Design and prototype testing of multi-fish descending devices in Mid-Atlantic recreational fisheries: a submission to the 2014 Special Project E Funding Competition "Development of a fish descending device in the Mid-Atlantic"

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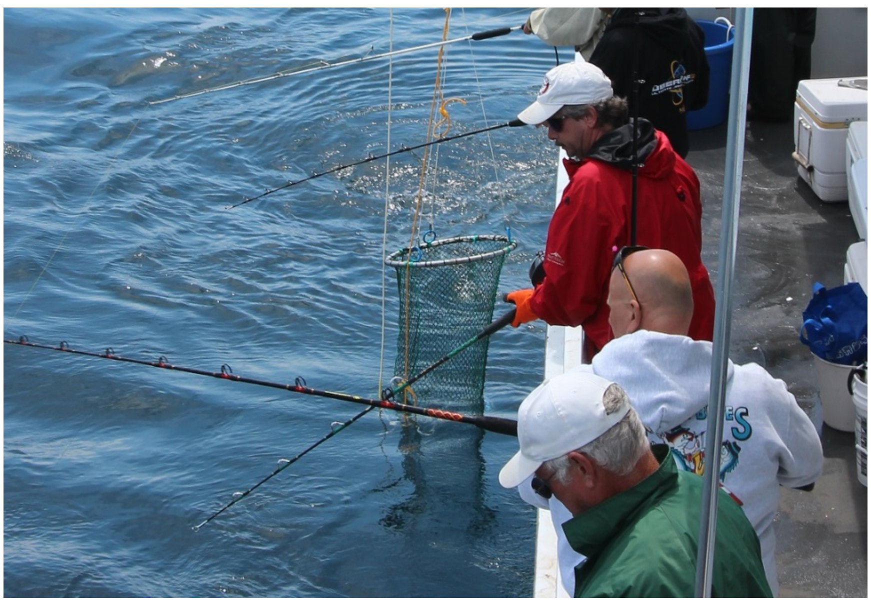

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EXECUTIVE SUMMARY:

Extension staff from New Jersey, Virginia and North Carolina worked together, along with for-hire boat captains, on the first regional collaboration to design and test prototype multi-fish descending devices in the Mid-Atlantic. From October 2014 through July 2015, seven field trials were completed: one trial in New Jersey, four trials in Virginia, and two trials in North Carolina. Seven multi-fish descending device prototypes were developed and tested including a weighted messenger system, varying sized weighted hoop nets, a weighted crate, and a weighted crab bushel basket. Each trial showed the hoop net regularly capable of descending multiple fish at a time. Informal trials showed the hoop net device capable of lowering up to 15 black sea bass at a time, with formal, recorded descents of seven to eight fish at a time observed in most trials. More than 200 fishes were descended in the study, and 161 of these were tagged and released for information regarding long-term survivorship and success of the descending devices. Of the 227 fishes that were descended in the prototype devices, 146 (64.3 percent) were successfully released, as determined by GoPro video depicting fish movement out of the descending device once recompressed. In terms of outreach, informal discussions during each trial provided Extension staff with the opportunity to learn more about recreational anglers' familiarity with the concept of barotrauma and their receptiveness towards multi-fish release devices. Conversations with anglers showed that 93 percent would support charter captains using a multi-fish descending device. Yet, it appeared full support from for-hire operators may only be garnered by offering incentives, such as expanded fishing seasons or catch limits for captains regularly using descending devices.

FINAL REPORT

Grant Number:	NA14OAR4170296
Project Title:	Design and prototype testing of multi-fish descending devices in Mid-Atlantic recreational fisheries: A submission to the 2014 Special Project E Funding Competition "Development of a fish descending device in the Mid-Atlantic."
Grantee:	Virginia Institute of Marine Science
Report Period:	September 1, 2014 to August 31, 2015
Partners:	Susanna Musick, VIMS/VASG; Robert Fisher, VIMS/VASG; Sara Mirabilio, NCSG; Scott Baker, NCSG; Michael Danko, NJSG

Work Accomplishments

- **Describe tasks scheduled for this period (from proposal and amendments, if appropriate)**

Extension staff from three states will work together, along with for-hire boat captains, to design and test prototype multi-fish descending devices offshore of New Jersey, Virginia and North Carolina. Our work will involve three phases.

The first phase will focus on initial device development and trials. Extension staff will meet in October 2014 in Wachapreague, Va., to test at least two prototype descending devices using feedback gathered from industry. During an offshore device trial, Extension staff will gather information regarding basic functionality, ease of deployment and recovery, and fish recovery response. Field work will also focus on testing GoPro video equipment and/or other video equipment (as availability and budget permit) in correlation with the prototype descending devices, so as to better document fish behavior. At this time, Extension staff also will discuss an angler outreach strategy for use in phase two and phase three trials.

The second phase of the project will concentrate on testing the most promising prototype descending devices in a "real-world" fishing setting aboard a for-hire head boat, (meaning that which is capable of carrying greater than six anglers), in winter 2015 out of Virginia Beach in cooperation with Rudee Inlet Charters. Both Extension staff and project partner captains will participate in the field trial. The project team will continue to explore deployment and handling logistics by captain and crew. The deployment and recovery process by staff will be documented, and the recovery rate (in terms of the number of fish that move out of the descending device once it is released) from the recompression process will be documented. We will follow previous studies (Jarvis and Lowe 2008) and will aim to hold fish at the surface for no more than 10 minutes.

Long-term survivorship of fish descended in the phase two trial will be tracked via tagging and recapture (reports) through a partnership with the Virginia Game Fish Tagging Program (VGFTP). We will also focus on angler outreach and disseminate information about the condition of barotrauma in marine fishes and the projected positive impacts of releasing fish through use of a descending device.

The third phase of the project will include individual state trials with the most promising prototype. Extension staff will conduct an independent trial off their respective coasts with their partner captains/boats during spring 2015. The state trials will allow staff to document the differences and similarities of the devices' use and effectiveness aboard different style head boats and with different fisheries and fish habitat.

Long term (with additional funding), there could be opportunities created for technology transfer, as successful multi-fish release devices developed during this project could also be shared in the future with the commercial fishing industry.

- **Describe tasks accomplished this period**

Phase One

Two prototype multi-fish descending devices were targeted for initial construction. Design concepts were shared with for-hire industry captains who provided feedback. These two devices were constructed as prototypes for testing on fishing vessels of mixed sizes and with varying gear configurations. Industry concerns, including deck-space storage, loss of rail space, ease of operation, and slowed fishing from deployment/retrieval time, were also taken into consideration during the design phase.

