Marine Invasive Species Benthic Fouling Study

A Salem Sound Coastwatch field study of lobster trap fouling conducted in Salem Sound
July – October, 2010

Report prepared by
Niels Hobbs,
Marine biologist
and
Cheyenne Azadan,
Coastal researcher

Salem Sound COASTWATCH

As part of the fulfillment of a grant awarded Salem Sound Coastwatch by the Massachusetts Office of Coastal Zone Management (CZM).

Salem Sound Coastwatch
201 Washington Street, suite 9
Salem, Massachusetts 01970
salemsound.org

Project Summary

This project sought to expand the monitoring of marine invasive species to the deeper waters of Salem Sound, and to research fouling impacts on fishing gear. Through a partnership with local lobstermen, Salem Sound Coastwatch was able to catalog fouling organisms on lobster traps within Salem Sound, and provide education and outreach to the fishing community.

INTRODUCTION

The spread of invasive species is widely considered to be one of the greatest threats to biodiversity. This threat can be particularly acute in the marine realm where there are few physical barriers to prevent the dispersal of non-native species, and global commerce now allows rapid movement of species across whole oceans. The coastline of New England has been hard-hit by such invasions, with some whole taxa and habitats entirely dominated by non-native species. Thus far, a great deal of study of marine invasion in the region's waters has centered on conducting monthly surveys of floating dock and rocky shore sites, as they are easy to reach and are often the first point of arrival and establishment for non-native species. Effective study, particularly over time, of invasive species in subtidal waters proves more difficult, being generally a matter for infrequent trawls that pull up a large jumble of specimens that are taken without context of their natural settlement and growth patterns. One such trawl was conducted in 1997 in Salem Sound, but since then no other study has focused on the status and composition of invasive species in inshore waters of Salem Sound, and nearby northshore Massachusetts coastal waters.

This project sought to expand the work of Salem Sound Coastwatch (SSCW) in its efforts to monitor established populations of coastal and marine invasive species and to watch for new invasions of priority species. SSCW's Coastal Habitat Invasives Monitoring Program has been monitoring floating docks and intertidal areas since 2004, but the deeper waters of Salem Sound have not been monitored since the 1997 trawl. Those trawl surveys identified four species of non-native ascidians (tunicates), two invasive invertebrates (European oyster and green crab), and one algae (*Codium fragile* ssp. *tomentosoides*). The fouling organisms, golden star tunicate (*Botryllus schlosseri*), orange sheath tunicate (*Botrylloides violaceus*) and *Didemnum* sp., were common at Beverly Cove and the Danvers River, and occasionally at other trawl stations. The solitary club tunicate (*Styela clava*) commonly occurred in Danvers River while green fleece (*Codium fragile* ssp. *tomentosoides*) was found in trawl and seine catches at a low frequency. This is in line with the invasive species composition of floating dock communities found around Salem Sound, as recorded by SSCW's ongoing surveys that started in 2004.

In order to extend our understanding of local invasive marine species dynamics, the present project worked with local commercial lobster fishermen and their vessels as research and monitoring platforms to document the fouling organisms that have been observed but not previously identified or quantified on lobster traps in the Sound. To that end, the fouling organisms that grow on lobster traps were documented for native and non-native species composition, as well as the distribution and abundance of non-native species. In doing so, this project addressed the existing priority goals of the Marine Invader Monitoring and Information Collaborative (MIMIC): 1) to find introduced non-native marine species before they spread and/or become established in the ecosystem, 2) to educate the general public about marine invasive species and how to reduce their spread, and 3) to provide data to all interested users.

The study's working hypothesis is that the same fouling organisms will be found on the lobster traps that are found at surveyed docks. Furthermore, this research has the potential to answer many questions, beyond just general patterns. Particularly, we sought to determine which species comprised fouling communities, and how many of these species are not native to these waters. We wanted to know if there were any patterns of growth, such as do some fouling species only grow on certain parts of traps, or solely on lines, etc, or possibly just fouling directly on other animals in the traps, particularly lobsters and crabs. Also, we were interested in learning if any measurable parameters accounted for differences in fouling communities on different traps, such as geographic region (particularly in and out of Salem Sound), water temperature, depth, or bottom type.

METHODS

SSCW partnered with two local lobstermen, husband and wife team Jay and Susan Michaud, who have several decades of fishing experience between them. Additionally, both have assisted with previous state and federal research projects, so they were very amenable to having SSCW staff on board. We went out with them once a month, starting the second week of July 2010, soon after their traps had been placed in the water for the start of the fishing season. Each month following, for the next four months, we worked on board the Michaud's fishing boat, as each trawl (line of connected traps) was hauled up to retrieve any caught lobsters. We went out each month for as many days as it took to haul up each of approximately 70 total trawls, with 10 traps per trawl; typically this took four or five full days each month. 53 trawls were placed around Salem Sound and the waters just around the islands at the mouth of the sound. Another 17 trawls were placed outside the Sound, south of Marblehead Neck, near Tinkers Island and Devereux Beach. These traps were placed a month later than the Salem Sound ones, so analysis of data from these traps will reflect this difference

As each trawl of ten traps was hauled onto the boat, we focused on a subset of three traps as a more manageable task that was sufficiently representative of the overall trawl. We selected the third, sixth, and ninth trap on each line, as these were the easiest and safest to inspect while on the back deck of the boat. Each trap we examined was first photographed and then manually examined to record the abundance and distribution of any fouling organisms growing on the sides, top and netting of the trap. Each month we took one overall high-resolution digital photograph of each trap, and any necessary close-up photos of unusual or noteworthy growth. We then carefully inspected and documented the identity of fouling organisms as determined on the spot. Unknown species were either collected and preserved for later identification, or photographed in a manner sufficient for positive identification when ashore.

While the primary focus of this project was the study of fouling invasive species, a record was made of all organisms found in or on the traps, including all lobsters, crabs, hermit crabs, large snails, and incidental algae that washed into the traps. Some fouling species that were either generally known to be native (such as hydroids), or were simply too difficult to distinguish to species level in a practical fashion (such as flatworms or filamentous algae) were cataloged by their general common name and were placed in larger general groups for the purpose of this study. Each species or organism grouping was given an abundance ranking of 1 to 3, with 1 being rare or few individuals or very small patches, 2 being common or more widespread in at least a few places on the trap, and 3 being dominant and widespread over much of the trap. Additionally, a record was made of how each species was distributed on each trap; whether they were on the sides, top, or on the netting of the trap (the nature of trap placement effectively precluded any fouling on the bottom of traps).

