# THE EFFECTS OF HANGING RATIO ON MARINE MAMMAL INTERACTIONS AND CATCH RETENTION OF COMMERCIALLY IMPORTANT FINFISH SPECIES

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## BACKGROUND

The Harbor Porpoise Take Reduction Plan (HPTRP) has been in effect since January 1, 1999 and requires gillnet gear to be modified during certain times of the year and in certain areas of the Gulf of Maine, southern New England, and the Mid-Atlantic when harbor porpoise (*Phocoena phocoena*) are present to reduce interactions with commercial gillnet gear. In the New England area, pingers (e.g., acoustic deterrents) are required on gear at various times of the year in seasonal management areas; in contrast, in the Mid-Atlantic, gear modification requirements have been implemented during the winter months of January through April in lieu of pinger requirements. In the past few years, there has been an increase in the number of harbor porpoises observed taken in gillnets, which may be due to a number of factors, including non-compliance with the HPTRP and takes occurring outside of the existing management areas (Palka et al 2008). Some gillnet fishermen have indicated financial difficulties associated with purchasing and maintaining pingers and feel that using gear modifications would be a more cost effective option.

Based on analysis of Observer data conducted by scientists at the National Marine Fisheries Service/Northeast Fisheries Science Center/Protected Species Branch (NMFS/NEFSC/PSB) in the area south of the Cape Cod South Management Area (CCSMA), gillnets with a hanging ratio of 0.33 have greater harbor porpoise by-catch compared to nets hung with a ratio of 0.5. Although this trend is not exhibited in all areas and the effort (number of hauls observed) vastly differs between the two hanging ratios (421observed hauls for 0.33 and 2,247 observed hauls for 0.50), this result suggests that there may be differences in the by-catch rate of harbor porpoises depending on the hanging ratio used (Palka et al 2008). In 2008 the National Oceanic Atmospheric Administration (NOAA), NMFS proposed an experiment to test the effect that differing hanging ratios have on harbor porpoise by-catch in the waters south of the CCSMA. From February 2009 to April 2009 and February 2010 to April 2010, field research was conducted to test if hanging ratio affects harbor porpoise bycatch and targeted finfish catch in the commercial gillnet fishery in southern New England.

## METHODS

*Vessels*

This project was conducted by A.I.S., Inc. in cooperation with NMFS and several commercial fishermen over the two field seasons. Four captains participated on the project: the *F/V Kim & Jake* owned and operated by Alan Dean, the *F/V Jessica Marie* owned and operated by Bradford Bowen, the *F/V D & S Express* owned and operated by Mike Sarapachillo, and the *F/V Shamrock*, owned and operated by Bill McCann, Sr. The *F/V Kim & Jake* out of Westport, MA, is a 47 foot commercial gillnet and crab/lobster vessel with a 450 hp engine and a working deck space of approximately 400 $ft^2$; the *F/V Jessica Marie* out of New Bedford, MA, is a 44 foot commercial gillnet and crab/lobster vessel with an 800hp engine and a working deck space of approximately 400 $ft^2$; the *F/V D & S Express* out of Pt. Pleasant, NJ is a 50 foot commercial gillnet and lobster vessel, with a 475 hp engine and a working deck space of approximately 660 $ft^2$; and the *F/V Shamrock*, a 75 foot commercial gillnet vessel with a 350 hp engine and a working deck space of 400 $ft^2$. Prior to each field season a thorough inspection of each vessel and the

safety equipment was performed by A.I.S. This inspection helped to ensure that the vessels carried the required safety equipment and that they possessed current USCG Commercial Fishing Vessel Safety decals. The results of the inspection were summarized into a vessel suitability report and submitted to the NMFS. The captains and crew of the *F/Vs Kim & Jake* and *Jessica Marie* participated in the 2009 field season. In 2010, the captain and crew of the *F/V D&S Express* participated for two trips and the remainder of the season was completed by the captains and crew of *F/Vs Kim & Jake* and the *Shamrock*. All vessels were equipped with four experimental gillnet strings, and spare nets were in supply if needed in the event of gear damage.

*Study Area*

The study area was south of the HPTRP CCSMA (South of the 40º 40' N Latitude). Figure 1 illustrates the study area and all hauls for both field seasons. Figure 1B shows 8 hauls that were completed off the coast of NJ in the 2010 field season. At the beginning of the 2010 field season, there were new HPTRP regulations that were expected to be implemented in March 2010. In anticipation of this and consulting with NMFS scientists, in order to avoid disruption to the study, the study area was shifted south where pingers would not be required. After completion of two trips (eight hauls), the captain of the *F/V D & S Express* opted out of the remainder of the study. At the same time it was announced that the expansion of the pinger requirement area would be delayed. This allowed us to charter the *F/Vs Kim & Jake* and the *Shamrock* for the remainder of the study in the initially proposed area.

*Fishing and Sampling Gear*

Standard commercial 12 inch mesh monofilament gillnets with a hanging ratio of 0.33 and 0.50 were used for this study. Hanging ratio describes the length to height ratio of the meshes or the stretch capacity of the net. It is often noted as a fraction of the length of meshes hung along the float line. A hanging ratio of 0.33 is less tightly hung on the float line versus a hanging ratio of 0.50. Figure 2 illustrates a basic schematic of a typical anchor sink gillnet string configuration and Figure 3 illustrates the visual differences between four hanging ratios. Nets were built at I.M.P. Fishing Gear LTD, New Bedford, MA. The nets were built based on the industry average. Table 1 illustrates the gear dimensions for the nets. With the exception of hanging ratio, net dimensions were identical for each panel and throughout the strings. Fifty-six nets of each hanging ratio were used to make up the 8 research strings, with 14 nets per string. At the beginning of the study there were 4 spare nets of each hanging ratio available in the event that the gear used during the study incurred significant damage and required full net replacement.

At the beginning of both field seasons, nets of each treatment type were delivered to the vessel owners. The 2009 field season consisted of two phases. For phase I of the 2009 field season, the nets were tied together according to the net plan developed by the NMFS (Table 2). As the gear was strung together, nets hung on the 0.50 were marked with red cable ties (Figure 4A), and nets hung on the 0.33 were marked with blue cable ties (Figure 4B). Cable ties in groups of three or four were placed every 4 or 5 floats along the float line. This allowed for quick visual distinction between treatment types. No pingers were used on the fishing gear.

Hauls 1-19 tested the experimental gear in a randomized array within 8 experimental strings. There were 14 nets per string, with 7 nets of each treatment randomly placed (Table 2). Phase I lasted from 18 February to 5 March 2009. During this phase, as each net came on board, captain and crew called out treatment type. Fish were separated into fish totes and Xactic containers spray painted blue or red to indicate the appropriate treatment type.

Following the 19th haul NMFS decided against the randomized array and requested that the fishing gear be reconfigured so that each of the 8 strings contained 14 nets of the same hanging ratio, (0.33 or 0.50). The reasoning behind the reconfiguration will be discussed in the Results section.

Fourteen panel strings of the same hanging ratio was the configuration used for the remainder of the study. Phase II of the 2009 field season occurred between 15 March and 29 April. During this time the team completed hauls 20-79. Since each string contained nets of the same hanging ratio, the catch was easier to sample and keep track of therefore it did not need to be separated during each haul. To prevent the possibility of catch from one stringing mixing with that of another string, all catch from one haul was sampled before another haul was started.

Throughout the study two biologists were deployed on each vessel to ensure complete sampling of finfish and marine mammals. Each biologist was equipped with Chatillon spring loaded 100 lb and 12 lb brass tube scales, which were utilized to collect weights. Customized wooden length frequency boards were used for fish lengths and a standard tape measure was used to take morphometric measurements of marine mammals. Each team was provided with 4 fish baskets and eight fish totes. Modified data forms from the Northeast Fisheries Observer Program (NEFOP) were used to record data during the study.

*Fishing Practices and Data Collection*

The Captains set and hauled the experimental gillnet gear in a manner consistent with typical fishing practices in a geographic area that they traditionally fish. Targeted soak time for the gear was 96 hours. For each haul standard gear characteristics were recorded. These characteristics are listed and defined in Appendix 1.

Accurate weight and length measurements were collected based on modifications of the Northeast Fisheries Observer Program (NEFOP) sea sampling protocols. Lengths were collected for retained target species. When possible, actual weights were collected for all retained and discarded species. If an actual weight was unattainable, then an estimated weight was collected using a tote count, basket count, tally count or visual estimate.

*Marine Mammal Sampling*

All mammal sampling was based on modified NEFOP protocols. All marine mammals caught during the study were tagged using orange marine mammal tags that were

provided by the NMFS /NEFSC/PSB. To document incidentally caught marine mammals, the biologists used Olympus stylus 850 SW digital cameras. For each mammal caught, the following information was collected: time, net location, hanging ratio, latitude and longitude, species, body temperature, and any information on wounds, body condition and gear entanglement. In 2010, location on each net was also documented. This was documented by counting the float number the mammal was located closest to. Since each float is placed 12ft apart, the float number was multiplied by 12ft to give an estimated distance from the end bridle. All animals were tagged and animals were brought in whole if dead fresh. A digital temperature probe was used to collect carcass temperature, and a digital waterproof camera was used to document all incidental takes. If unable to bring in the whole animal, additional data were collected: body measurements and sex determination. Definitions for marine mammal codes can be found in the Appendix 2.

*Atlantic Sturgeon Collection and Sampling*

In the event an Atlantic sturgeon (*Acipenser oxyrhynchus*) was caught, the following data were to be collected: length and weights, fin clip, and scan fish for PIT tags. Fin clips were to be placed in ETOH vials provided by NMFS/NEFSC/PSB.

**RESULTS**

All raw data can be found in Appendix 3.

No statistical analyses were conducted under this contract, however marine mammal by-catch and finfish catch data has been examined. NMFS /NEFSC will be analyzing the data to test for levels of significance.