The first design was a hoop net (Appendix A, Figure 1) wherein two metal hoops of different weights were connected by an encircling panel of 1.5-inch stretched mesh seine netting. The two hoops, measuring 24 inches in outer diameter, were constructed from round steel stock; one hoop from one inch stock, and the other, from half-inch stock. Critical to function was one hoop weighing more than the other. Netting was laced onto each hoop, thus connecting hoops with a distance of 40 inches when hung. To prevent the netting from collapsing inward centrally (i.e., hour-glass shape) as the mesh is stretched when hung, thereby reducing internal fish-holding capacity of the net, four pieces of polypropylene twine were woven through the webbing and tied between each hoop, evenly distributed around the circumference of hoops and at a distance equaling non-stretched mesh distance. These "ribbings" prevented the hoops from fully stretching the webbing between them, thus reducing the collapsing of space within the net. The resulting volume capacity of the net was approximately nine cubic feet (0.26 m3). The smaller steel diameter (and lighter weight) hoop was covered with the same seine mesh; the mesh was stretched and sewn to provide a barrier across the hoop. The larger diameter and heavier steel hoop was not covered with mesh and left open. A three-arm bridle was placed on the outside of both hoops. The heavier hoop bridle was unequal in arm length, which resulted in a slope of the hoop from horizontal when hung. This bridle was connected to a two-inch cull ring, which in turn was placed into a quick-release hook. The setup for the initial prototype had this hook fixed on a boom of an electric reel or a steadfast boom, both on the rail of the boat. The bridle connected to the lighter-weight hoop joins into a single haul back line, which was either spooled line on an electric reel, or a hand line attached to the rail. The total weight of the net was 24.5 pounds (11.1kg). The hoop-net device was hung overboard from the davit/boom with two-thirds of the netting in the water. The heavier, open hoop was suspended above the water surface with its bridle ring engaged in the quick-release hook. Fish were passed through this open hoop into the submerged section of the device and were confined there until descent. Deployment was done by releasing the heavier hoop bridle from the quick-release hook, which caused the heavier ring to fall and collapse the device (enveloping contained fish) and sending the opening of the net down towards the ocean floor. At depth, recompressed fish were therefore allowed to swim out freely through the open, heavier hoop. The haul-back, which involved retrieving the line connected to the lighter, closed hoop, allowed any fish remaining in the device (those either still experiencing barotrauma or in poor condition) to be left at depth.

The second device was a messenger system (Appendix A, Figure 1) wherein weighted messengers were attached to a weighted line (a downrigger-type system where a weight is placed on the end of a line at certain depths to keep line from scoping) and descended to a predetermined depth. Messengers were made from either 1.5-inch or 2-inch short sections of schedule 40 PVC pipes filled with Portland cement and capped with PVC rounded end caps. Varying lengths and diameters of PVC tubing permitted adjustment of the total device weight, providing a range of weighted messengers to test for fish of varying size (weight). A stainless steel eye-blot was fixed into the top end cap to which a 200-pound test monofilament tether line was attached. The tether line allowed the messenger to travel along the weighted line using a stainless steel carabiner clip. A two-millimeter diameter stainless steel wire was passed through the body of the messenger (through a stainless steel tube built into the body of the messenger one-third the linear distance from the messenger top). The end of the wire was terminated with a short bend to prevent the wire from backing out of the tubing. The other end of the wire extended outward perpendicular from the messenger body and was bent into a V-shape hook configuration with the leg-length of the "V" terminating to form a hook tip twice the leg-length of the "V" extending from the messenger body. This prevented the wire hook from becoming free of the messenger body and thus freely able to swivel unrestricted. The bottom of the "V" in the hook was matched for each size messenger to extend approximately to the bottom edge of that messenger, resulting in attached fish contacting the water surface before the messenger when deployed. In preparation for descent, fish were attached to the barbless V-hook by running the end of the hook through the fish operculum back-to-front. This resulted in the fish hanging from the device head facing upward. Upon deployment, the fish would enter the water just prior to the weighted messenger, tail first followed by body, which due to positive buoyancy, would result in the fish swiveling on the hook to a head first orientation as the weight of the device pulls the fish to depth. Descending fish head-first also allowed ram ventilation to occur during deployment, theoretically helping with fish recovery. Upon reaching a predetermined depth, any forward movement (swimming activity) generated by the recompressed fish allowed the fish to slip off of the barbless hook. Upon de-hooking fish when reeled in, fish were directly placed on the messenger and descended without delay. Multiple messengers with fish attached were sent down the weighted line. When the maximum accumulated messenger weight was reached at the end of the weighted line, the main line was hauled back and the messengers removed.

The phase one sea trial took place aboard the *Foxy Lady* on Oct. 28, 2014, offshore of Wachapreague, Va. in and around the Monroe Wreck (with fishing depths ranging from 80 to 100 feet). The hoop net device proved to be more successful in descending fish to the bottom. This device was also slightly easier to deploy, though adverse weather conditions with steep waves and chop caused strain on the hull of the boat and rod holder. The messenger device's action did not facilitate easy release of the fish and difficulties were encountered with the deployment because of the wave action and concerns of the captain regarding line tangling.

During the phase one trial, 24 black sea bass were tagged with VGFTP tags and descended. There were a total of three descents and the cohort size (number of fish descended at one time) ranged from one to seven. No recaptures from these fish have been reported thus far.

Feedback from partner captains also favored the hoop net design. However, partner captains had concerns about the space needed to use a boom to deploy the device. Project partners suggested a modified design that would be deployed and retrieved by hand, and small enough to be stowed when not in use. These suggestions were considered and a modified hoop net device was created for use in the phase two trials.

Extension partners also worked together during the first phase of the project to create a draft outreach brochure (final version, Appendix C) explaining the process of barotrauma, various release options, and the research project, to be disseminated to anglers in phases two and three. Additionally, video footage taken during the phase one sea trial was combined with explanatory text to produce nearly a 3.5-minute introductory video to be played for anglers (final version available here: https://youtu.be/fREWb8kwRcE).