Both abundance and distribution were conducted by a single trained observer for the entirety of the study in order to minimize error. For each trawl inspected, observations were grouped into geographic regions (Figure 1: Salem Harbor, North Sound, South Sound, Mid Sound, Outer Islands, Inshore South of Marblehead Neck, and Outer-shore South of Marblehead Neck), bottom type (Mud, Gravel, Cobble, Hard Bottom, Sand, and Eelgrass), and Depth (0'-20', 21'-39', 40'+). Trawl locations were solely placed at the discretion of the boat captain, so a random sampling across the Sound was not possible.

DATA ANALYSIS

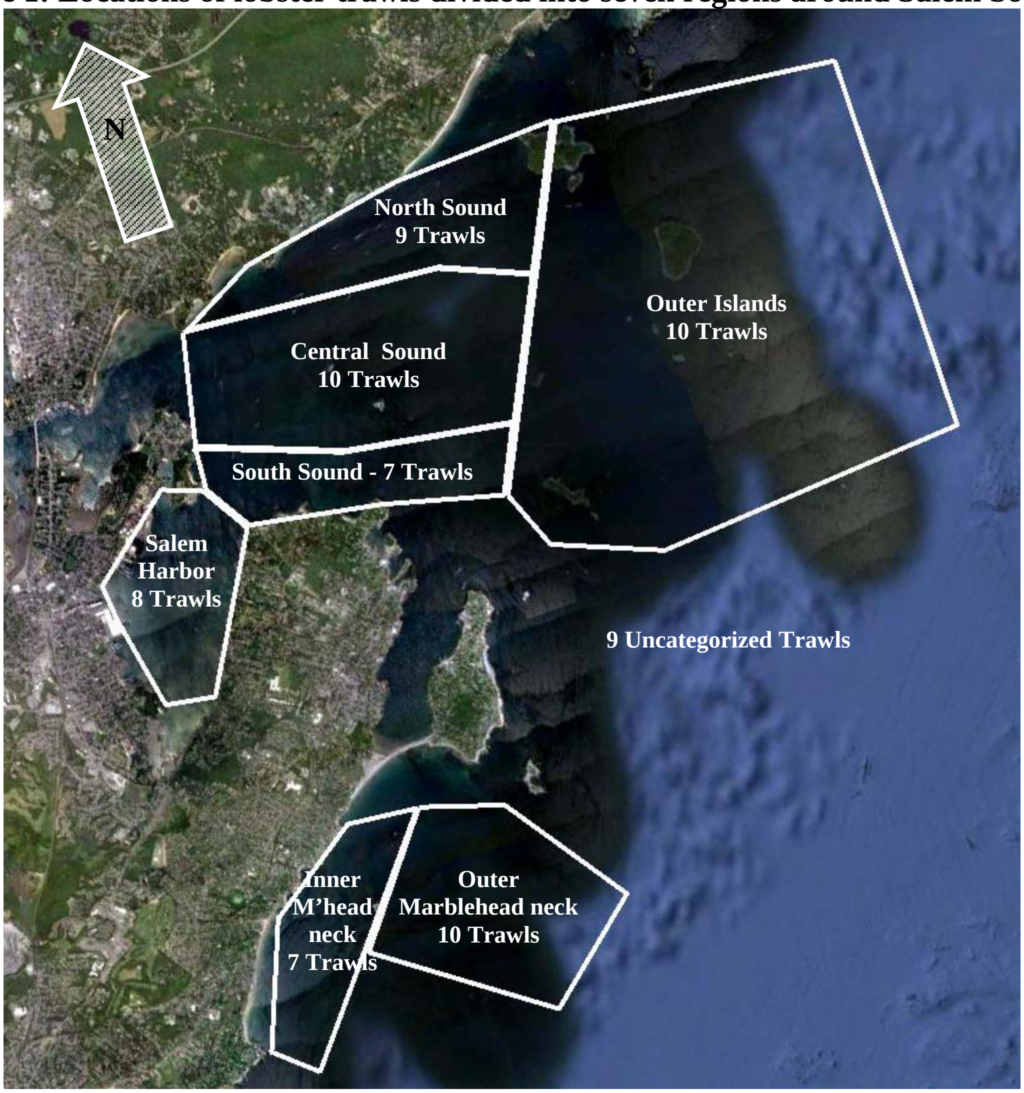
After the data were collected and organized within the three categories (geographic regions, bottom type, and depth), they were condensed into manageable averages. Each species' abundance rankings, for example, were averaged for each trawl, so that each of the three traps examined for each trawl produced just one final abundance number, between 0 and 3, for that particular trawl in that particular month. Similarly, the observed distribution of organisms on each trap was first converted to a 0-to-3 numeric ranking similar to abundance, with 1 indicating the organism was only found on one portion of a trap, whether top, side, or netting. A distribution score of 2 indicated an organism was recorded on two parts of a trap (top, and netting, for example), and a 3 indicated an organism was recorded on all three possible parts of a trap. Likewise, these distribution rankings for each trap were averaged to create a single ranking for each trawl. Finally, abundance rankings across all four months were combined to give an overall abundance for each species, which was then used to look for patterns based on geographic, bottom-type, and depth groupings. For each of these three groupings, consistency was required over the course of the study so that, for example, to be grouped in the "Mud" bottom-type group, a particular trawl had to be recorded as being in mud for at least the first three months, contingent on the fouling patterns observed.

RESULTS

Fieldwork took place over a total of thirteen full days aboard the *F/V International Harvester* for the four months of the study: two days in July, three in August, and four each in September and October. A total of 29 trawls were hauled and 87 traps inspected in July; 69 trawls hauled and 207 traps inspected in August, and 70 trawls hauled and 210 traps inspected in both September and October. Each month saw a steady increase in fouling, with September and October seeing a comparably heavy amount of fouling. All four months saw large amounts of incidental fouling from algae washed into many traps as well as a lot of mobile animals captured in the traps, including *Homarus americanus* lobster, *Cancer* spp. crabs, *Pagurus acadianus* hermit crabs, *Buccinum undatum* snails, and several species of fish (particularly Scorpaeniformes and Rajiformes). Given their mobile nature, these species are not analyzed in this report, though some larger snails, hermit crabs, and, to a limited extent, crabs and lobsters showed some fouling on their shells.