*Gear Reconfiguration*

Seventy-nine hauls were completed between 18 February and 29 April, 2009, and 80 hauls were completed between 28 February and 28 April, 2010. This study was divided into two phases. After haul 19, gear was reconfigured because NMFS scientists believed that the randomized net configuration was resulting in marine mammal takes that were not necessarily representative of interactions that occur in this fishery and that the panels may not have been independent of one another. Additionally, based on the examination of observed marine mammal takes in nets hung on the 0.50 and on the 0.33 described in the Background section, more takes in nets hung on the 0.33 were expected in this study. At the time the decision to reconfigure the gear, all takes had occurred in gear hung on the 0.50 and ultimately hauls 1-19 had more incidental takes seen in gear hung on the 0.50. Hauls 1-19 are referred to as Phase I, and hauls 20-159 are referred to as Phase II. Phase II spanned both the 2009 and 2010 field seasons.

*Finfish*

The average soak time for all the hauls was 128.0 hours with depths ranging from 41 to 84 fathoms. This varied from trip to trip depending on weather and catch rates from the previous trip. Total poundage caught of commercially important and regulated fish species, both retained and discarded, for both field seasons can be seen in Table 3

(excluding Phase I data) and Table 4 illustrates the total poundage in each field season for the Phase II configuration only.

Due to high catch volumes of skates on the *F/V Jessica Marie* at the beginning of the 2009 field season and on the *F/V Shamrock* in the 2010 season, estimated weights were collected. On the *F/V Jessica Marie*, estimated weights were collected based on fish tote counts and multiplied by an average weight of skates per tote. An average weight per tote was determined each trip and was used for each haul of that trip. On average, a tote of skates was approximately 130lbs. On the F/V Shamrock tally counts of individual winter skates (*Leucoraja ocellata*) were utilized, and an average weight was calculated for each haul. The average weight per skate was approximately 7.5lbs.

On average, nets with a hanging ratio of 0.33 caught more commercially important finfish species, both for retained and discarded catch (Figures 5 and 6). Over the course of the study there were always more retained winter skate and monkfish (*Lophius americanus*) caught in gear hung on the 0.33 than on the 0.50. There was approximately 18% more winter skates caught in gear hung on the 0.33, while there was only 4% difference for retained monkfish. Discarded monkfish was the only species whose overall catch had more poundage caught in gear hung on the 0.50 (Figure 6). Monkfish was discarded for various reasons (as noted by disposition code in the raw data) including decomposition, size regulations and market driven selectivity. Barndoor skates and summer flounder were both discarded as these species could not be retained due to regulations. Winter skates and little skate (*Leucoraja erinacea)* were discarded if they were too small or decomposed and had no market value.

Comparison of study phases did indicate a pattern in catch of retained and discarded species (Figures 7 and 8). In Phase I, there appeared to be more skate species caught, while there were more retained monkfish and discarded summer flounder caught in Phase II.

To determine if hanging ratios affected size selection of the target species, length frequency distributions of monkfish and winter skate were plotted. Comparison of length frequency distributions between hanging ratios, showed more fish were caught in gear hung on the 0.33 at most size intervals, except for at higher sizes where there were deviations from this pattern for both monkfish and winter skates (Figures 9 and 10). This pattern was clear until both species reached upper size ranges. For monkfish, the trend was no longer apparent in fish greater than 80cm, while in the winter skates, it appeared in fish greater than 87cm.

*Marine Mammals*

There were 59 marine mammals incidentally caught during the course of this study: 23 harbor porpoises, 10 harp seals *(Pagophilus groenlandicus)*, 19 gray seals (*Halichoerus grypus*), 4 harbor seals (*Phoca vitulina*), 2 common dolphins (*Delphinus delphis*), and one unidentifiable small cetacean (less than 6 feet in length) as shown in Table 4. A total of two mammals were not tagged as they fell from the net as the gear was being hauled. Of the 57 tagged mammals tagged, 26 were brought in whole. These animals were

delivered to NMFS scientists, and raw necropsy results can be seen in Appendix 4. Mammal data excluding Phase I can be seen in Table 5 and Figure 11, and Figure 12 shows the harbor porpoise by-catch also excluding Phase I data. As seen in these figures, incidental catch of harbor porpoises differed by 1 animal or 8% between treatments. Examination of data from the 2009 field season, including Phase I showed that in Phase I, 19 animals were caught, while in Phase II of 2009, 9 animals were caught. Additionally, in Phase I of 2009 there were 10 harbor porpoises caught, and the number between treatments was the same (Figure 13). In Phase II, two harbor porpoises were caught in gear hung on the 0.33, while none were caught in gear hung on the 0.50.

Comparison of hanging ratio data in 2009 regardless of phase showed that gear hung on the 0.33 caught 13 animals, while gear hung on the 0.50 caught 15 animals (Figure 14). There were more harbor porpoises caught in gear on the 0.33 in 2009.

Figure 15 displays where all the takes occurred for both 2009 and 2010 field seasons. There were also three birds caught in the 2010 field season, one Northern gannet and two sooty shearwaters. The shearwaters were caught in gear on the 0.50 and the Northern gannet was in gear hung on the 0.33. It should be noted, that one harbor porpoise (HO-001) was caught on two consecutive trips in 2009 and was not counted twice in the overall number of animals caught.

Examination of soak time in relation to the frequency of mammals caught is illustrated in Figure 15. It shows that gear soaked for 120 to 139 hours had the highest number of incidental takes. Gear soaked for less than 120 or greater than 139 hours appeared to have fewer and varied numbers of interactions.

After the 2009 industry debriefing at the end of the sampling season, it was determined that horizontal location on the net would be an important variable to record. Figure 16 shows the frequency of marine mammal takes in relation to the distance from the end bridle of the net. The highest number of takes occurred closest to the end of the bridles in the 0-19 feet range.

*Atlantic Sturgeon Collection and Sampling*

No sturgeon were caught in any of the experimental research gear during the course of the study.

## DISCUSSION

The goal of this study was to examine the effects hanging ratio had on harbor porpoise by-catch and catch of targeted finfish species. These data presented are preliminary and still require statistical analysis to determine the significance of the relationships identified here; that analysis will be conducted by NMFS staff. Initial findings of the study indicate there was more commercially important finfish species caught in gear hung on the 0.33. This is similar to the results of studies in the tuna fishery, where it was

determined that smaller hanging ratios increase slack within the nets creating pockets and ultimately increasing fish catch (Samaranayaka et al 1997).

While there were discernable differences in retained catch between Phases I and II in 2009, it is not apparent that experimental design was the cause. Late February/early March is when captains have noticed increased catches from past fishing years. This resulted in an increase in retained and discarded monkfish quantities. The predicted movement of monkfish also coincided with when the gear was reconfigured, therefore, it is inconclusive whether or not the re-configuration influenced the increase in monkfish catch or the decrease in retained skates.

While more fish were caught in gear hung on the 0.33, there were no apparent patterns in marine mammal by-catch. Gear was reconfigured after haul 19 as it was believed the experimental design was altering the behavior of the marine mammals and increasing the number of incidental takes. Historically, observer data has shown higher by-catch rates in gear hung on 0.33, but in Phase I, greater takes were observed in gear hung on the 0.50. After reconfiguration, there were more takes encountered in gear hung on the 0.33. One theory discussed during post sampling meetings was that the gear hung on the 0.33 might "appear" as an obstacle to the animals and that the animals "viewed" gear hung on the 0.50 as an opening to move through, resulting in the bycatch seen in Phase I. On several occasions in 2009, it was anecdotally noted that animals were located at the very beginning or end of the net near the bridle. During this season, the net location was collected, but not the horizontal location within each individual net. After the post-experiment debriefing in 2009, it was determined that the horizontal location of bycatch within the net would be a valuable variable to collect. Therefore, it was collected in the 2010 field season. The highest number of incidental takes was seen in the range of 0-19 feet from the end bridle, suggesting the mammals may be searching for an opening or escape outlet between the nets of a gillnet string. As little is known regarding marine mammal behavior around fishing gear, this is just a theory which could be investigated in future research.

According to the NEFOP database and the NEFSC Stock Assessment Reports (Waring et al. 2009), the marine mammal species incidentally caught most commonly in Northwest Atlantic sink gillnets during February to April include various Odontocete species such as Harbor porpoise and Atlantic white sided dolphins (*Lagenorhynchu acutus*), and Pinniped species such as Harbor seals, Gray seals and Harp seals. Harbor porpoises of all age classes were caught in the research gear of this study, while pinnipeds were comprised of primarily young of the year and juvenile seals. Looking at the overall number of incidental takes caught between the two phases in 2009, it appears there was a potential effect of the experimental design influencing marine mammal interactions. In Phase I a total of 19 takes occurred, while in Phase II of 2009 there were only 9. Interestingly, the majority of takes in Phase I were comprised of harbor porpoises (10), while the majority in Phase II were grey seals (4), and only 2 harbor porpoises were taken in this phase. Based on the 2009 post-experiment debriefing, the need for more replicates of the Phase II configuration was identified, which resulted in another field season in 2010 and usage of all one hanging ratio per string. There were no apparent

patterns in incidental takes of mammals in 2010, and once again more poundage of fish was caught in gear hung on the 0.33, with the exception of discarded monkfish for which 4% more was caught in gear hung on the 0.50 over the course of the experiment. This percent difference was highly influenced by the 2009 field season.

Ancillary to this project, marine mammals in fresh dead condition were brought back in whole and delivered to NMFS and WHOI scientists. Necropsies were conducted on all animals that were brought in. Gross analysis did not show anything out of the ordinary, and raw data from the necropsies can be seen in Appendix 4. One item to note, catch of Common Dolphins in the anchor sink gillnet fishery is rare. Based on the 2008 US and Gulf of Mexico Marine Mammal Stock Assessments, only seven common dolphins were observed in the Northeast and Mid-Atlantic sink gillnet fisheries combined (Waring et al. 2009). In this study, one common dolphin was incidentally caught in each of the field seasons, and both dolphins were caught in gear hung on the 0.50.