Phase Two

The second phase of the project was completed on April 18, 2015 aboard the *Rudee Mariner* head boat out of Virginia Beach, Va. The project team documented deployment logistics, including device location on deck, time to deploy and recover the device, and size of black sea bass descended. Two modifications to the hoop net prototype were tested at-sea, both smaller than the original prototype described above (phase one trial) and more readily hand-deployable. The first of the smaller nets was constructed of stainless steel hoops of equal diameter (15.75 inch OD) but with one hoop (open hoop) made from heavier, three-quarter-inch rod stock, and the other (closed hoop), from lighter, half-inch rod stock. Hoops were connected by a 22-inch panel of 1.5-inch stretched mesh seine netting and ribbed and bridled as the original larger net with the acceptation of bridle rings attached by a braided yellow rope to ease in hand-deployment. The resulting volume of this net was a little over two cubic feet (0.06 m3) with a total weight of 8.4 pounds (3.8 kg). The second smaller net was nearly identical, but the heavier, three-quarter-inch rod stock was made to have an 18 inch outer diameter, thus requiring a mesh netting panel length of 24 inches. The resulting volume of this net was just over three-and-a-third cubic feet (0.1 m3) with a total weight of 9.5 pounds (4.3 kg). These smaller hoop net versions were designed to fit into a standard 20 gallon, rope-handled plastic tote readily available in most hardware or department retail outlets. The 15.75-inch diameter hoop net equaled the tote bottom diameter and so fully collapsed inside the tote. The 18-inch diameter ring in the second modification allowed the smaller hoop to rest in the bottom of the tote while the larger hoop nested near the top of the tote (water line) (Appendix A, Figure 2) at a point equaling the diameter of the hoop. This modification was made to help prevent possible spillage of fish during hand-hauling of the net from the tote overboard, since fish with barotrauma readily float at the water surface in the tote. Both nets were kept submerged in totes filled with ambient sea water, so fish could be loaded over the course of several minutes before descent. Again, this configuration was tested because of feedback from captains regarding rail and rod holder space. Both nets could be deployed and retrieved by hand, but the setup did not preclude future deployment and retrieval with a boom-pulley setup or Bandit reel. The deployment protocol was as follows: a modified hoop net, alternating between each modification style, was submerged in a tote; fish were measured, tagged and placed in the net-lined tote; when one or more fish were ready for deployment the net was deployed by hand over the side of the boat.

Twenty-four black sea bass were descended in the 18-inch device, and 20 were descended in the 15.75-inch device. All 44 black sea bass were tagged with VGFTP tags and descended. All fishing activity and descending trials took place in the Norfolk Canyon area, with water depths ranging from 320 to 750 feet. There were a total of ten descents and the cohort size ranged from one to eight fish per descent. Of the 40 black sea bass that were descended, 16 were no longer present in the device when it was brought to the surface as observed in GoPro video footage. All fish were descended to approximately 66 feet (2 atmospheres). Of the 40 fish descended, ten did not have visible signs of barotrauma; the other 34 fish had some degree of visible barotrauma ranging from exophthalmia, to stomach or anus protrusion, or a combination of the three.

Informal discussions were held with 17 of the 34 anglers onboard the *Rudee Mariner* to learn more about their familiarity with the concept of barotrauma and descending devices. This was the first deep-drop trip ever for four of the anglers, with another four anglers going on 1-2 deep drop trips per year. Eight anglers said they regularly go on two or more trips per year. Three anglers were familiar with the term "barotrauma," while ten were not familiar with the term. Twelve anglers said they would support a captain who used a release device for barotrauma (three did not), and eight of these would still support use of a device even if it slowed fishing by ten minutes or so. Six anglers did not support using a device if it slowed fishing. Ten anglers would be willing to change their fishing practice (by using a slower retrieve or lower gear ratio) to improve catch-and-release survivorship, but six would not. Outreach packets (including project brochures and other promotional items like logoed drink cozies, measuring tapes, and etc.) were distributed to all anglers, and the outreach video for the project also was played for anglers during the trip. The overall informal reception of the anglers was positive in regard to the concept of the research and feasibility of the device, especially during the closed seasons. The brochure disseminated during the trip then was further adapted by Extension staff for use in their Phase Three trials later in the spring.

<u>Phase Three</u>

North Carolina

The first phase three, state trial took place offshore of Cape Hatteras, N.C., on May 30, 2015 aboard the *Miss Hatteras* head boat (Appendix A, Figure 3). To recruit anglers for the trip as the boat was chartered solely for research that day, North Carolina Sea Grant formed a partnership with the North Carolina Coastal Federation's Office in Manteo, N.C., and with River City YouthBuild in Elizabeth City, N.C., to provide economically disadvantaged youth with education on ethical angling and an outdoor fishing experience. For many of these youth, it was their first time fishing, and for one, his first time on a boat. North Carolina Sea Grant also partnered with the N.C. Division of Marine Fisheries (NCDMF) to tag fish (for this trial only) and track post-release survivorship. The DMF received a NOAA Fisheries Marine Fisheries Initiative (MARFIN) grant (No. NA10NMF4330117) to conduct, from August 2010 through March 2015, an analysis on North Carolina snapper-grouper species ageing and estimation of release mortality. For the release mortality portion of the MARFIN study, NCDMF observed commercial and recreational fishing boats and tested recompression techniques. Their purpose was aligned with the Sea Grant research purpose: determine the release mortality of species in the snapper-grouper fishery and determine the preferred recompression technique to reduce discard mortality by fishery. During the phase three trial, NCDMF staff accompanied North Carolina Sea Grant project members Sara Mirabilio and Scott Baker to deploy the remaining tags from the MARFIN study. Captured black sea bass were assigned randomly to one of three release treatment methods: none, venting or multi-fish descender. The North Carolina project team felt, for their boat size, gear configuration and fishing style, the hoop net that weighed 9.5 pounds and rested near the water line of the tote (18-inch outer diameter closed-net ring) was the most promising candidate and tested that solely. The fish were held on deck no longer than ten minutes (Jarvis and Lowe, 2008) in a water-filled, 20-gallon tote prior to descent.

Eighty-eight black sea bass were used in the North Carolina trial. Of these, 56 were descended in the hoop net, 13 were vented, and 23 were thrown overboard with no treatment. There were a total of 11 descents and the cohort size per descent ranged from one to thirteen fish. Depth of capture ranged from 158 feet to 217 feet. Depth of descent either equaled approximately one-third or one-half of capture depth (Lowe, pers. comm., 2015). Fifty-two black sea bass were descended, with eight fish released at 50 feet, 39 fish released at 75 feet, four fish released at 80 feet and five fish released at 110 feet. Of the 56 fish descended, 52 were assumed successfully returned to depth (meaning they moved out of the net as observed in the video footage). We observed three fish come back up with the multi-fish descender. One fish fell out of the net before being sent down. In terms of visible barotrauma, 18 fish had no visible barotrauma; the other 74 fish had some degree of visible barotrauma ranging from exophthalmia, to stomach or anus protrusion, or some combination of the three. The DMF tagged 61 fish. As of report time, the agency has not reported any recaptures.

Informal discussions were held with 21 of the 35 anglers aboard the *Miss Hatteras* to learn more about their knowledge in terms of barotrauma and release devices. This was the first offshore fishing trip for six of the anglers, with another 11 anglers going on 1-2 offshore fishing trips per year. Four anglers were more seasoned, stating they go on two or more trips per year. Six anglers were familiar with the term “barotrauma,” but the majority (15 persons) was not familiar with the term. All 21 anglers participating in the discussion said they would support a captain who used a release device for barotrauma and would still support use of a device even if it slowed fishing by ten minutes or so. As with phase two, outreach packets (including North Carolina adapted project brochures and other promotional items like logoed measuring tapes, etc.) were distributed to all anglers, and the outreach video for the project was also played for anglers during a topside educational briefing on the run out. Again, the overall informal reception of anglers was positive in regard to the research taking place and utility of the device.