Over the course of the field study, the trawls were generally moved from shallower and warmer waters to deeper and colder waters, as the lobsters started to move away from more near-shore habitats (Figure 1). As the four months of fieldwork progressed, and fouling increased, the crew of the *International Harvester* began cleaning off traps to make them easier and safer to haul; however, fouling on the traps we were inspecting were left intact. As the floats and lines for each trawl became more fouled, they were cleaned using sprayed-on bleach and hand-scrubbing, but were generally fouled again by the next month, no matter the location of the trawl.

Figure 1: Locations of lobster trawls divided into seven regions around Salem Sound



By September, all 53 trawls that comprised the Salem Sound subset (see Figure 1) were generally well-fouled and showed a large variety of species from encrusting tunicates, hydroids, bryozoans, to small mobile snails, acoel flatworms, and amphipods. The 17 trawls that were outside of the sound, on the southern side of Marblehead neck (see Figure 1), showed much less fouling by the end of the study; some appeared to be nearly as clear of fouling in October as they did at the project start in August. Overall, most growth seemed to occur in the middle months of the study, as a result of location in the first months of the study, so location (for all three general groups) in the first month was given twice as much weight as the second and third month, i.e. when adding up abundances across the four months for each species, the location in the first month was counted twice as that month seemed to have the greatest impact on overall fouling patterns.

By the fourth month, for all trawls, growth appeared to level off (see Table 1, which shows the complete list of fouling species recorded) and, therefore, the location of trawls in this final month were not factored when grouping trawls into the different location categories. The only exception to this weighting method was made for those trawls that spent the first month in Salem Harbor but were then moved to sites outside of the harbor. The boat captain felt that fouling would become too great on these traps to make them practical or safe to haul, so they were moved after a month and no further trawls were placed in the harbor for the rest of the study. Nonetheless, given the high degree of fouling that did occur on these traps regardless of subsequent location, grouping based solely on this one month was deemed appropriate (Figure 2 presents photographs, over the full four months, of the fouling occurring on a trap that started in Salem Harbor).

For geographic location, trawls were divided into seven categories, based on the patterns of trawl placement over the course of the first three months of the study: Salem Harbor with ten trawls, South Sound with seven, Mid Sound with ten, North Sound with nine, Outer Islands with ten, Outer-shore South of Marblehead Neck with ten, and Inshore South of Marblehead Neck with seven trawls. Nine trawls were not geographically categorized, as their location was not consistent. Geographic location demonstrated clear differences in the species composition of fouling communities found on traps, particularly with a few key species (Figure 7). Inner sound trawls, particularly those that started in Salem Harbor, showed a much greater amount of overall fouling, particularly by the invasive solitary tunicate *Ascidiella aspersa*, with an overall abundance of 2.22, hydroids (mostly native genera *Ectopleura* or *Tubularia*), with an overall abundance of 1.9, and the invasive colonial tunicate *Botrylloides violaceus*, with an abundance of 1.37.

The three geographic regions in the main part of the sound, the North, Middle, and South, all had comparable abundances of fouling species across their areas, with some similarity to the Salem Harbor trawls, though these three areas had a lot less *A. aspersa* and more algal growth (primarily unidentified filamentous Rhodophyta, and slender unbranching Phaeophyta). All three areas had relatively common amounts of three invasive colonial tunicate species: *B. violaceus*, *Diplosoma listerianum*, and *Botryllus schlosseri*, as well as the small native bivalve, the jingle shell, *Anomia* sp. Of the three, the central sound area had the least amount of fouling (see Figure 3) The Outer Islands had almost no *A. aspersa*, with an abundance of 0.09 but a disproportionately greater amount of *D. listerianum* than any other site, with an abundance of 1.71. Otherwise, there was much less fouling than in any of the inner sound sites (see Figure 4). The greatest difference in fouling composition, though, occurred among the trawls located south of Marblehead neck,

Table 1: Occurrences of fouling species, by month

Species	July	August	September	October
Ciona intestinalis	**0**	**4**	**6**	**16**
Styela clava	**0**	**0**	**2**	**8**
Molgula spp.	0	4	1	1
Ascidiella aspersa	**0**	**30**	**84**	**112**
Botrylloides violaceus	**0**	**150**	**179**	**190**
Botryllus schlosseri	**0**	**9**	**58**	**76**
Didemnum vexillum	**0**	**0**	**0**	**2**
Diplosoma listerianum	**0**	**4**	**111**	**149**
***Membranipora* spp.**	**0**	**11**	**97**	**122**
Encrusting Bryozoans (**?**)	0	26	10	40
Bushy Bryozoans (**?**)	0	1	8	8
Hydroids (**?**)	17	94	186	195
Flatworms (?)	0	30	41	20
Crepidula spp.	2	6	44	60
Notoacmea testudinalis	0	1	0	3
Anomia spp.	0	3	92	142
Mytilus edulis	0	0	2	5
Barnacles (**?**)	0	3	0	6
Caprellid amphipods (**?**)	0	1	0	1
Amphipods (**?**)	0	25	19	37
Filamentous algae (?)	0	103	53	29
macroalgae – brown + red (**?**)	0	0	14	12

Table 1 shows the number of times each listed fouling species was recorded as present on an examined trap for each month of the study, regardless of abundance or distribution on traps. **Red** denotes invasive species; **?** denotes unidentified species or groups which may include invasive species.

with little fouling being recorded there, as demonstrated in Figure 7.

Factoring depth as a possible cause for fouling patterns, 14 trawls were categorized as shallow (0-20’), 23 trawls as mid-depth (21-39’), and 31 as deep (40’+). When fouling species abundance data were organized into these depth categories, a distinct pattern was seen for most of the common fouling organisms (Figure 8). The invasive tunicates, *A. aspersa*, *B. violaceus*, and *D. listerianum*, as well as the general hydroid group, all showed a decrease in abundance as depth increased, most clearly among *A. aspersa*. The sole exception is the native bivalve, the jingle shell, *Anomia* spp., which showed no clear difference across all three depths. When using bottom type to determine causes for fouling patterns, the lack of trawls consistently in any given substrate over the course of the study made conclusions difficult. Only two substrates, mud (8 trawls) and gravel (12 trawls), were sufficiently comparable. Regardless, unlike geography and depth, no clear pattern can be deduced from the most common fouling species found based on bottom type (Figure 9).