Hanging ratio may not be the answer to mitigation of harbor porpoise by-catch, but it is a step in the correct direction in providing baseline data for additional studies that incorporate different gear configurations and new technologies.

**FUTURE RESEARCH**

There are several avenues to pursue for future research. Post-experiment debriefings with several industry members, Northeast Region Office managers and NEFSC scientists were held in 2009 and 2010 at the A.I.S., Inc. office in New Bedford, MA. The intent of these meetings was to summarize the project and discuss further avenues for research. First and foremost, it was determined that additional replicates of Phase II were necessary to obtain more data to test for levels of significance to assess and document conservation benefits for reducing harbor porpoise by-catch in the CCSMA. One option discussed was to configure the gear with a tie down at every float and compare it to gear using a foam core float line. Increasing tie downs at every float would decrease the profile of nets in the water column and it is believed the foam core float maintains the integrity of the float line even better than floats allowing for a consistent height in the water column. Both these configurations would ultimately reduce the net profile and ultimately could decrease the potential of marine mammal interactions. Experiments by Trippel et al. (1996) showed that the majority of harbor porpoise takes occurred in the upper two-thirds of standing gillnets. Low profile nets could have a diminished likelihood of interacting with not just harbor porpoise, but other marine mammals. Keeping the nets at 12 meshes deep should also be maintained, as past research indicated that monkfish gear with tie downs and 12 meshes deep caught significant and commercially viable quantities of fish (He 2006). Future studies could also vary bridle length between nets. This would test the theory that the animals are looking for openings and would present an outlet for escape. As noted in the results section, the highest frequency of mammals caught was in the zone closest to the end of the net. Any future studies could be improved by attaching video cameras to the gillnet gear to provide insight into the behavior of marine mammal around the fishing gear.

**Table 1.** Gillnet gear net characteristics

| **Characteristic** | **Amount/Size** |
|---|---|
| Length of Nets | 300 ft. |
| Depth of Nets | 12 meshes |
| Twine Thickness | 0.90 mm |
| Mesh Size | 12 in. |
| Mesh Color | Chatham Green |
| Float Line | 3/8" polypropylene |
| Float Spacing | 12 ft. |
| Weak Links | 5 per net |
| Leadline Weight | 75 lb. |
| Spacing between nets within string | 3 ft. |
| Tie down length | 42 inches |
| Tie down spacing | 24 ft. |

**Table 2**. Randomized net configuration for Phase I of 2009 field season. H-1/2 is the hanging ratio of gear hung on the 0.50 and H-1/3 is hung on the 0.33.

| **Kim and Jake** | | | | | **Jessica Marie** | | | |
|---|---|---|---|---|---|---|---|---|
| **Net 1** | **Net 2** | **Net 3** | **Net 4** | | **Net 5** | **Net 6** | **Net 7** | **Net 8** |
| H-1/2 | 1/3rd | H-1/2 | H-1/2 | | H-1/2 | H-1/2 | H-1/2 | 1/3rd |
| 1/3rd | H-1/2 | 1/3rd | 1/3rd | | 1/3rd | 1/3rd | H-1/2 | 1/3rd |
| H-1/2 | H-1/2 | H-1/2 | 1/3rd | | 1/3rd | H-1/2 | 1/3rd | H-1/2 |
| 1/3rd | H-1/2 | 1/3rd | 1/3rd | | H-1/2 | 1/3rd | H-1/2 | H-1/2 |
| 1/3rd | 1/3rd | 1/3rd | H-1/2 | | 1/3rd | 1/3rd | 1/3rd | H-1/2 |
| 1/3rd | 1/3rd | 1/3rd | 1/3rd | | 1/3rd | 1/3rd | H-1/2 | 1/3rd |
| H-1/2 | 1/3rd | H-1/2 | H-1/2 | | H-1/2 | H-1/2 | 1/3rd | 1/3rd |
| 1/3rd | 1/3rd | 1/3rd | H-1/2 | | H-1/2 | 1/3rd | 1/3rd | H-1/2 |
| 1/3rd | H-1/2 | H-1/2 | H-1/2 | | 1/3rd | 1/3rd | 1/3rd | H-1/2 |
| H-1/2 | 1/3rd | 1/3rd | 1/3rd | | H-1/2 | H-1/2 | 1/3rd | 1/3rd |
| H-1/2 | H-1/2 | H-1/2 | H-1/2 | | H-1/2 | H-1/2 | H-1/2 | H-1/2 |
| H-1/2 | 1/3rd | H-1/2 | H-1/2 | | H-1/2 | H-1/2 | H-1/2 | 1/3rd |
| 1/3rd | H-1/2 | 1/3rd | 1/3rd | | 1/3rd | 1/3rd | H-1/2 | 1/3rd |
| H-1/2 | H-1/2 | H-1/2 | 1/3rd | | 1/3rd | H-1/2 | 1/3rd | H-1/2 |

**Table 3.** Total pounds of finfish species caught in 2009 and 2010 field seasons. nk=unknown

| Kept or Discarded | Species | Hanging Ratio 0.50 | Hanging Ratio 0.33 |
|---|---|---|---|
| K | Monkfish | 75,940 | 81,568 |
| K | Winter Skate | 47,750 | 68,736 |
| D | Barndoor Skate | 13,529 | 22,051 |
| D | Monkfish | 10,729 | 9,927 |
| D | Summer Flounder | 2,313 | 3,179 |
| D | Winter Skate | 1,023 | 1,647 |
| D | Skate, nk | 1,095 | 1,468 |
| D | Little skate | 303 | 601 |

**Table 4.** Total number of marine mammals caught over the course of the study in nets with 0.33 and 0.50 hanging ratios (includes both Phases).

| Species | 0.33 | 0.50 |
|---|---|---|
| **Harbor Porpoise** | 12 | 11 |
| **Harp Seal** | 4 | 6 |
| **Grey Seal** | 6 | 13 |
| **Harbor Seal** | 1 | 3 |
| **Common D.** | 0 | 2 |
| **Cetacean, nk** | 1 | 0 |
| | | |
| **Total** | 24 | 35 |

**Table 5**. Total number of marine mammal interactions in the Phase II configuration for 2009 and 2010 field seasons.

| | 0.33 | | | | 0.5 | | |
|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | Total | | 2009 | 2010 | Total |
| **Harbor Porpoise** | 2 | 5 | 7 | | 0 | 6 | 6 |
| **Harp Seal** | 1 | 1 | 2 | | 2 | 0 | 2 |
| **Grey Seal** | 3 | 3 | 6 | | 1 | 10 | 11 |
| **Harbor Seal** | 0 | 1 | 1 | | 0 | 3 | 3 |
| **Common Dolphin** | 0 | 0 | 0 | | 0 | 1 | 1 |
| **Cetacean, nk** | 0 | 1 | 1 | | 0 | 0 | 0 |
| **Total** | | | 17 | | | | 23 |

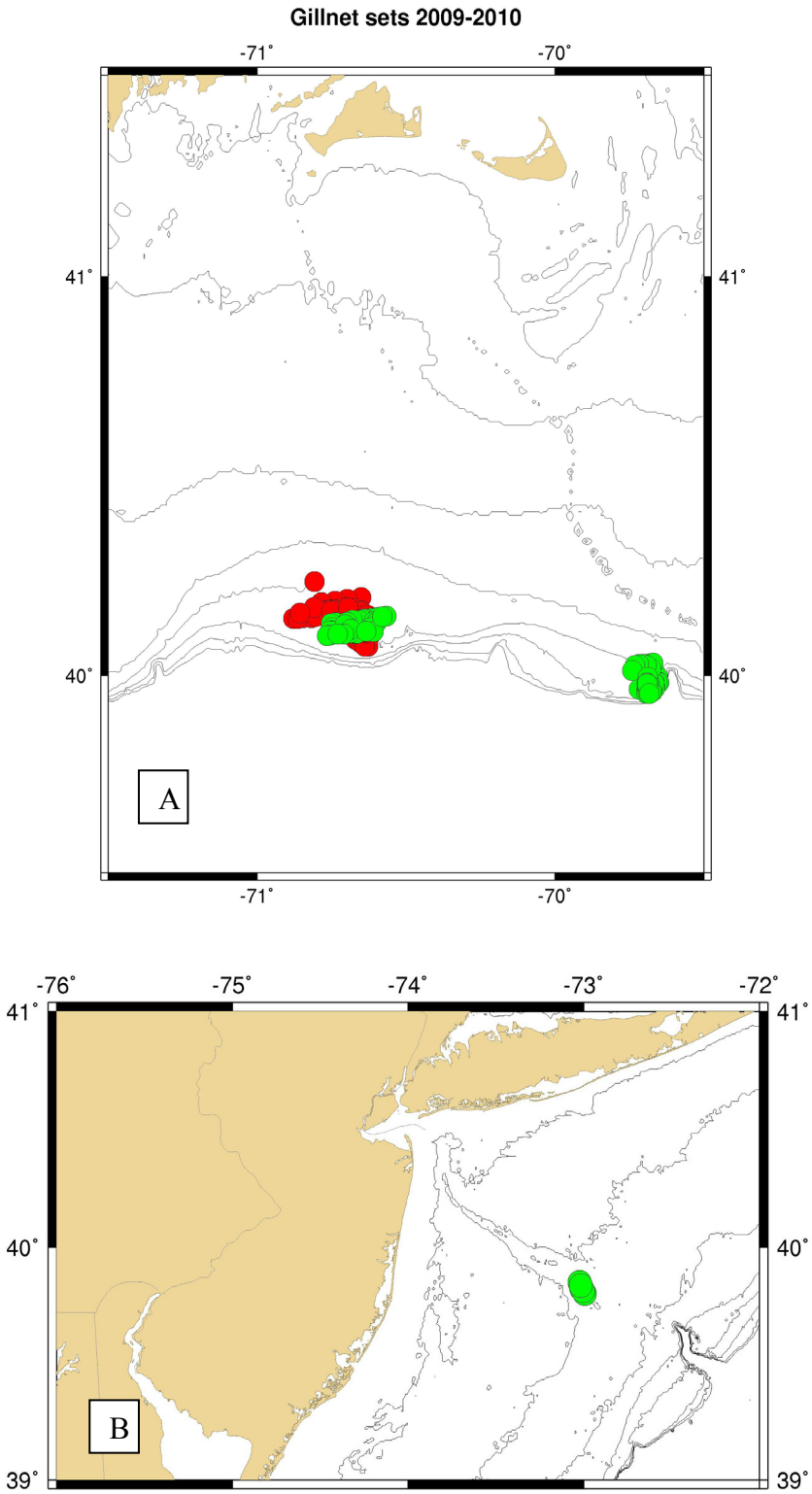


**Figure 1.** Hauls in 2009 and 2010 field season off of southern New England (A) and hauls in the 2010 field season off of NJ (B). Red= 2009 and Green = 2010.