Virginia

On June 11, 2015, Virginia Institute of Marine Science (VIMS) Extension staff affiliated with Virginia Sea Grant, Susanna Musick and Bob Fisher, took part in the third phase of research in Virginia aboard the *Rudee Angler* head boat (Appendix A, Figure 4). Unlike the North Carolina trial, both of the phase two modified hoop net prototypes were used. The fishes were held on deck no longer than ten minutes in water-filled, 20-gallon totes prior to descent. Nine fishes in total were descended in seven descents, six in the larger device and three in the smaller device. Blueline tilefish, black sea bass, black-bellied rosefish, chain dogfish and a ling cod were descended, and one fish was successfully released (the chain dogfish). One black sea bass was released with a VGFTP tag. It should be noted that obtaining a larger sample size was challenging, as this was not a research-only charter. The black sea bass season had opened, and most of the anglers were keeping their catches. All fishing activity took place in the Norfolk Canyon area between 276 and roughly 500 feet. Unlike the North Carolina phase three trial, it was unfeasible to release fishes at one-third to one-half depth due to the deep fishing profile. Instead, almost all fishes were descended to at least two atmospheres (66 feet) (Lowe, pers. comm., 2015). Two fishes were descended to 99 feet; one was descended to 33 feet; six were descended to approximately 66 feet. Of the fishes descended, five did not have visible signs of barotrauma; the other four fishes had some degree of visible barotrauma ranging from exophthalmia, to stomach or anus protrusion, or some combination of the three.

Informal discussions were held with 15 of the 34 anglers aboard the *Rudee Angler* to gain insight into their awareness of barotrauma and release devices. This was the first deep-drop trip for one of the anglers, with another eight anglers going on 1-2 deep-drop trips per year. Seven anglers reported going on two or more trips per year. Three anglers were familiar with the term "barotrauma," but 14 were unfamiliar with the term. Thirteen anglers said they would support a captain who used a release device for barotrauma. One did not. Ten of the anglers would still support use of a device even if it slowed fishing by ten minutes or so. Five anglers did not support using a device if it slowed fishing. Seven anglers would be willing to change their fishing practice (such as using a slower retrieve or lower gear ratio) to improve survivorship of fishes, but four would not, while still four more were undecided. Outreach materials (including a Virginia adapted brochure, etc.) were distributed to all anglers. The general customer receptiveness towards the project and device usefulness was positive.

New Jersey

The phase three trial took place off the New Jersey coast on June 15, 2015, aboard the *Ocean Explorer* head boat out of Belmar, NJ (Appendix A, Figure 5). Project team member Mike Danko of the New Jersey Sea Grant Consortium was joined by Jeff Dement of the American Littoral Society (ALS) and NOAA staff Pete Plantamura and John Rosendale of the Northeast Fisheries Science Center. Like the North Carolina project team, only the larger hoop net (18-inch outer diameter closed-net ring, 9.5 lbs.) was tested. Fishing took place off the Sea Girt and Shark River Inlet, in water depths that ranged 65-85 feet. Fishes were held on deck no longer than ten minutes in a water-filled, 20-gallon tote. A total of 38 fishes were descended (36 black sea bass and 2 tautog), and all were sent to approximately 66 feet (2 atmospheres) (Lowe, pers. comm., 2015). There were a total of 14 descents and the cohort size (number of fish in the net during descent) ranged from one to six. Of the fishes descended, 12 did not have visible signs of barotrauma; the other 26 fishes had some degree of visible barotrauma ranging from exophthalmia, to stomach or anus protrusion, or some combination of the three. Thirty-two of the fishes were tagged through a partnership with the ALS. As of final report writing, one recapture had been reported at Klondike Bank, N.J., on July 11, 2015 (Appendix B).

Informal discussions were held with 16 of the 31 anglers aboard the *Ocean Explorer* to learn more about their knowledge in relation to barotrauma and release devices. This was the first offshore fishing trip for seven of the anglers, with another five anglers going on 1-2 deep-drop trips per year. Four anglers stated going on two or more trips per year. Seven anglers were familiar with the term "barotrauma," while nine were not familiar with the term. All anglers (16 participants) said they would support a captain who used a release device for barotrauma. Half of these anglers would still support use of a device even if it slowed fishing by 10 minutes or so, (the other eight did not support using a device if it slowed fishing). Seven anglers would be willing to change their fishing practice (such as using a slower retrieve or lower gear ratio) to improve survivorship of fishes, but two would not; one was undecided. Outreach materials were shared with the anglers.

Supplemental Trial
Project cost-savings allowed for an additional field trial to test out further descending device prototypes and handling protocols. Another goal was to obtain further GoPro video for use in additional outreach endeavors. On July 23, 2015, the Extension staff made a trip offshore aboard a smaller ("six-pack") charter boat, the *Albatross III*, out of Hatteras, N.C. Fishing effort took place in depths ranging from 180 to 787 feet. The larger hoop net (18-inch outer diameter closed-net ring, 9.5 lbs.) was tested in addition to a weighted (5-10 pounds) bushel crab/fish basket (14 inches in height, 13.5 inch diameter base, 17 inch diameter top, equal to 1.5 U.S. bushels) and a weighted (10 pound) four-gallon milk crate (Appendix A, Figure 6). The crab basket prototype had a coated wire trap door that was triggered to open with a SeaQualizer at a prescribed depth. Fish were loaded into the open basket, which was submerged in the water-filled, 20-gallon tote (as used with the hoop net). When the ten minute mark was reached, the trap door was closed and secured to the handle of the basket using a standard (50-100-150 feet) SeaQualizer, thereby allowing for release of fish at a set depth. For this trial, descent depth mimicked the North Carolina phase three trial, wherein the descent ranged from one-third to one-half of the capture depth. The basket was deployed initially with five pounds of external weight; subsequent deployments were done with an additional five pounds of weight, for a total of ten pounds. The device was hand-deployed over the side of the boat similar to the hoop net. The weighted milk crate prototype trials followed the same protocol.

Fishes were held on deck no longer than ten minutes. Nineteen total fishes were descended in 11 total descents: four in the hoop net, one in the five-pound weighted fish basket, seven in the ten-pound weighted fish basket, and seven in the weighted milk crate. Blueline tilefish, grey triggerfish, red grouper, and black sea bass were among the species descended. Four fishes were descended to 198 feet; one was descended to 99 feet; 13 were descended to approximately 66 feet. Of the fishes descended, one did not have visible signs of barotrauma, while the other 18 fishes had some degree of visible barotrauma ranging from exophthalmia, to stomach or anus protrusion, or some combination of the three. Of the 19 fishes that were descended, 14 were released successfully in a device; four of these were released in the large net, five in the milk crate, and five in the basket (this is the total of all descents per device). The cohort size ranged from one to five fish per descent.