Significant physical differences were observed between the two major areas trawled (Salem Sound and south of Marblehead). Particularly, the south of Marblehead trawls were in greater depth, on a more homogeneous bottom type, and were exposed to colder water temperatures, compared to Salem Sound trawls. Furthermore, they were not in use for the first month of the study. Despite the differences, particularly the shorter time frame and later start, these 17 trawls are useful as a contrast to the trawls from the sound.

Figure 7: Abundance of most common fouling organisms by geographic location

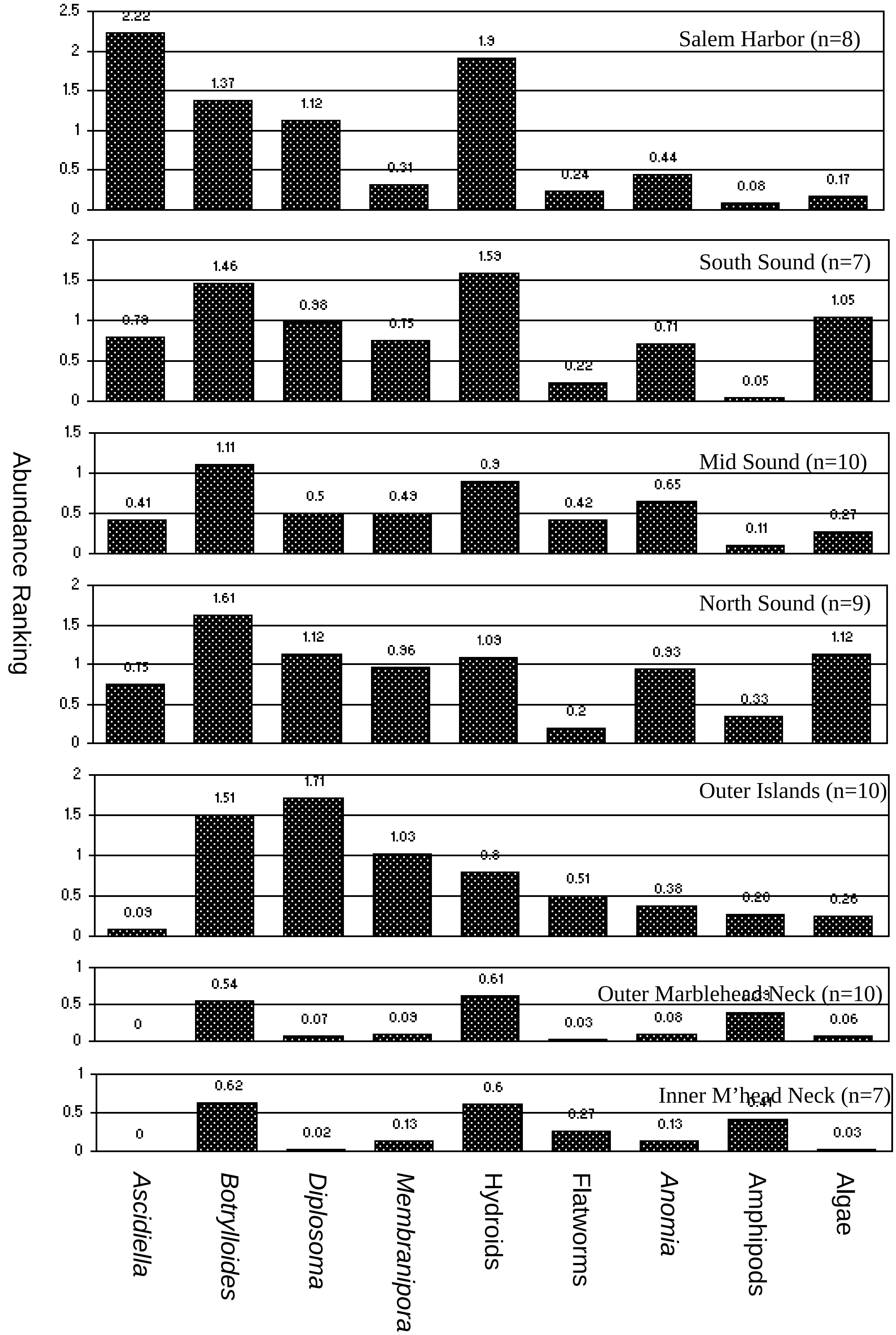


Figure 8: Abundance of most common fouling organisms by depth

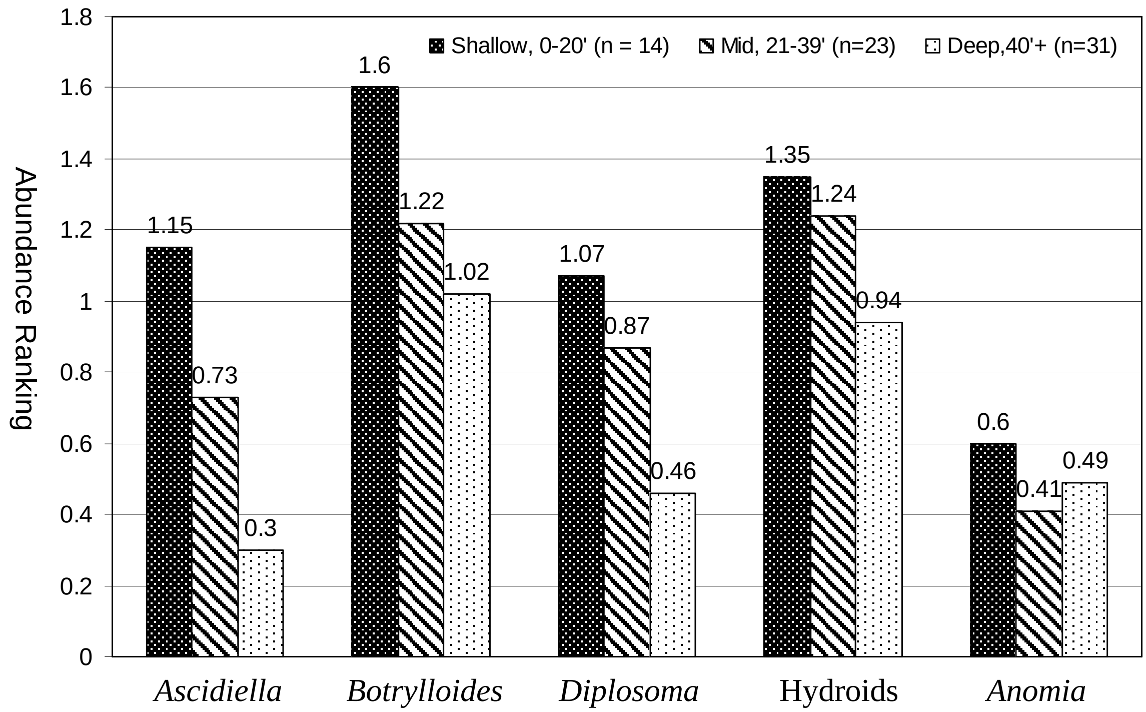
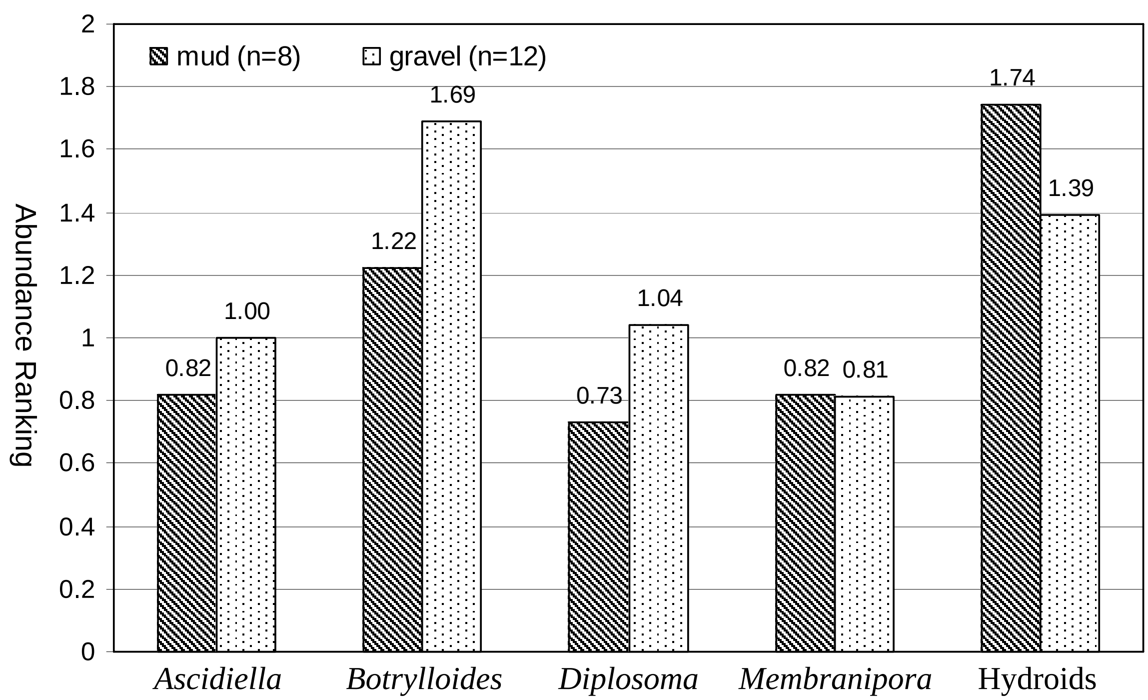


Figure 9: Abundance of most common fouling organisms by bottom type



DISCUSSION

Fouling increased substantially after the first month and then leveled off for the last month (Table 1), though the actual cause of this is not clear based on the present research. Most likely, this pattern correlates to either a decrease in water temperature, or an increase in depth, or both, as both occurred as traps were moved farther toward the outer boundary of Salem Sound over the course of the fishing season. These patterns, and the likely explanations, are corroborated by comments made by local lobstermen as part of this project's survey of them. As both depth and temperature are closely linked, it is not surprising that fouling became so dense on traps from near-shore sites. Fouling was most pronounced on the trawls that started in the shallow Salem Harbor area (see Figure 2, versus Figs. 3 and 4) in July, when both water temperature and larval recruitment are typically near their peaks. It is also possible that this region of the sound saw such extensive fouling due to its more enclosed hydrology, experiencing less flushing with fresh oceanic waters than any of the sites we trawled, coupled with higher nutrient levels. These characteristics of the harbor are confirmed by a 1997 report that assessed the impact of secondary sewage treatment in Salem Sound.