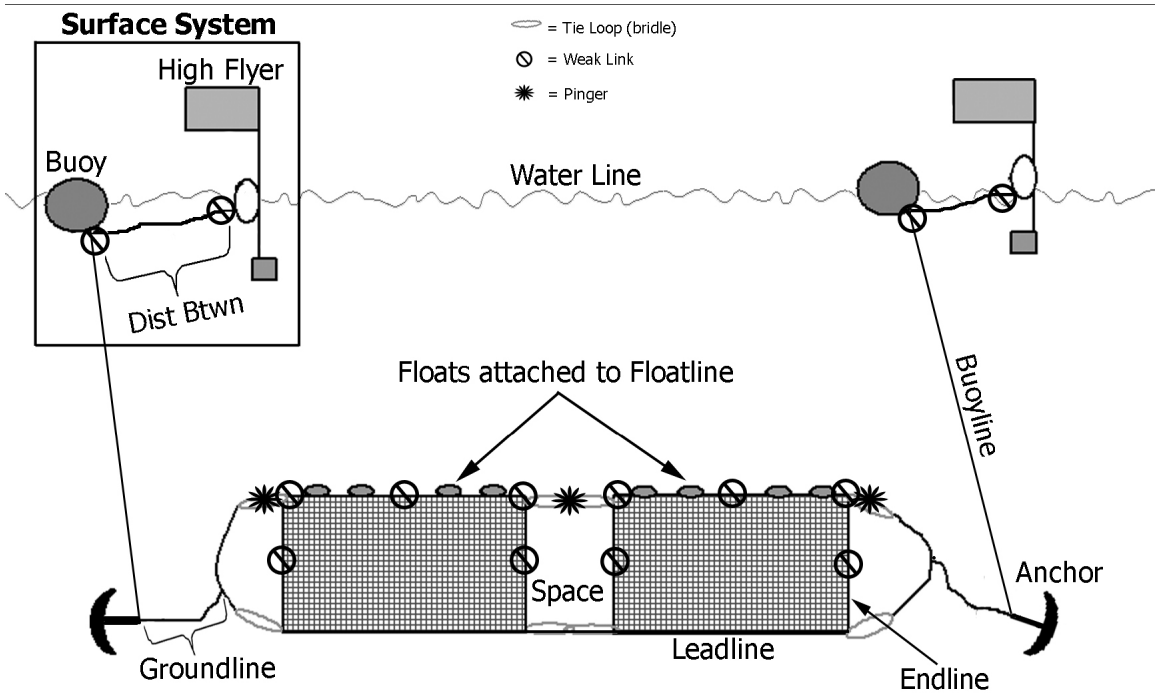


**Figure 2.** Gillnet gear system. Photo credit: NOAA Fisheries Service, Northeast Regional Office.

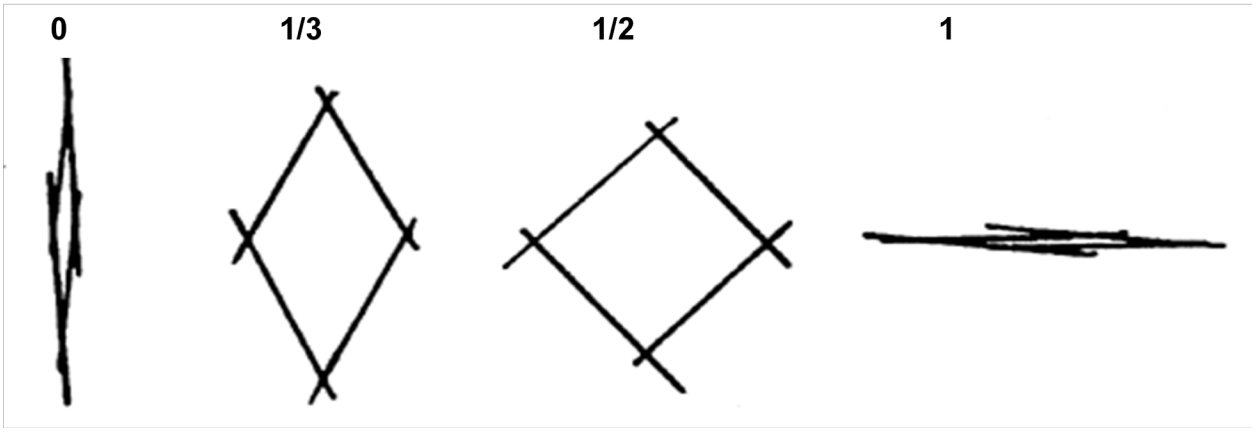


**Figure 3**. Appearance of gillnet mesh at four different hanging ratios.



**Figure 4**. Gear hung on the 0.50 (A) and gear hung on the 0.33 (B).

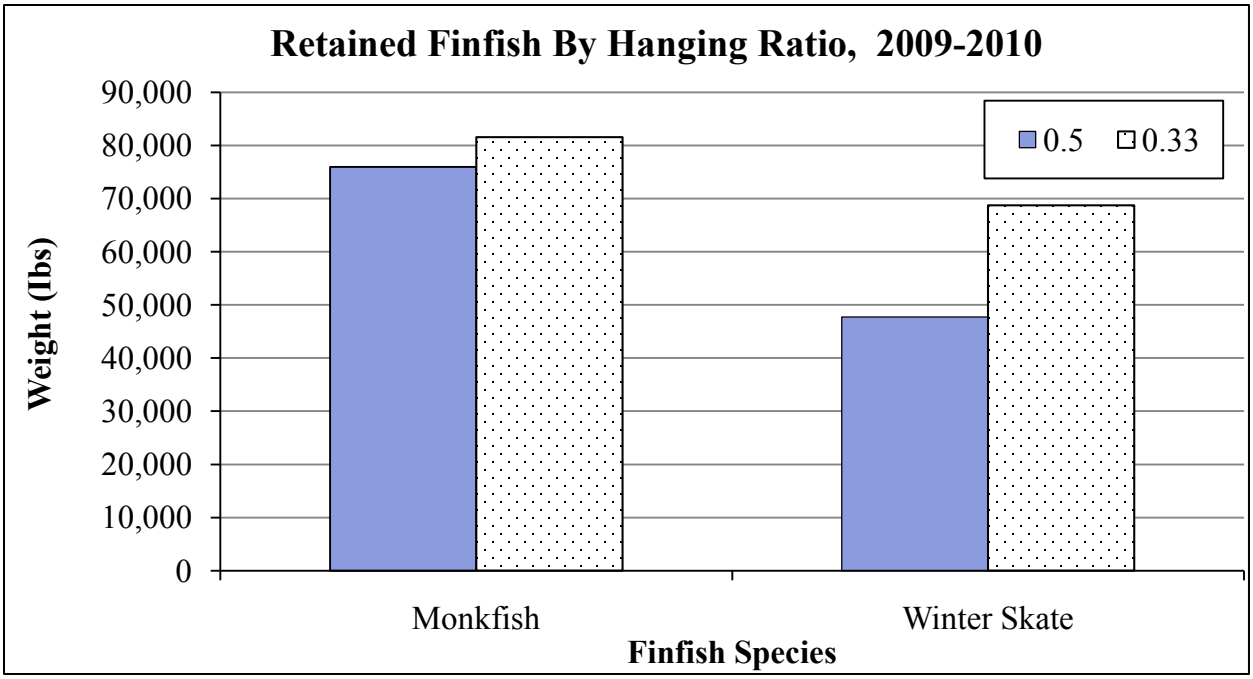


**Figure 5.** Weights of retained finfish catch by hanging ratio for 2009 and 2010 field seasons.

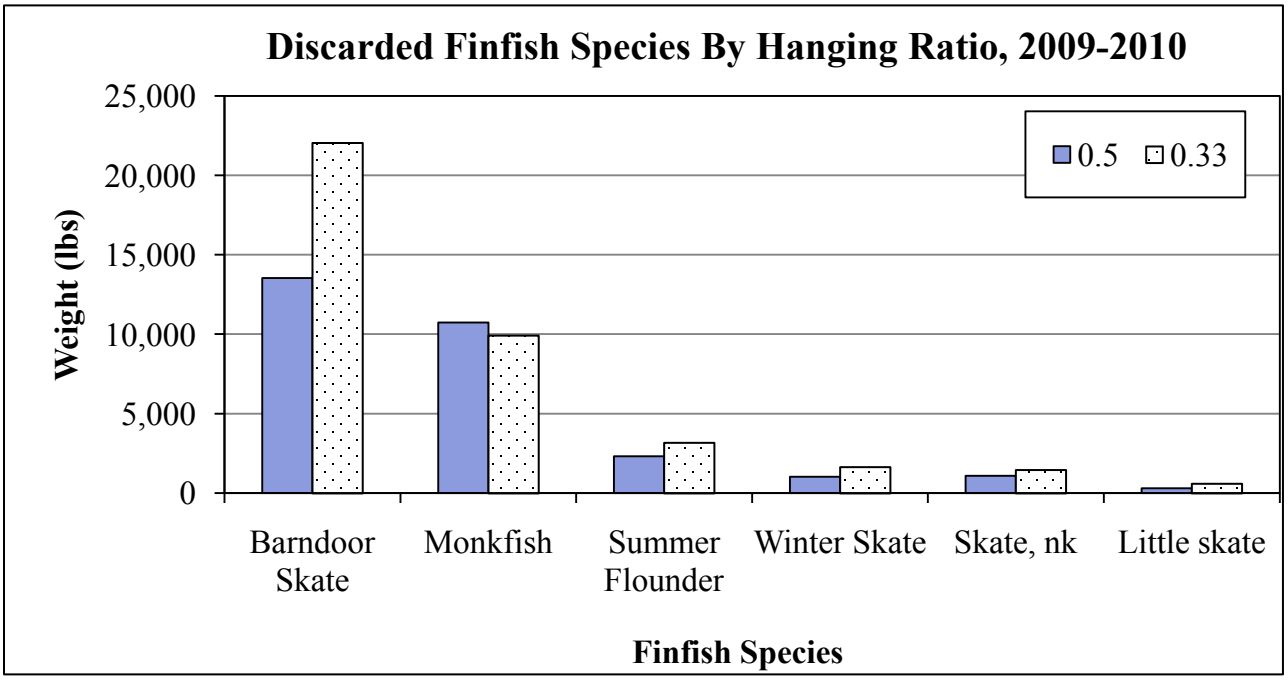


**Figure 6.** Weights of discarded finfish catch by hanging ratio.

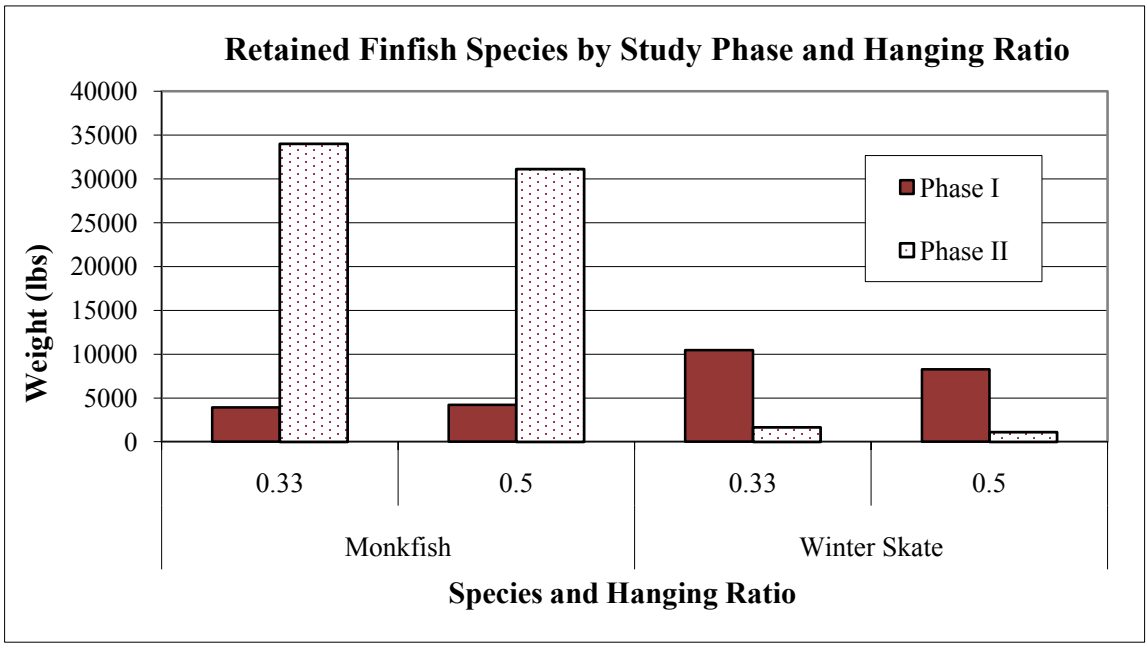