<u>Overall Results</u>
This was the first cooperative research project for barotrauma research among Extension staff and recreational industry partners in New Jersey, Virginia and North Carolina. From October 2014 through July 2015, seven field trials were completed: one trial in New Jersey, four trials in Virginia, and two trials in North Carolina. For-hire captains in each state were an integral part of the project and provided valuable feedback for device development and testing.

Seven multi-fish, descending device prototypes were developed and tested including a weighted messenger system, varying size weighted hoop nets, a weighted crate, and a weighted fish bushel basket. Each trial provided another layer of information about deep-drop recreational fishing in each state. The deployment and success (in terms of releasing fish) varied greatly by boat, region and environmental conditions on the day of the trial. The weighted hoop net was the most widely tested across the region (it was used at least once in each state), with more than 127 fishes descended in the net during the project. While most descended fish were black sea bass, several additional species comprised those successfully deployed: blueline tilefish, black-bellied rosefish, chain dogfish, grey triggerfish, ling cod, red grouper, and tautog. Each trial proved the hoop net regularly capable of descending multiple fish at a time. Informal trials showed the hoop net device capable of lowering up to 15 black sea bass at a time, with more formal, recorded descents of seven to eight fish at a time observed in most trials. More than 227 fish were descended; of these, 161 were tagged in partnership with the VGFTP, NCDMF and the ALS. Of the 227 fishes that were descended in the prototype devices, 146 (64.3 percent) were successfully released, as determined by GoPro video depicting fish movement out of the descending device once recompressed.

In terms of outreach, informal discussions during each trial provided Extension staff with the opportunity to learn more about recreational anglers' familiarity with the process of barotrauma and their receptiveness towards multi-fish release devices. More than 130 anglers took part in trips during the barotrauma trials, and about 52 percent of these anglers participated in discussions about barotrauma. Overall, about 74 percent of anglers participating in discussions had been on a previous deep-drop trip, with 33 percent going more than twice a year. Although there were barriers in terminology (72 percent of anglers were not familiar with the term "barotrauma"), there was support for the research. More than 93 percent of anglers would support a charter captain who used a release device, and of these anglers, 71 percent would support use of the device even if it slowed fishing. These discussion results suggest that there is support within the regional customer base for use of a multi-fish descending device. Industry partners were open to using the device, although they were concerned about feasibility of deploying and retrieving the device, especially during a crowded charter. However, even hand-deployed releases were relatively quick (2-3 minutes in total); this should help in terms of industry acceptance. Further, support within the recreational industry could be garnered by offering incentives, such as expanded fishing seasons or catch limits, for captains regularly using devices.

- **Explain special problems, differences between scheduled and accomplished work, etc.**

Phase One

All Phase One trials were intended to take place in the fall in 2014 aboard a commercial black sea bass boat. However, the boat was too small to accommodate all of the project partners, and only one prototype was trialed aboard the commercial vessel trip, so a second trip was scheduled with a recreational charter boat in Wachapreague. Rough weather prompted the trip to be rescheduled and the work took place aboard the recreational charter in suboptimal weather conditions.

Phase Two

The phase two trials were scheduled more than 5 times since January 24, 2015 due to adverse weather conditions and the actual trial did not take place until April 18, 2015. All subsequent proposed work including further field testing of the devices and outreach with deep-drop anglers took place as detailed in the original work plan. However, all project partners were not able to participate in the phase two trials because of their work schedules (e.g. captains needed to be present to run their own charter trips in their respective state). Further, initial discussion with the NMFS Cooperative Research Liaison suggests that there may be regulatory issues with using a release device if undersized fishes are held (even temporarily) during deployment of the device. If a device is successfully adopted and used throughout the industry, enforcement considerations may be needed to allow captains to integrate potential release devices as part of their fishing. Post-project outreach should include discussion with respective local enforcement officers in each partner state.

Research-Associated Mortality

Many factors can be associated with increased release mortality of deep-water species experiencing barotrauma. Excessive handling of fish at the surface is one main factor influencing survivability post-release. By nature of this study, excessive handling of fish was unavoidable, often resulting in stressed fishes for use in testing functionality of multi-fish descending devices. Almost all fishes in the project were tagged for survival validation. To allow for maximum number of fishes to accumulate ahead of device testing, the project team delayed descent to depth by holding fishes either on-board within a water-filled (ambient sea water), 20-gallon tote or overboard confined in the hoop net. This practice was done for research purposes and would not reflect the process of using these devices to descend multiple fish during a normal fishing trip. A more standard for-hire, catch-and-release fishing practice would entail placing de-hooked (or trapped, in a commercial setting) fishes immediately into either a water-filled tote on board or net hung overboard followed by deployment within a defined time frame as dictated by passive gas law (i.e., level of barotrauma as a function of capture depth, water temperature and fish size). Fishes classified in this study as "came back up" with the device largely were those in poor condition that were not able to recompress, remaining buoyant within the device at-depth and resurfacing with the device. Some of these fishes were captured on video during device deployment and retrieval, wherein they showed little to no active movements or signs of recompression. Further, upon returning to the surface and falling out of device, fish were observed to be highly lethargic and lifeless.

Descent Protocol

GoPro video footage showed that fishes caught at deep depths (>700ft) and so displaying severe barotrauma, seemed to have highly variable recompression rates. Initial prototypes were not designed for use in waters over 200 feet, and so in these instances Extension staff had to part from the protocol of a descent depth approximately one-third or one-half of capture depth. At shallower descent ratios, some fish recompressed to a state of acquiring full swimming ability and swam out of device and continued down, while others were observed to remain in the net recompressing, and upon device haul-back, were left suspended in the water column or at the water surface. These fish appeared lethargic with little active swimming movement observed. However, subsequent video of deployments in which the prototype descending device was held at-depth for short periods of time (30 seconds to 2 minutes) in a "rest stop" suggests that fish may need more time to recompress in order to achieve a state whereby they can more actively swim to reach bottom habitat and avoid predation. Further, recompression of fish is facilitated by multiple physiological processes, rather than a solely passive gas law process. Fishes experiencing a high degree of barotrauma may need rest stops (held at determined depth for “x” time) at a depth shallower than their original capture depth, (i.e., sending back down to 1/3-1/2 depth caught) to more fully recompress and regain active swimming (and predator avoidance) as they return back to their natural habitat.