A clear shift in species composition seems to occur as one looks across geographic locations, with greater amounts of fouling, primarily by the invasive tunicate *Ascidiella aspera* and the ubiquitous native fouling hydroids, as well as invasive Botryllid tunicates (Figure 7) in the confined Salem Harbor area. This then shifts to a more heterogeneous mix of fouling species in the main body of Salem Sound, whether inshore or more centrally located in the sound, with the three colonial invasive tunicates (*Botryllloides violaceus, Botryllus schlosseri*, and *Diplosoma listerianum*) becoming more abundant than *A. aspersa*. As might be expected in the near shore areas to the north and south of the sound, macroalgae are found to be a common part of trap fouling. These areas are fairly shallow and well-flushed, allowing for high photosynthetic productivity. Salem Sound, however, showed relatively little fouling by algae, possibly due to higher turbidity. Traps that were more in the central part of the sound showed less algal growth than the north and south sound areas. The reason for this is unclear, though it may be due to diminished photosynthetic ability at increased depth in some parts of the central sound.

The most interesting difference in fouling composition from Salem Harbor was seen around the Outer Islands, the region that defines the boundary between Salem Sound and the open ocean. Here, the fouling community is almost a reverse image of Salem Harbor, as *A. aspersa* is rarely seen, and the invasive *D. listerianum* becomes the most dominant fouling organism, with both invasive Botryllids and the invasive lacy bryozoan, *Membranipora membranacea*, comprising the more common species (see Figure 4 for an example trap). The unusual small black acoel flatworms, an unexpected and interesting find for this study, were the most common here of all seven sites, with the adjacent central sound area having the second highest abundance. Finally, the two areas south of Marblehead Neck displayed their own growth pattern, though much decreased in amount than the other five areas, most likely due to a combination of starting later in the season when larval recruitment and settlement are decreasing, and being in more exposed oceanic conditions where such recruitment is more diluted.