**Figure 7.** Comparison of retained catch by hanging ratio between the two phases of the study in 2009.

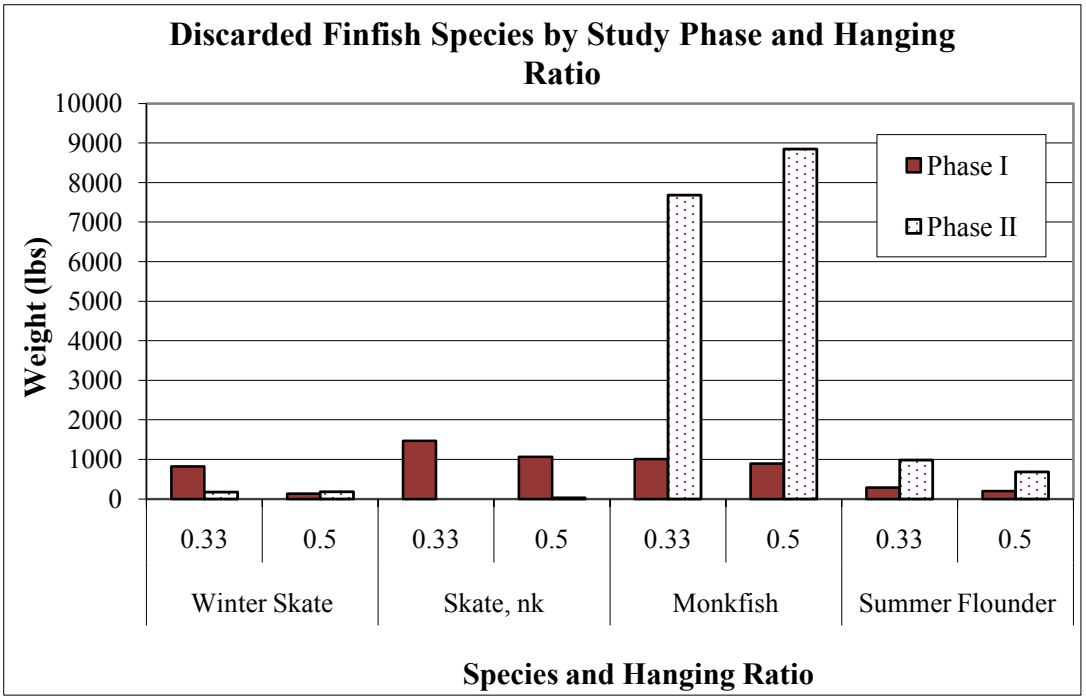


**Figure 8 .** Comparison of discarded catch by hanging ratio between the two phases of the study in 2009.

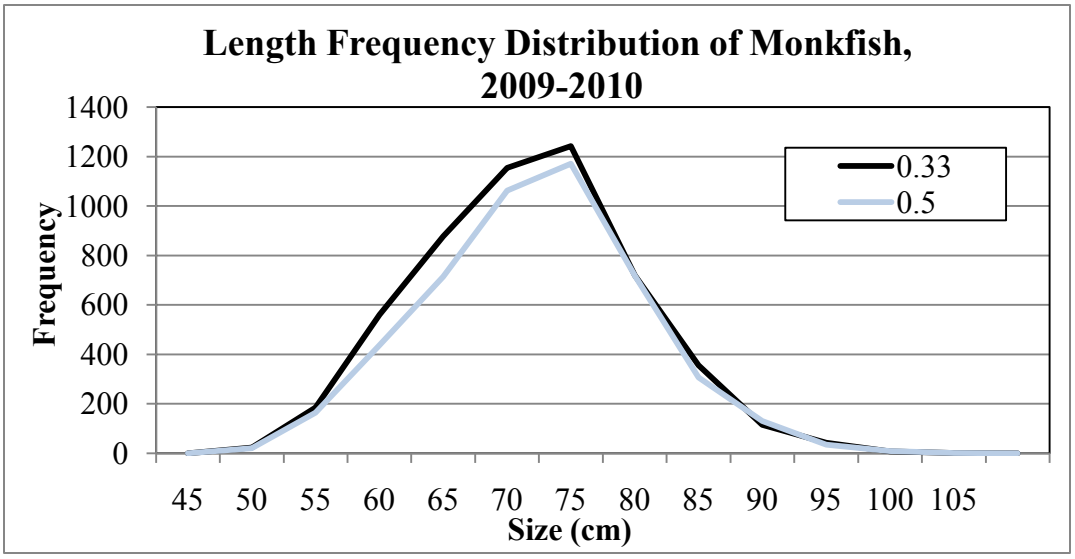


**Figure 9.** Length frequency distribution by hanging ratio for retained monkfish.

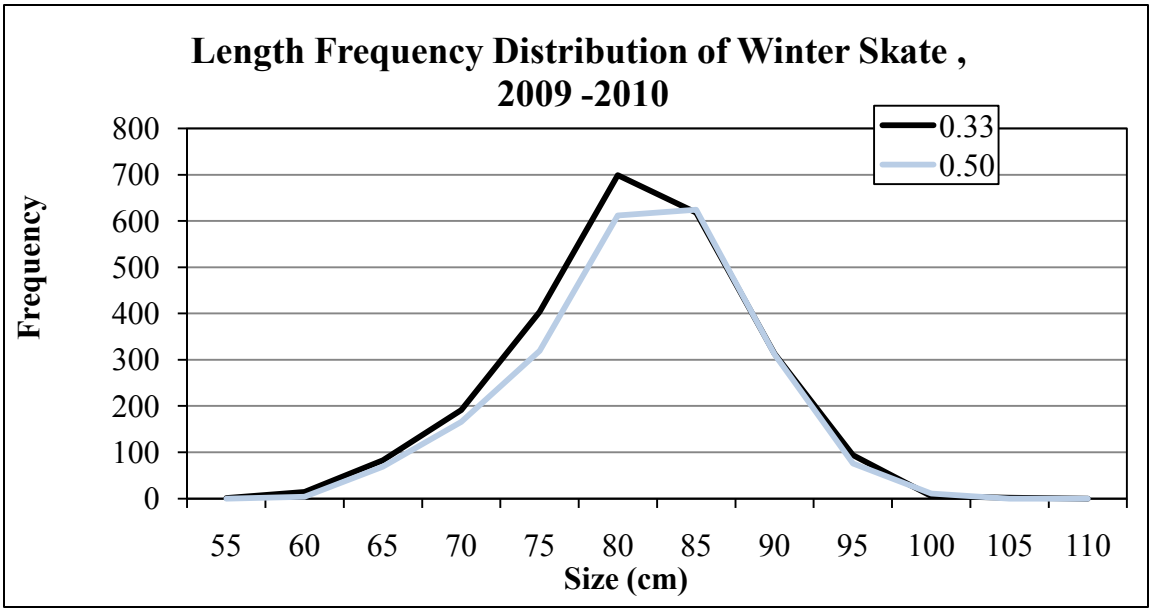


**Figure 10.** Length frequency distribution by hanging ratio for retained winter skate.

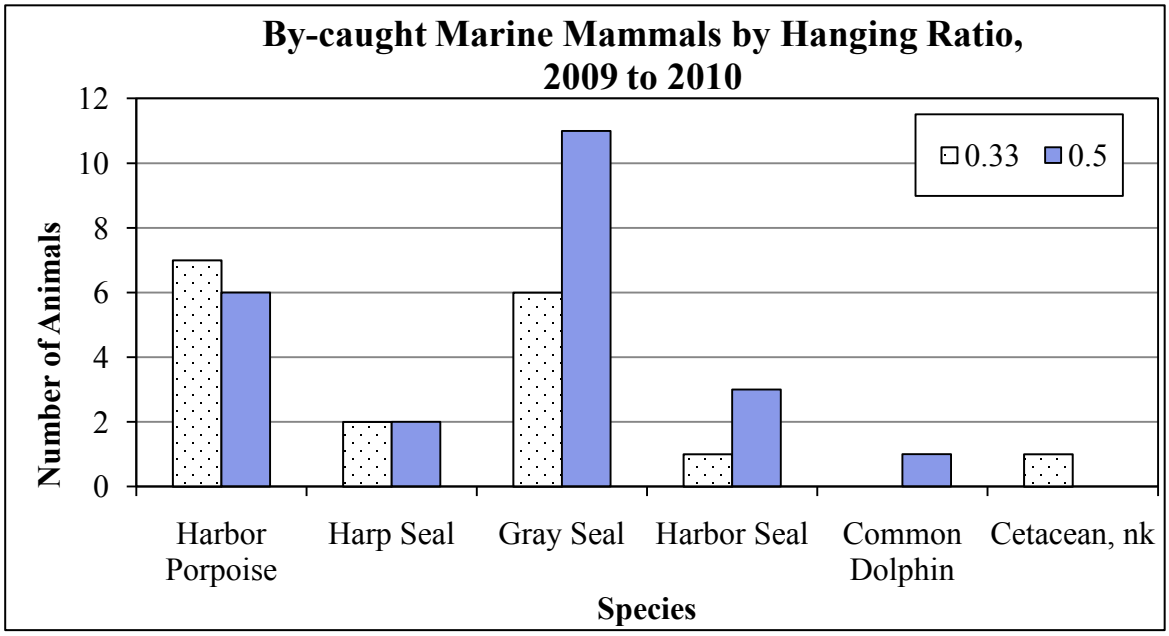


**Figure 11**. By-caught mammals for 2009 and 2010 field seasons. Excludes Phase I configuration, solely based on Phase II configuration.