Works Consulted

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Appendix A. Prototype Multi-fish Descending Devices

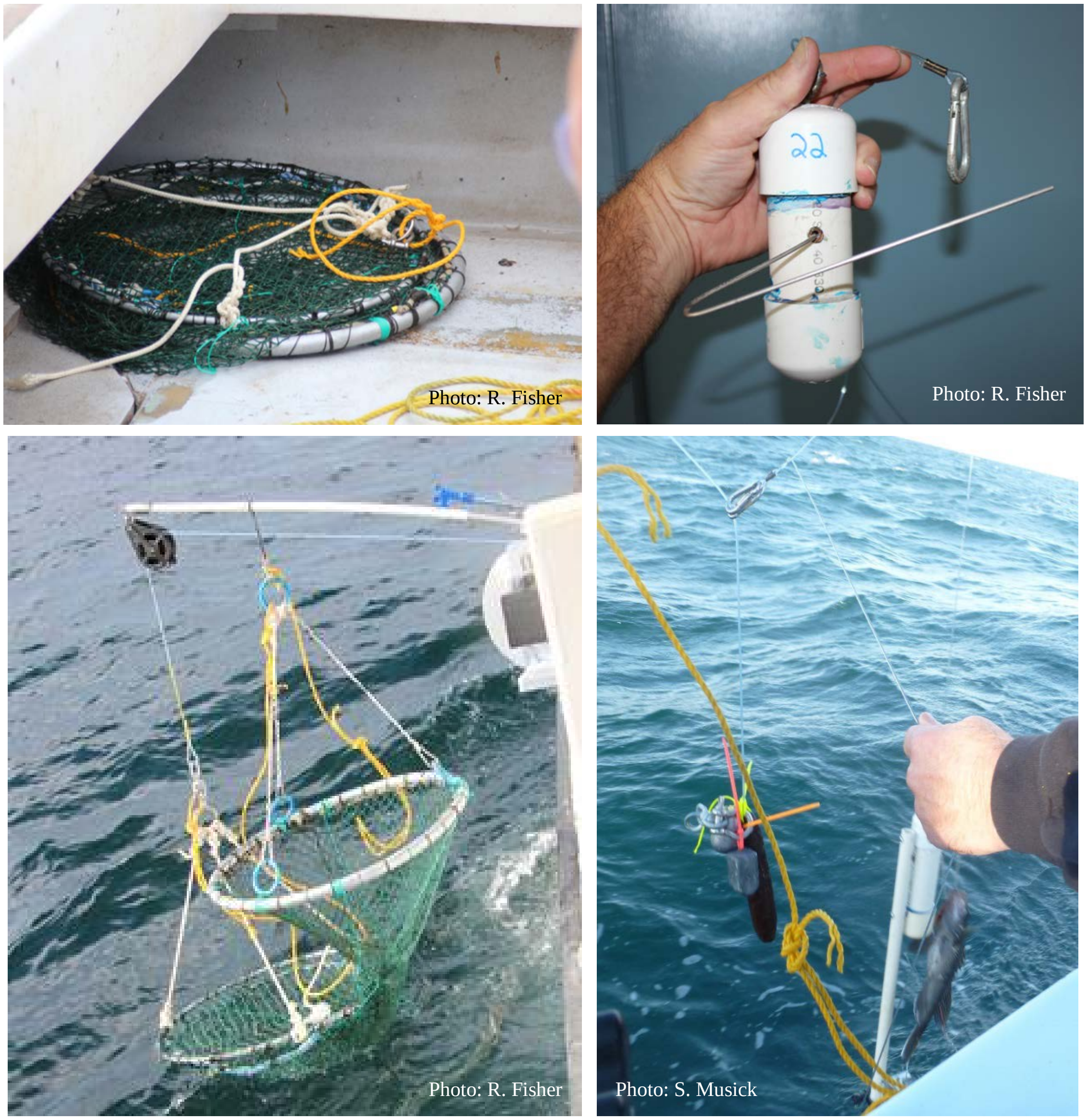


Figure 1.
Phase one multi-fish descending devices trialed offshore of Wachapreague, Va., October 2014. The left two photos illustrate the hoop net collapsed on deck and hanging from a boom ready for deployment. The right two photos display the weighted messenger detached and attached to a main stanchion line for deployment (Note: PVC pipe was only used temporarily to attach the GoPro unit to the messenger for filming).