Though geographic location seems to account for the majority of the general differences between fouling composition on different trawls, there are a few notable patterns relating to substrate type and depth that warrant mention. The small black acoel flatworms, for example, were found on six of twelve trawls on gravel bottoms. However, no flatworms were recorded on any of the eight trawls that were categorized as being predominately on mud bottoms. As these flatworms were seen across all geographic areas, it seems that benthic habitats free of turbidity are key to flatworm success. Interestingly, this is the only fouling organism we recorded that had such a clear connection with substrate type. For the solitary tunicates *Ciona intestinalis*, *Styela clava*, and *Molgula manhattensis*, depth may have played a role in the compositional patterns we observed; all three were rarely found on shallow and mid-depth trawl, and not on deep water trawls, though their overall rarity on examined traps precludes any accurate conclusion. Likewise, the three algae groups recorded, filamentous algae, brown macroalgae, and red macroalgae, which could be predicted to grow primarily on shallower traps, appeared to follow that prediction, though the numbers are insufficient to more than speculate.

Numerous interesting patterns of growth were observed on the traps, with some fouling species clearly preferring different parts of the traps. From the distribution data, it was clear that the particularly soft-bodied *D. listerianum* grew very well on the netting of traps, an area where few other species appeared capable of settling, though it was also relatively common on other parts of the traps (see Figure 5a). *A. aspersa* seemed to prefer the more dense and hard surfaces of traps but was capable of thick growth on nearly any portion of a trap except the bottom – an area of the trap that was evidently a no-man's-land for all fouling species besides a few mobile amphipods. The fouling mollusks that were observed on traps, particularly the jingle shells, *Anomia* spp., and the slipper shells *Crepidula* spp., not surprisingly greatly preferred the large, flat, and solid surfaces of the bricks used at the bottoms of traps for ballast (see Figure 5b). Similarly, the hard plastic vents used to allow an escape for juvenile lobsters would often be a significant site for fouling by a variety of early fouling species, particularly the Botryllid tunicates.

In some cases, some species seemed to occur only on traps previously free of fouling, whereas others, such as most of the solitary tunicates, appeared readily capable of growing over other fouling species (see Figure 5c); *A. aspersa* and *S. clava* both preferred dense, thick substrates, whether created by previous fouling, or not. Conversely, the acoel flatworms were only observed on the smooth plastic coating that surrounded the wire frame of each trap and only in areas that were not fouled by other species (see Figure 5d), since this allowed them more freedom of movement. Interestingly, one portion of traps rarely became fouled, no matter the other factors involved; the portion of the trap known to lobstermen as the "bedroom" or "parlor" was almost always clear of fouling (see Figure 5a). This is the part of the trap where caught lobsters spend most of their time before they are hauled up and collected, so probably the constant movement of the trapped lobsters seeking escape works to keep this part of the trap free of fouling.

The observed rarity of the invasive solitary tunicate, *S. clava*, and the near-nonexistence of the well studied and normally widespread invasive colonial tunicate, *Didemnum vexillum*, came as a surprise, as both are abundant fouling species among the floating dock fouling communities that SSCW has been monitoring. Small individual *S. clava* were beginning to be recorded on traps in the last month of the study, so it may be possible that their abundance would continue to increase were the studied traps left in the water for a longer period. Reports from lobstermen who fish with their traps year-round confirm this, describing often thick growths of *S. clava* on many traps. *D. vexillum* was expected to be a major component of the trap fouling community, yet was only found twice, on two very different traps, one of which spent most of its time just offshore on the north side of the sound and the other that was in deeper water south of Marblehead Neck. In both cases, the observed *D. vexillum* colonies never grew beyond a very small size, quite different from the rampant fouling growth commonly observed for the species. This surprising result certainly deserves more investigation, as there is great value to any insight into what makes this particular invader highly successful in certain well-documented situations and not in others.

Other potential avenues for future research are numerous, beyond simply increasing the number of traps and trawls studied. For a start, a more long-term study of lobster trap fouling, with an early spring start in the fishing season, six to eight months in duration, would afford a much more thorough picture of the fouling community dynamics as they change over the year, particularly for those species that recruit and settle in the early part of the year, such as barnacles. Additionally, it would be valuable to gauge the effect of fouling in regard to mobile species, such as lobsters, crabs, and large snails, both looking at the actual fouling that occurs on their bodies, but also how this fouling may or may not reflect the fouling communities on traps and nearby natural hard bottoms.

Over the course of the study, we witnessed a great deal of fouling on buoys, lines and moorings, usually of species quite different from what was seen on traps – primarily hydroids, mussels, green macroalgae, and Caprellid amphipods. A study of such fouling communities would be very interesting, particularly given their overall similarity to floating dock fouling communities and the large number of such mini-habitats that suggest they could play a significant role in near-shore dispersal, recruitment, and retention of fouling species. Likewise, a study of the composition of benthic communities on hard substrates along the bottom of Salem Sound would be very useful in determining how representative fouling on lobster traps is to growth on more naturally occurring and permanent structures such as rocks, boulder, cobble, etc. Figure 6 shows a photograph of a ballast brick from an unrelated sedimentation study being conducted in Salem Sound; it is interesting to see a fouling community growing on it quite similar to that which was observed on lobster traps in this study. Further study in this regard would do a lot to inform us of the local origin of the species we find fouling lobster traps, as well as help to ascertain the role traps themselves may play as a mechanism for dispersal of fouling species, particularly invasive ones. Ideally, such a study would be undertaken concurrently with another lobster trap study, to diminish any role of seasonal or yearly variations in fouling community dynamics.

OUTREACH

The outreach component of this project was largely directed toward the local fishing community. There are more than 1,330 lobster permits issued to commercial fishermen in Massachusetts and 11,000 recreational lobster permits with some 335,000 lobster traps in state waters. Salem Sound has four of the 49 Massachusetts commercial lobster ports. The Massachusetts lobster trap fishery is conducted by individual, small, owner-operated enterprises. As a way to engage local fishermen and lobstermen, ascertain their level of awareness, and learn about their experiences, informal surveys were conducted of lobstermen from the region, both in person and on line via an internet survey (http://www.surveymonkey.com/s/KBSKSYQ) targeted toward lobstermen who fish in or around the waters of Salem Sound. The eight-question survey was developed to address certain aspects of the study in order to most easily receive useful responses from experienced lobster boat crewmen. Nine veteran lobstermen, covering an area from Rockport to Boston Harbor, answered the survey, which is summarized in Table 2. They were asked a series of questions about their years of experience, general location of fishing grounds, seasons fished, substrate type where fouling issues occur the most, methods for removing fouling, and which type of fouling they commonly experience.