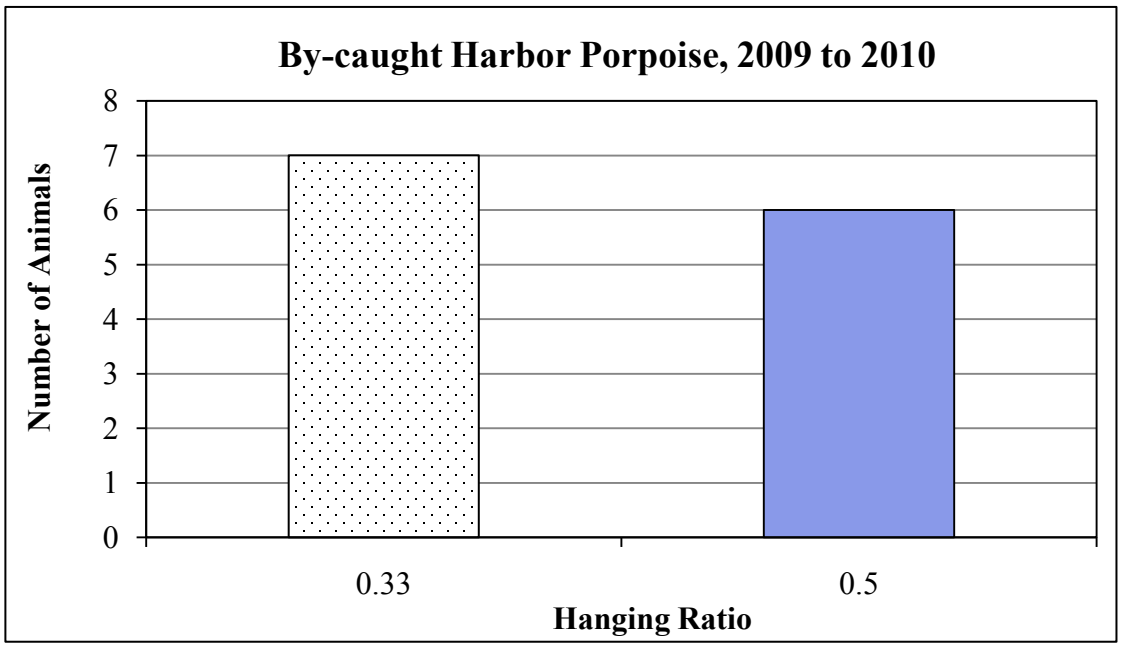


**Figure 12 .** Harbor porpoise by-catch for 2009 and 2010 field seasons. Excludes Phase I data.

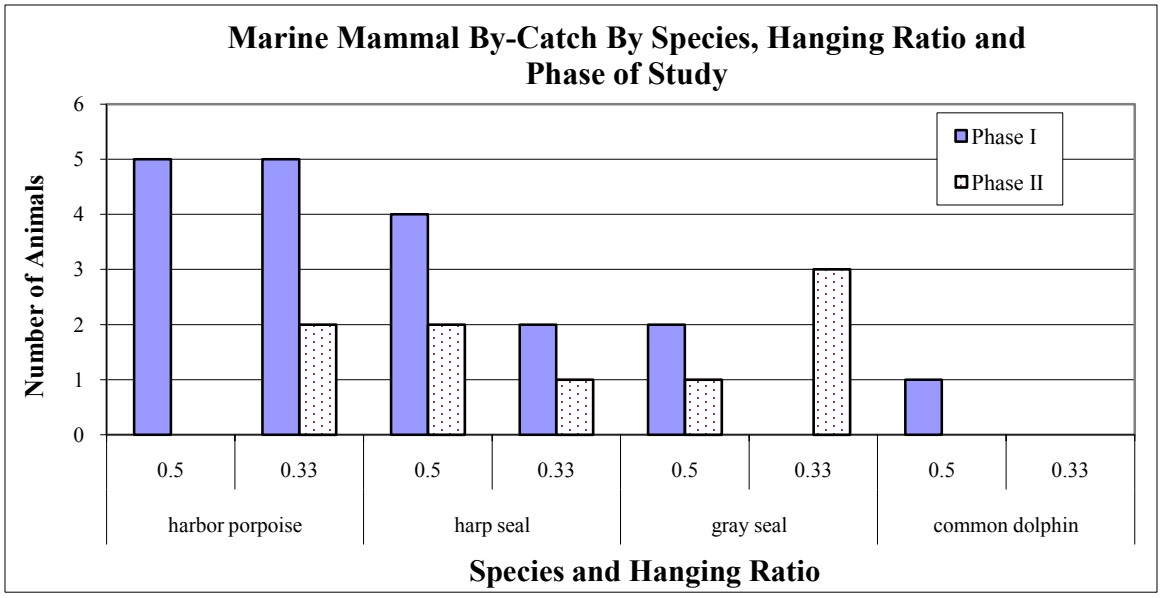


**Figure 13**. By-catch of marine mammals by study phase and hanging ratio for 2009 field season.

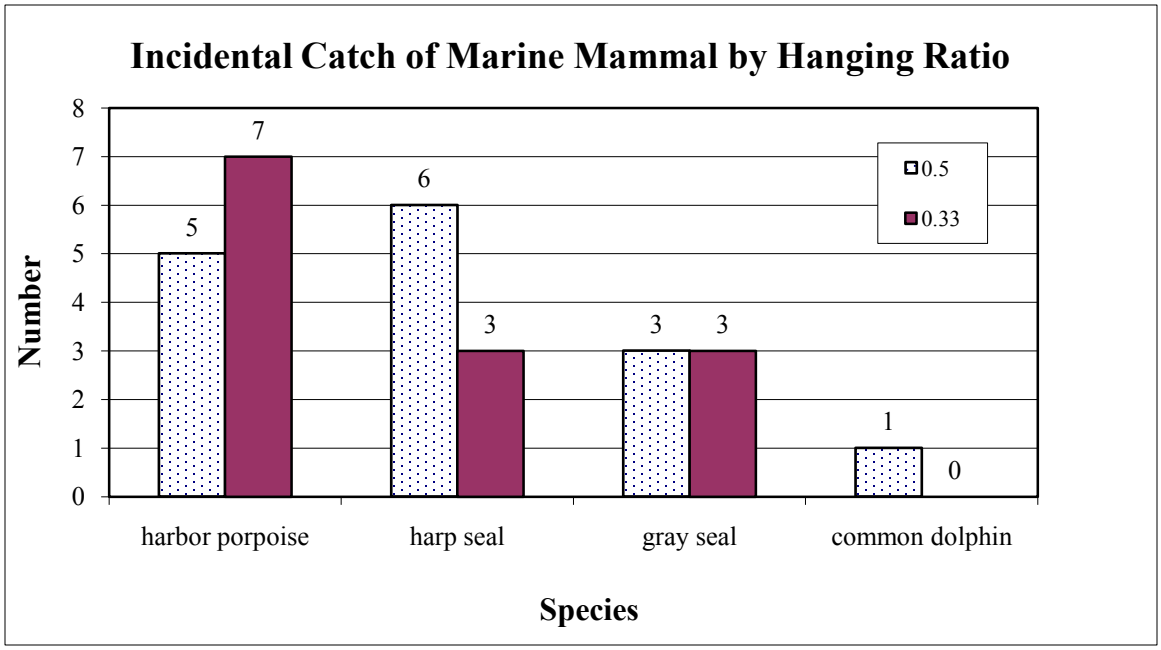


**Figure 14**. Incidental marine mammal catch by hanging ratio in 2009.

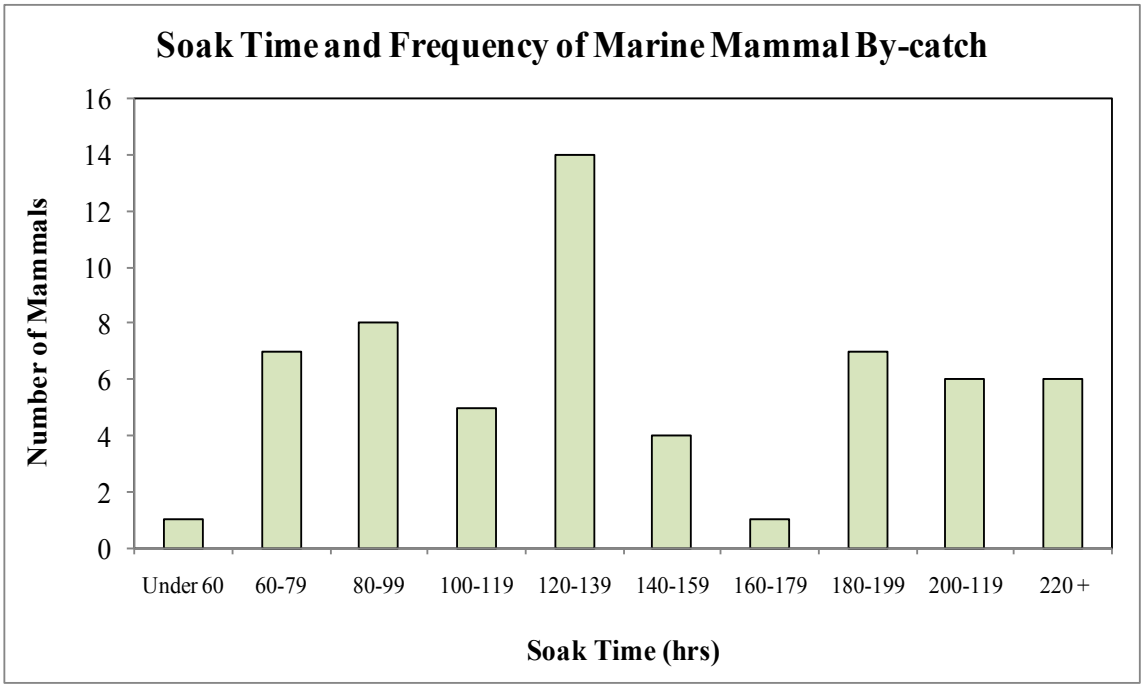


**Figure 15.** Frequency of marine mammal by-catch based on soak time, 2009 to 2010.

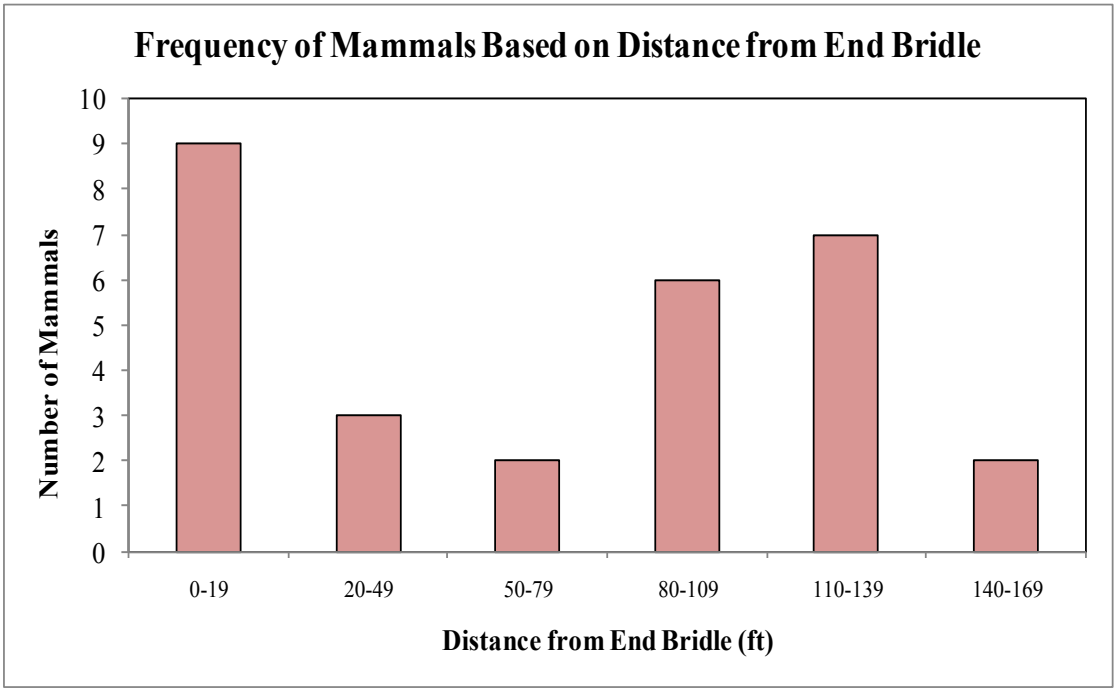


**Figure 16.** Frequency of marine mammal by-catch based on distance from the end bridle for 2010.

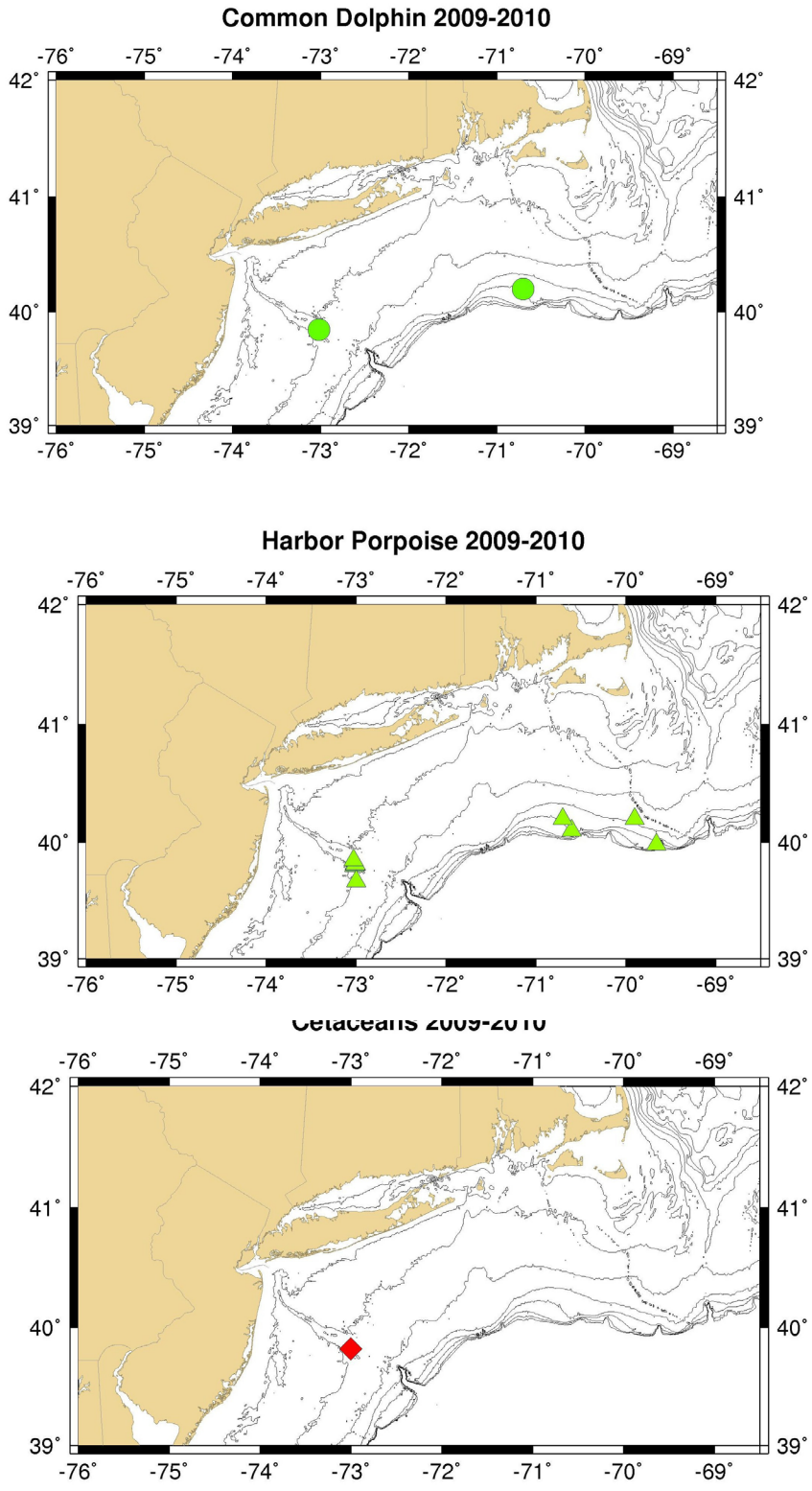


**Figure 17.** Locations of cetacean by-catch for both field seasons.

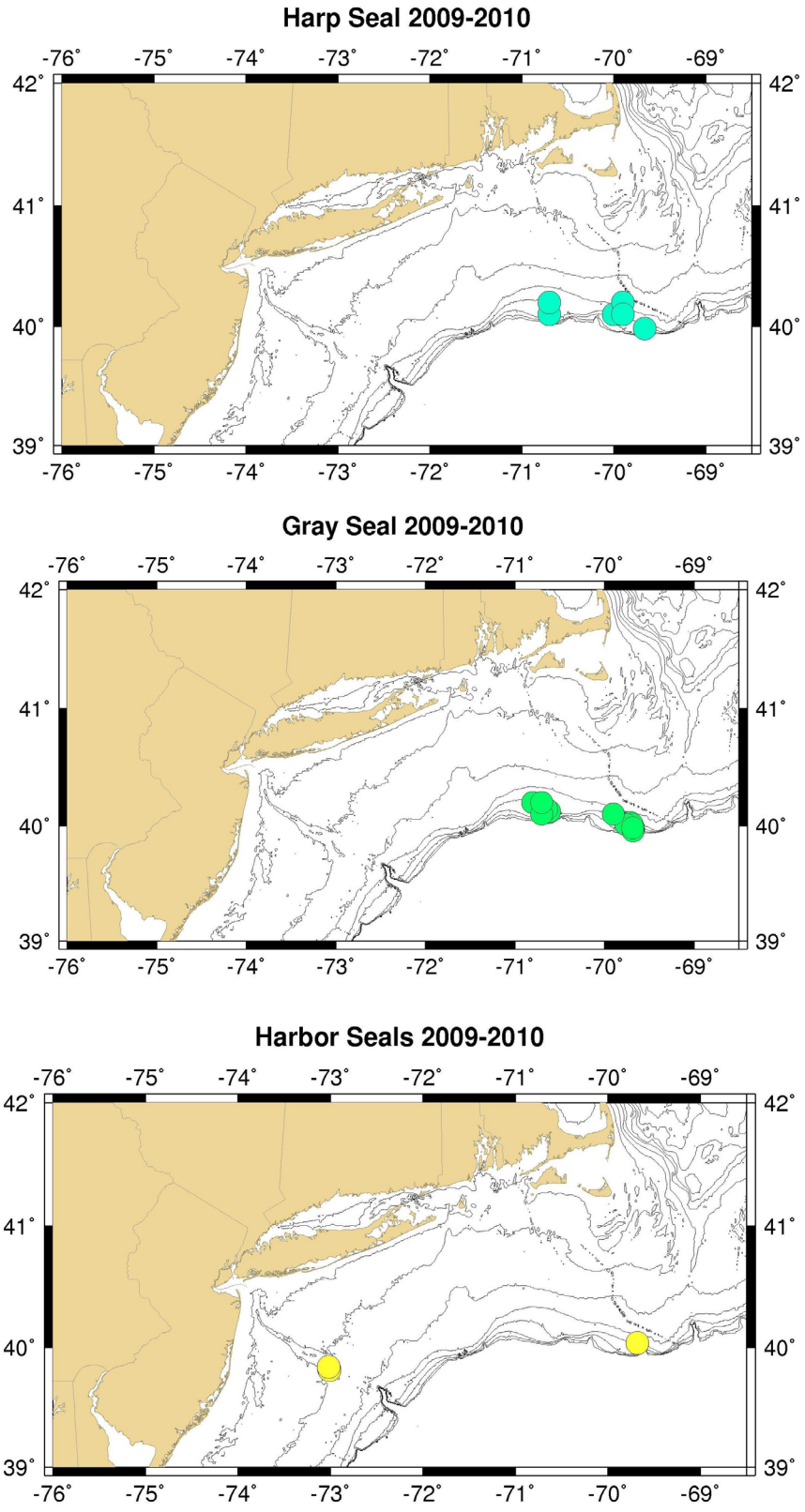


**Figure 18.** Location of pinniped by-catch for both field seasons.

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## APPENDIX 1

| Variable Name | Description |
|---|---|
| **GEAR CHARACTERISTICS** | |
| Twine size | Size of the twine (mm) |
| Mesh count | Number of meshs in the vertical direction of the net |
| Length tie downs | Length of tie downs |
| Number of anchors | Number of anchors used on the string |
| Type of anchor | Type of anchor used |
| Lead line depth | Depth the lead line of the net is at (fathoms) |
| Weight of lead line | Total weight of the lead line |
| Space width | Width of spaces between nets |
| Float distance | Distance between floats |
| Hanging Ratio | How taughtly net is hung on float line |
| | |
| | |
| **FISHING PRACTICES** | |
| Wx Code | Weather conditions |
| Direction | Wind Direction |