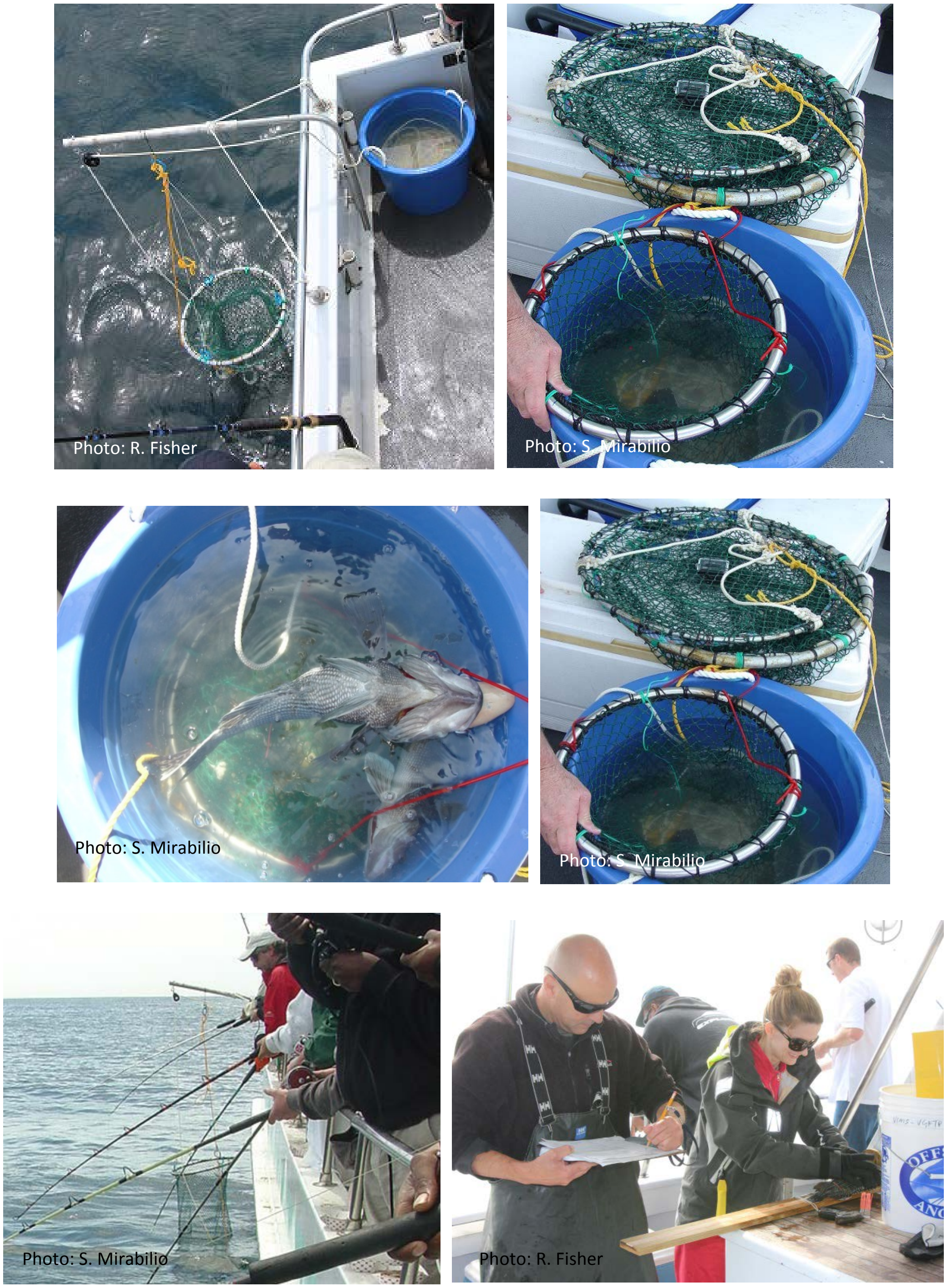


Figure 2.
Phase two multi-fish descending devices trialed in Norfolk Canyon, offshore of Va., April 2015. The top left photo displays the net and boom over the rail; the top right photo shows the large and small nets; the middle left photo features black sea bass with barotrauma, the middle right photo shows the net loaded with eight black sea bass, the bottom left photo displays the net next to active fishing lines; the bottom right photo highlights VGFTP tag application.

Figure 3.
Phase three multi-fish descending devices trialed offshore of Hatteras, N.C., May 2015. Top four photos illustrate the 18-inch hoop net device deployment sequence: the top left photo shows the net submerged in a water-filled tote; the top right photo features the net extended with black sea bass, the middle left photo shows the net being carried over the rail; the middle right photo displays the net being lowered by hand into the water. The last photo documents the NCDMF tagging procedure. Photos: Sara Hallas, NCSG.

Figure 4.
Phase three multi-fish descending devices trialed in the Norfolk Canyon, offshore of Va., June 2015. The top left photo shows the l8-inch net in the tote ready for deployment (Note: the cross-wiring was only used to support the camera). The top right photo illustrates the 15-inch net placement in the tote. The middle left photo displays the equipment setup near the rail with the 18-inch net in the tote. The middle right photo shows the larger net being hand-retrieved over the rail. The last photo features a blueline tilefish with barotrauma and the stomach protruding out of the mouth. Photos: Susanna Musick, VIMS/VASG.

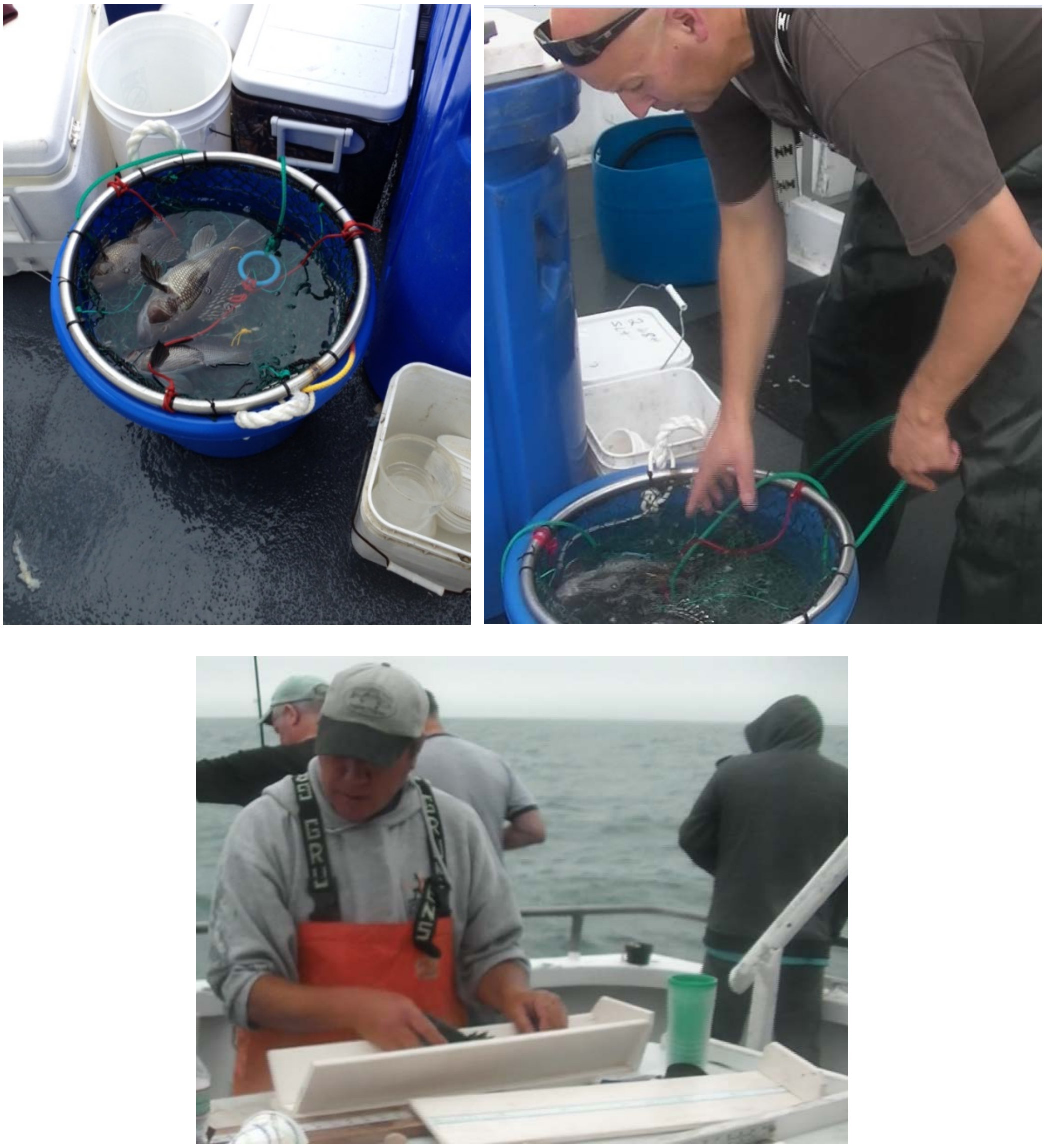


Figure 5.
Phase three multi-fish descending devices trialed offshore of Belmar, N.J., June 2015. The top left photo features the l8-inch net, loaded with black sea bass, in the tote ready for deployment. The top right photo shows the harness being readied; the bottom photo documents the tagging procedure by the ALS. Photos: NJSG.

Figure 6.
Multi-fish descending devices trialed offshore of Hatteras, N.C., July 2015 in a supplemental trial. The top left photo shows the l8-inch net, being prepared for deployment over the rail of the ("6 pack") boat. The top right photo features the net being lowered into the water; the middle left photo displays the crab basket with the wire trap door and Seaqualizer closure. The middle right photo shows the weights (10-pounds) attached to the basket. The bottom photo illustrates the weighted milk crate. Photos: S.Musick, VIMS/VASG.