Six of the lobstermen fish both in and out of Salem Sound, four fish off Gloucester and Rockport, and one works out of Boston Harbor. When asked about where and when the most fouling was observed, all stated in warmer and shallower waters, confirming the results of our field study. Comments gathered from captains stated that the closer one fishes to a freshwater-influenced area, the worse fouling becomes. As a result of our experiences during the primary field study, we became interested in the methods lobstermen use to remove or counter trap fouling and incorporated this into the survey. We learned that they use several means for removal: scrubbing the traps, power washing heavily fouled traps, bleaching certain areas of the trawl, dunking traps into hot water wells, relocating traps, and removing traps from the water to dry.

In addition to this survey, SSCW held a workshop where we used an illustrated field guide to invasive species along with live specimens in an effort to discover which fouling species other local lobstermen encounter, and to raise awareness of the issue of invasive marine species. We informally surveyed these lobstermen on what type of fouling they experience, using their common jargon in describing and identifying the different fouling species (ex. "cancer," "snot" and "pizza cheese" were a common terms used to describe colonial tunicates, especially Botryllids and *Didemnum vexillum*). Table 2 lists the species that lobstermen find on their traps, mostly during the summer months. The most commonly observed invasive species by all captains appear to be *Botrylloides violaceous* and *Ascidiella aspersa*.

Conducting these surveys gave SSCW the opportunity to confirm some of the information gathered through the primary study. It also allowed us the opportunity to collect new and useful data from lobstermen in the surrounding area. This will help highlight many issues that fishermen are experiencing in the Massachusetts Bay area. With efforts such as the workshop, we can obtain even more information that can help us directly. Furthermore, the workshops and surveys provided SSCW with an opportunity to distribute educational materials and raise awareness of invaders such as the potential invader, the Chinese mitten crab, *Eriocheir sinensis*. These targeted outreach efforts had the benefit of reaching a group of people whose livelihood depends on the sea but are not normally engaged in, or exposed to, marine invasive species research. It gave us the chance to hear from and learn about the concerns of the local fishing community, and to expand the network of knowledgeable people who can provide early detection.

As part of this project, we also developed three new Marine Invasive Species ID cards for use by monitoring volunteers and any interested members of the general public to supplement the twenty cards that are already in circulation. The three cards are for *Bugula neritina*, a non-native byrozoan, *Caprella mutica*, an Asian skeleton shrimp that has been in New England waters for at least a decade, and *Palaemon elegans*, a European shrimp species that was first recorded in North America in Salem Harbor in the summer of 2010.

CONCLUSIONS

Working with lobstermen has proven to be both a unique challenge and a singularly rewarding experience. By their nature, lobstermen are very independent and often leery of outsiders taking unusual interest in their profession. As they are entirely dependent on their skills (often honed over many years and generations of hard-earned experience) in harvesting a wild product – essentially they are a rare example of hunter-gatherers in our modern world – they are particularly protective of their methods and “hunting grounds,” something we had to be respectful of while conducting this study and making use of the results. As the wild product they catch becomes more difficult to harvest in numbers that support a viable fishery, lobstermen have become the subject of increasing management restriction from state and federal agencies and, therefore, are particularly wary of interactions with scientists who are often seen as playing a role in creating the management restrictions they view as threatening their livelihoods. Research involving lobstermen therefore proves difficult, as it is not easy to gain their trust. Our initial attempts at finding local lobstermen who would be willing to work with us failed for this very reason: they were reticent to be involved with any efforts that may, in some way, lead to further government management and restrictions of their fishery.

Nonetheless, the information that can be gathered from working with lobstermen, as well as surveying them on their experiences, often proves invaluable to gaining an understanding of daily biological conditions from the point of view of observers who have been on the front lines virtually every day for years or decades. While some caveats must be applied when gathering and considering information from sources who may not have scientific training and are providing essentially anecdotal information, the first-hand accounts that can be gathered are virtually indispensable for gaining a long-term view of patterns and changes that may occur in the coastal marine realm of local waters. The lobstermen with whom we did our fieldwork had detailed insights that proved invaluable. Working with and listening to the experiences of veteran lobstermen allow for a long-term database of information that, with a little care, can greatly enhance research.

To date, no similar study is known to have been conducted of the composition of fouling communities on lobster traps, particularly emphasizing the occurrence of non-native species on them. Moving forward, however, of particular value is the knowledge that much can be gained from the formation of partnerships among commercial fishermen, scientists, and other stakeholders to engage in the type of collaborative research and monitoring projects as described here. By enabling commercial fishermen and their fishing vessels to participate in collaborative research, this project has provided an assessment of non-native species across Salem Sound and has involved one of the key stakeholders, the fishing community, directly in the collection of scientific data. Future such endeavors will bring more benefits than simply greater scientific knowledge.

Figure 2: Time series photographs of traps from Salem Harbor, (trawl 33, trap 9)

JULY 13, 2010

AUGUST 9, 2010

Figure 2, continued.

SEPTEMBER 10, 2010

OCTOBER 13 (note debris on deck from pressure washing of fouling)

Figure 3: Time series photos of traps from central Salem Sound (trawl 38, trap3)

JULY 13, 2010

AUGUST 9, 2010

Figure 3, continued

SEPTEMBER 8, 2010

OCTOBER 13, 2010

Figure 4: Time series photographs of traps from the outer Islands (trawl 3, trap 1)

