	unload	
Nov-02	Barge RTC 503	USA	Oil	unload	
Nov-02	Barge B 210	USA	Gas	unload	
Nov-02	Stolt Heron	Libya	Tallow		load
Nov-02	Barkald	Norway	Coal	unload	
Nov-02	Irving Canada	Canada	Oil	unload	
Nov-02	World Trumpet	Panama	Oil	unload	
Nov-02	CSL Atlas	Bahamas	Gypsum	unload	
Nov-02	Barge Penn 90	USA	Asphalt	unload	
Nov-02	Barge Florida	USA	Oil	unload	
Nov-02	Barge B 35	USA	Gas	unload	
Nov-02	Irving Canada	Canada	Oil	unload	
Nov-02	Melini	Libya	Salt	unload	
Nov-02	Barge KTC 135	USA	Oil	unload	
Nov-02	Axion	Malta	Salt	unload	
Nov-02	Pioneer	vanuatu	Gypsum	unload	
Nov-02	Irving Canada	Canada	Oil	unload	
Nov-02	Irving Canada	Canada	Gas	unload	
Nov-02	Baltic Chief	Cyprus	Oil	unload	
Nov-02	Irving Canada	Canada	Oil	unload	
Nov-02	Gali	Marshall Islands	Caustic	unload	
Nov-02	Nejma	Bahamas	Propane	unload	
Nov-02	Barge B 65	USA	Gas	unload	
Nov-02	Aquamar	Cyprus	Oil	unload	
Dec-02	Barkald	Norway	Coal	unload	
Dec-02	Acushnet	Bahamas	Gas	unload	
Dec-02	Wellington Kent	Bahamas	Oil	unload	
Dec-02	Barge Adalaide	USA	Cement	unload	
Dec-02	Irving Canada	Canada	Oil	unload	
Dec-02	Barge-B-160	USA	Oil	unload	
Dec-02	Irving Eskimo	Canada	Oil	unload	
Dec-02	Uranus	Marshall Islands	Oil	unload	
Dec-02	Sky Bulker	Panama	Salt	unload	
Dec-02	Barge KTC 71	USA	Oil	unload	
Dec-02	Barge B 35	USA	Gas	unload	
Dec-02	Barge - PENN 300	USA	Oil	unload	
Dec-02	Maersk Rochester	Britain	Oil	unload	
Dec-02	Nordeuropa	Netherlands	Oil	unload	
Dec-02	Advance	Singapore	Oil	unload	
Dec-02	Barge B 45	USA	Kerosine	unload	

Dec-02	Barge B 4 5	USA	Kerosine	unload	
Dec-02	Pioneer	vanuatu	Gypsum	unload	
Dec-02	Gypsum Centennial	Bermuda	Coal	unload	
Dec-02	Clipper lady	Norway	Propane	unload	
Dec-02	Athenian Freedom	Malta	Oil	unload	
Dec-02	Vega	Marshall Islands	Gas	unload	
Dec-02	Barge B 4 5	USA	Kerosine	unload	
Dec-02	Vega	Marshall Islands	Gas	unload	