Appendix B: New Jersey tag return

AMERICAN LITTORAL SOCIETY
18 HARTSHORNE DR., SUITE 1, HIGHLANDS, NJ 07732

July 30, 2015

Dear NJ Sea Grant

Congratulations. A fish that you tagged has been recaptured. We have the information, and it will be published in the UNDERWATER NATURALIST.

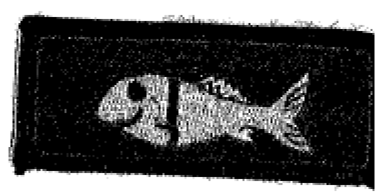
Our records show 1 of your tagged fish have been returned to date. I hope you get many more. The enclosed 'goldfish' patch denotes the recapture of your fish.

Tag: 870353	Species: Black Sea Bass
Date Released: 6/13/2015	Date Recaptured: 7/11/2015
Length: 9.50 Inches (FL)	Length: - Inches
Weight: Lbs. Ounces:	Weight: - Lbs. - Ounces:
Released at:	Recaptured at:
5 NM E Sea Girt, NJ	Klondike Bank, NJ
Tagger: NJ Sea Grant	Recapturer: Jeffrey Schwarz

Thanks for your interest in the Society and for working with other volunteer taggers to help scientists learn more about fish migrations and growth rates. Your participation is important to us, and we appreciate your help.

Sincerely,

Jeff Dement
ALS Tagging Director



P.S. Remember, tag kits are now $7.00 with needles ($6.00 without) for a set of 10 tags. Society membership dues and tag kit costs are tax deductible.

fish released w/o Tag
Barotrauma study - Mike Danko

Phone: 732-291-0055 • WWW.LITTORALSOCIETY.ORG

Appendix C: Barotrauma outreach brochure, Janet Krenn and Emma Fass, VASG

What is Barotrauma?

Barotrauma occurs when a fish experiences a rapid change in pressure and generally occurs when retrieving fish from depths greater than 60 feet.

When the fish took your bait, it was possibly hundreds of feet below the water surface where the pressure is high. As it's reeled in towards the surface, it experiences less and less pressure. Air in the swim bladder expands as the pressure decreases. When you release the fish, it still has this expanded swim bladder.

What Happens to Fish Experiencing Barotrauma?

With this high volume of air, it's like trying to push an inflated beach ball under water—it's nearly impossible for the fish to submerge itself.

As it floats on the surface, the fish is easy game for circling birds and other predators.

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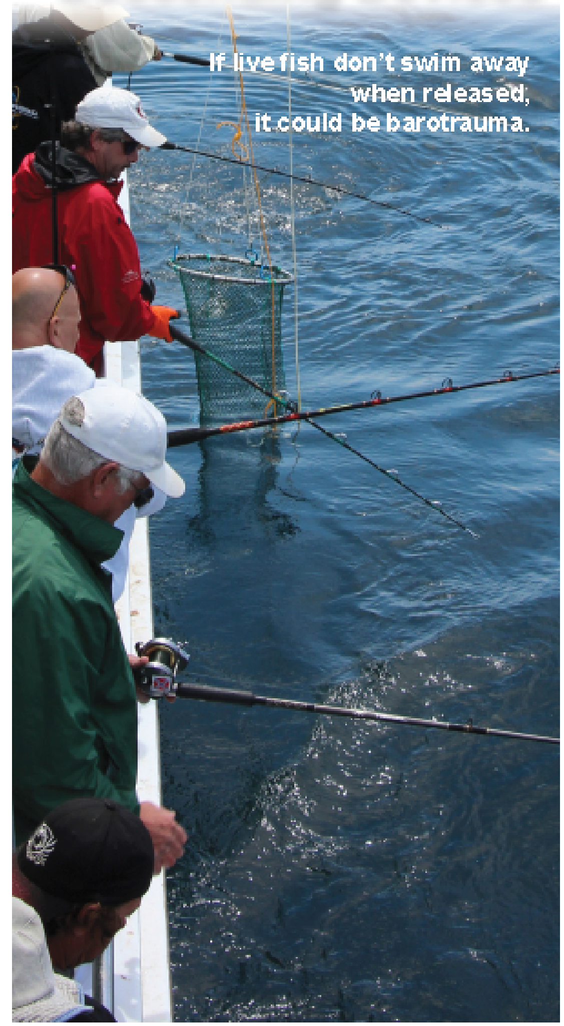
Photos ©Bob Fisher/VIMS-VASG

Returning Fish to the Deep With Descending Devices



Science Behind Barotrauma

It's called the ideal gas law: bubbles of gas rising through the water column expand because the pressure at the surface is much lower than the pressure at the bottom. This law of physics is simple enough to be on a middle school science test and real enough to affect divers and the fishing world. A fish swimming 60 feet below the surface could have its swim bladder double – even triple – as a fisherman gives it even a quick trip topside.

Do All Fish Get Barotrauma?

Barotrauma doesn't affect all fish the same way, and that has to do with the type of swim bladder they have. There are two types of swim bladders. One type of swim bladder is connected to the gut, and fish can burp gas to relieve pressure. Other fish can't burp because their swim bladders don't have this connection. These fish are susceptible to barotrauma and include recreational species like black sea bass, triggerfish, and red snapper.

Text was adapted from a Minnesota Sea Grant article titled, "Let 'Em Down Easy: Returning a Fish to the Deep Water." Written by Jeff Gunderson.

What Can Anglers Do?

Fish suffering from barotrauma can survive if released properly and quickly. According to a North Carolina Sea Grant study led by NC State University researcher Jeff Buckel (2014), approximately 90% of the black sea bass in the experimental group with visible barotrauma, but weren't floaters, survived. This was about the same survival rate as for fish that exhibited no visible injury at all.

1. Recognize the Problem

The physical signs are:

- Bloated abdominal area
- Bulging eyes (shown in image on left)
- Balloon-like tissue protruding from the mouth, gills, or anus

2. Help the Fish Get to Depth

Single Fish Descending Devices

Fish descending devices are proving to be a more effective practice than previous practices like fish venting. Descending devices result in less injury to the fish. These devices have a hook and weight system that helps lower a fish to depth. When air pressure is equalized in the swim bladder, the fish can swim away, releasing itself from the hook.

Multiple Fish Descending Devices

Descending devices are currently being tested to release several fish that might be experiencing barotrauma.

Multiple Fish Descending Devices are Currently Under Study!

For headboats and large-volume fishing, single descending devices isn't practical.

In 2015, a collaboration of Sea Grant extension staff from North Carolina, New Jersey, and Virginia joined with for-hire industry leaders to develop descending devices to quickly return multiple fish to depth in an effort to increase post-release survivorship. Prototype designs included a weighted crate, basket, messenger system, and net (shown below) to help lower the fish to depth.

Initial tests were promising, with more than 226 fishes from 7 species descended. 161 of these fishes were tagged and released and will be monitored for recapture through partner programs. The research team intends to continue investigating the effectiveness of multiple-fish descending devices.