JULY 15, 2010

AUGUST 10, 2010

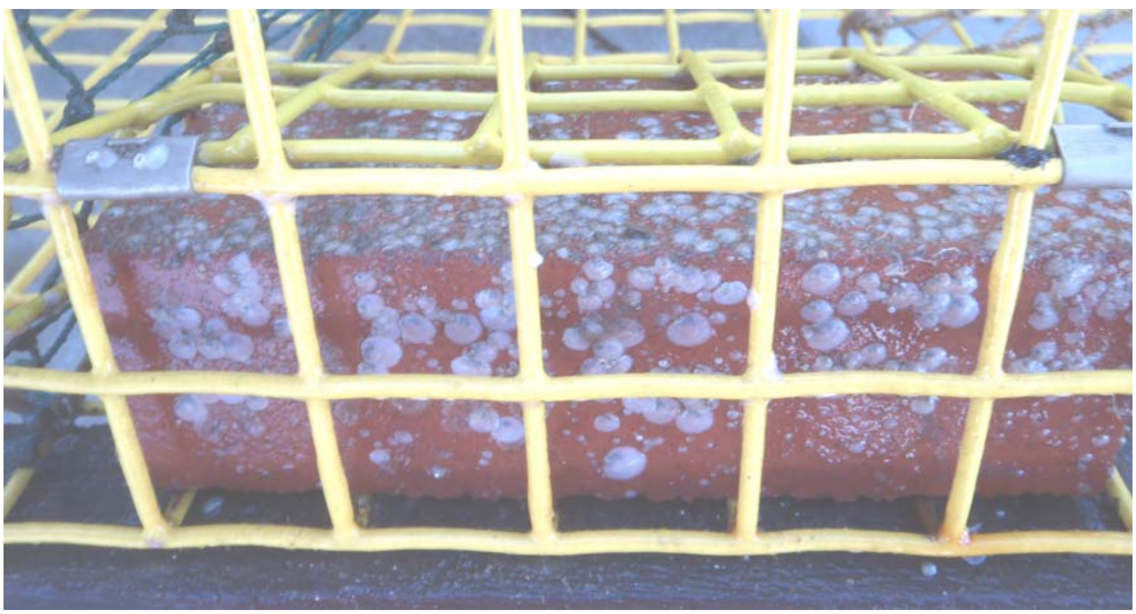
Figure 4, continued

SEPTEMBER 9, 2010

OCTOBER 13, 2010

Figure 5: Close-up images of different examples of trap fouling

5a: Trawl 34, trap 9 on September 8, 2010. Note dense growths of the invasive tunicates *Ascidiella aspera (*on narrow or solid parts of trap) and *Diplosoma listerianum* (completely covering net). Trap is noticeably clear around lobster parlor, due to constant movement of lobsters, a common pattern.



5b: Trawl 37, trap 3 on October 13, 2010. Note large numbers of the jingle shell bivalve *Anomia* spp. on brick

Figure 5, continued

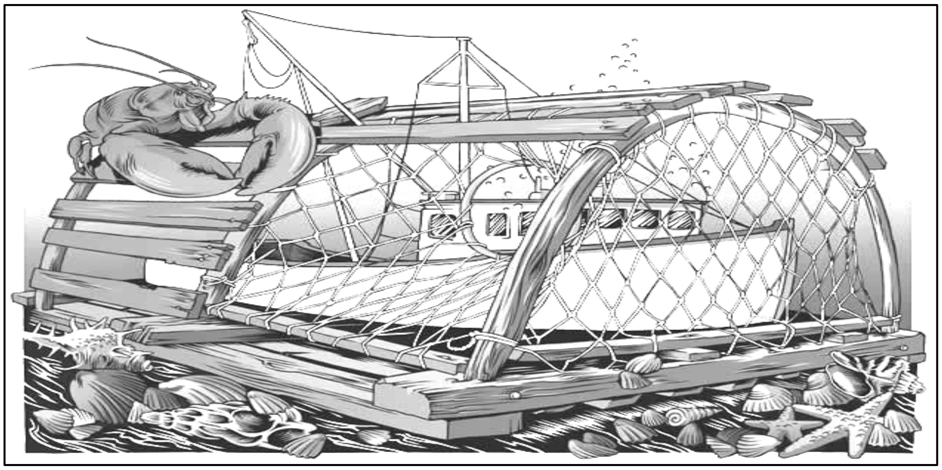
5c: Trawl 33, trap 1, on October 13, 2010. Note thick clusters of small solitary invasive tunicates *Ascidiella aspera* and *Styela clava*, hydroids, and some fine branching red macroalgae (green algae is incidental) growing on cage and ropes.

5d: Trawl 3, trap 3, August 10, 2010. Note small black acoel flatworms (inset is magnified detail), and a few small colonies of the invasive bryozoan *Membranipora membranacea*.

Figure 6: Fouling on natural and artificial hard substrates collected in Salem Sound

Fig. 6 shows a photograph of a small rock, and a cinder block weight used for a sediment collector in an unrelated study; both were collected from the bottom of central Salem Sound. Note thick growths of fouling organisms that are similar in composition to fouling found on lobster traps during the course of the primary study, including *Diplosoma listerianum*, *Botrylloides violaceous*, and *Ascidiella aspersa*.

WHAT'S THAT CRAP GROWING ON YOUR TRAP???



Salem Sound Coastwatch wants to hear from **YOU!**

Lobster Trap Fouling Session

Monday, December 13, 2010

The Anchor Pub & Grille

20 Cabot St - Beverly, MA 01915

Drop in from 5:00 – 7:00 pm

Salem Sound Coastwatch is studying fouling organisms on lobster traps. We're looking at the problem of marine invaders and what they might be doing to local fisheries. We need your help to better understand what's happening in our waters.

Join us at the Anchor Pub. Share your knowledge and personal experiences with fouling troubles, and learn more about what we're doing.

We appreciate your input and time.

Salem Sound Coastwatch is a non-profit organization working to improve the quality of our coastal waters and marine habitats.

Salem Sound COASTWATCH

201 Washington Street Suite 9| Salem, Massachusetts 01970 | (978) 741-7900 | salemsound.org

Lobster Boat Captain Survey - 2010

Years Fished	Areas Fished	Season	Fouling Season	Fouling Location	Fouling Bottom	Removal Practices	Species Encountered
3 to 10 yrs.- (3)	Salem Sound or nearby - (6)	All year -(6)	June through Sept. - (7)	Shallow, Bay areas - (3)	Mud - (4)	Power washing - (6)	*Botrylloides* - (9)
10+ yrs. - (6)	North Shore - (4)	Spring to Fall - (3)			Rock - (2)	Scrubbing - (3)	*Ascidiella*- (8)
	Mass Bays - (1)					Bleach - (3)	Hydroids - (8)
						Leave out to dry - (3)	Encrusting bryozoans - (7)
						Hot water baths - (2)	*Styela* - (5)
						Relocation in deep water - (2)	Mussels - (3)
						Swap out traps - (1)	*Botryllus* - (2)
							Didemnum - (2)
							Diplosoma- (2)
							Barnacle - (1)
							Codium - (1)

Table 2 shows the breakdown of responses to the questionnaire conducted of experienced lobstermen in and around the Salem Sound area, including those questioned at boat docks; at the Gloucester grant meeting on December 9; at the fouling session workshop in Beverly on December 13; and via the online surveymonkey.com questionnaire. The numbers in parentheses are the number of respondents identifying that particular choice.