| Wave height | Wave height (ft) |
| Speed | Wind Speed (knots) |
| Surf. Temp | Sea Surface Temperature |
| Long | Longitude |
| Lat | Latitude |
| Number of nets set | Number of nets that were set |
| Number of nets hauled | Number of nets that were hauled back |
| Soak time | Time net in the water (hrs) |
| Target species | Species captain said they were trying to get |
| Gear Code | Condition of gear at time of haul |
| Steam time | Time spent steaming to fishing grounds from port |
| Bottom depth | Bottom depth (fathoms) |
| Retained/Discard | Indicates whether fish was retained or discarded |
| Disposition Code | Specific retained category or discard reason |
| | |
| **WEATHER CODES** | |
| 1 | Clear. |
| 2 | Partly cloudy. |
| 3 | Continuous layers of clouds. |
| 4 | Drizzle. |
| 5 | Rain. |

| | |
|---|---|
| 6 | Showers. |
| 7 | Thunderstorms. |
| 8 | Rain and fog. |
| 9 | Fog or thick haze. |
| 10 | Snow, or rain and snow mixed. |
| 11 | Blowing snow. |
| 99 | Other. Describe in COMMENTS. |
| | |
| **FISH DISPOSITION CODES** | |
| 001 | No market, reason not specified. |
| 002 | No market, too small. |
| 003 | No market, too large. |
| 012 | Regulations prohibit retention, too small. |
| 025 | Regulations prohibit any retention (including no permit). |
| 031 | Poor quality, reason not specified. |
| 038 | Poor quality, due to gear damage. |
| 053 | Debris. |
| 062 | Upgraded. |
| 063 | Vessel retaining only certain size for best price due to trip quota in effect. |
| 100 | Retained. |
| 171 | Retained, consumed by captain/crew. |
| | |
| **GILLNET GEAR CONDITION CODES** | |
| 210 | No gear damage, or very few small, scattered holes. |
| 220 | Small number of torn meshes, not exceeding 25% of any one net, each net may be torn slightly. |
| 230 | Less than 50% of the nets have less than 50% of the meshes torn. |
| 240 | 50% or more of the nets have less than 50% of the meshes torn. |
| 250 | Less than 50% of the nets are obstructed by a large object. |
| 260 | 50% or more of the nets are obstructed by a large object. |
| 270 | Less than 50% of the nets have 50% or more of the meshes torn. |
| 280 | 50% or more of the nets have 50% or more of the meshes torn. |
| 290 | Nets in the string totally balled up. |

## APPENDIX 2

| ANIMAL CONDITION CODE | |
|---|---|
| 0 | Unknown |
| 1 | Alive |
| 4 | Alive, hook/gear in/around mouth |
| 5 | Alive, hook/gear in/around flipper |
| 6 | Alive, hook/gear in/around another single body part. |
| 7 | Alive, hook/gear in/around several body parts |
| 8 | Alive, seen by captain and/or crew ONLY. |
| 9 | Alive, resuscitated (turtle). |
| 10 | Dead, condition unknown. |
| 11 | Dead, fresh. |
| 12 | Dead, moderately decomposed. |
| 13 | Dead, severely decomposed. |
| 14 | Dead, seen by captain and/or crew ONLY. |
| | |
| **ENTANGLEMENT CODE** | |
| 0 | Unknown. |
| 1 | Fell from gear at a point unknown. |
| 2 | Fell from gear before exiting water. |
| 3 | Fell from gear once hauled out of the water. |
| 4 | Fell from gear due to force of roller. |
| 5 | Removal requires cutting of gear/animal. |
| 6 | Removal does NOT require cutting of gear/animal. |
| 28 | Contact with vessel or vessel equipment other than fishing gear. |
| | other than fishing gear. |
| 29 | Entangled in gear other than vessel's fishing gear (ie ghost gear) |