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SEA TURTLES & FISHING PIERS IN VIRGINIA: Mitigating hook & line interactions

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Acknowledgements

This report summarizes work conducted under a number of different projects and funding streams surrounding the problem of interactions between sea turtles and recreational hook and line fishing. The majority of the work described here has focused on fishing from piers, but interactions are by no means isolated to that platform. Piers are the easiest place to gain access to a high number of recreational anglers at one time. Over the course of the various projects summarized here, many groups and organizations have provided assistance and they are too numerous to name here. The authors do want to thank the Virginia Aquarium Pier Partner volunteers, as well as staff and owners of the piers that collaborated with the program. We also want to acknowledge the generous contribution of signage and outreach materials provided by Loggerhead Marine Life Center (Juno Beach, FL) at the inception of the Pier Partner Program. Thanks also go out to anglers who have reported interactions to Virginia Aquarium. We especially want to acknowledge the work of Virginia Aquarium Stranding Response staff and volunteers as well as the Aquarium's veterinarian and collaborating veterinary clinics. Success of the Pier Partner Program resulted in a huge increase in work load for our rehabilitation side. Finally we want to thank Laura McKay and the Virginia Coastal Zone Management Program, as well as Becky Gwynn, Ruth Boettcher and Fred Leckie of the Virginia Department of Game and Inland Fisheries for funding this project. Thanks also to Alex Epple and Cathy Roberts for helpful editing on this report.

Introduction

Sea turtles in Virginia face many threats to their survival, including serious injury and mortality from entanglement in commercial fishing gear, vessel strikes from both commercial and recreational vessels, interactions with dredge operations, and entanglement and ingestion of recreational hook and line gear and marine debris (Swingle *et al.* 2016). While federal regulations address many concerns posed by commercial fishing, interactions with the recreational hook and line fishery remains largely unreported and thus unaddressed. According to the Federal Loggerhead Recovery Plan, interactions with recreational hook and line fisheries *"…are not uncommon, but the overall level of take and percent mortality are unknown*" (NMFS and FWS 2008). The Federal Kemp's Ridley Recovery plan reports that, "*Empirical data indicate Kemp's ridleys are caught by recreational hook and line fisheries, but there are no estimates of total take*" (NMFS and USFWS 2011). In addition, the plan identifies the reduction of hook and line interactions as a high priority action (NMFS and FWS 2011). Most of the work done thus far on recreational fishing interactions has been conducted in the Gulf of Mexico, including Florida (Rudloe and Rudloe 2005), Texas (Cannon et al. 1994; Seney 2008), and Mississippi, Louisiana, and Alabama (Coleman et al. 2016). The draft Virginia/ Maryland Sea Turtle Conservation Plan completed in July of 2015 also addresses sea turtle interactions with recreational hook and line gear (Action item II_1.1.1 and Strategy II_2.3).

The Virginia Aquarium Stranding Response Program (VAQS) responds to all reports of hooked sea turtles in Virginia, along with managing all other sea turtle and marine mammal stranding reports in the state. VAQS also operates the only sea turtle rehabilitation facility in the Commonwealth. In recent years, reported interactions between recreational anglers and sea turtles in Virginia have been steadily increasing (Rodrique et. al 2014, Rose et. al 2015). From 2008-2012, an average of 2.5 “hooked” sea turtles were reported per season, but the numbers of these interactions, as well as the number of turtles admitted into rehab per season, have climbed drastically since 2013 (Figure 1). The increase in reports is due, in part, to a change in guidance from NOAA Fisheries pertaining to the reporting of hooked turtle interactions for which we did not have direct involvement in responses. Nevertheless, the number of turtles recovered for rehabilitation indicates that the reporting policy change was not the sole source of increases in hooked turtle reports.

In 2013, VAQS received 18 reports of sea turtles hooked by recreational anglers. Seven of the reported animals were admitted into rehabilitation (rehab), all of which were loggerhead turtles with secondary health issues. In response to this increase in hooked turtle reports over previous years, the Virginia Pier Partner Program was initiated in 2014 as a pilot study to convey VAQS/NMFS concerns to pier anglers about the importance of responsibly reporting and handling hooked sea turtles. Through the Virginia Pier Partner Program, VAQS interviewed pier

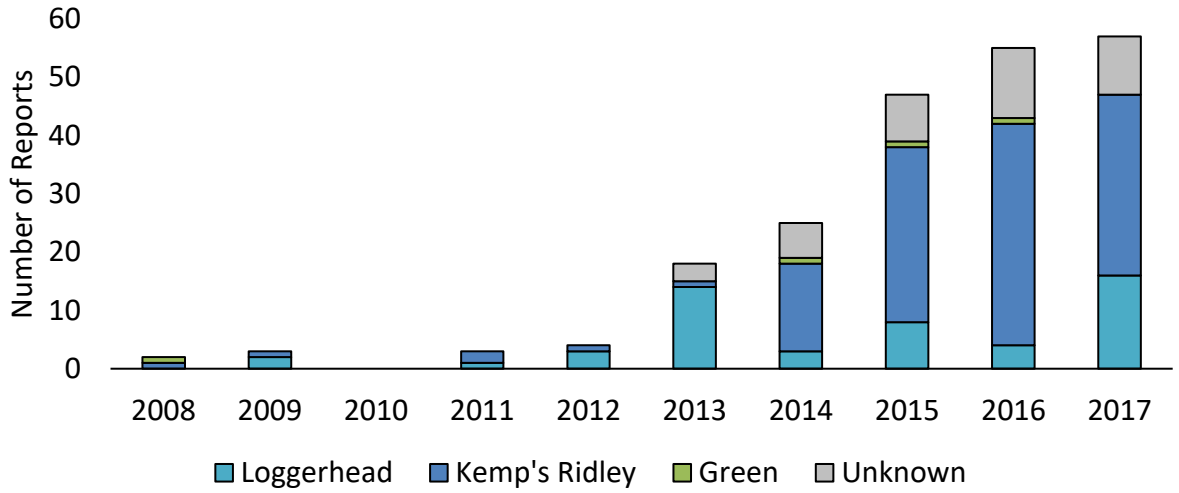


Figure 1: Reported interactions between sea turtles and recreational anglers from 2008-2017. Prior to 2013, VAQS was instructed not to report turtles that were hooked, but not recovered.

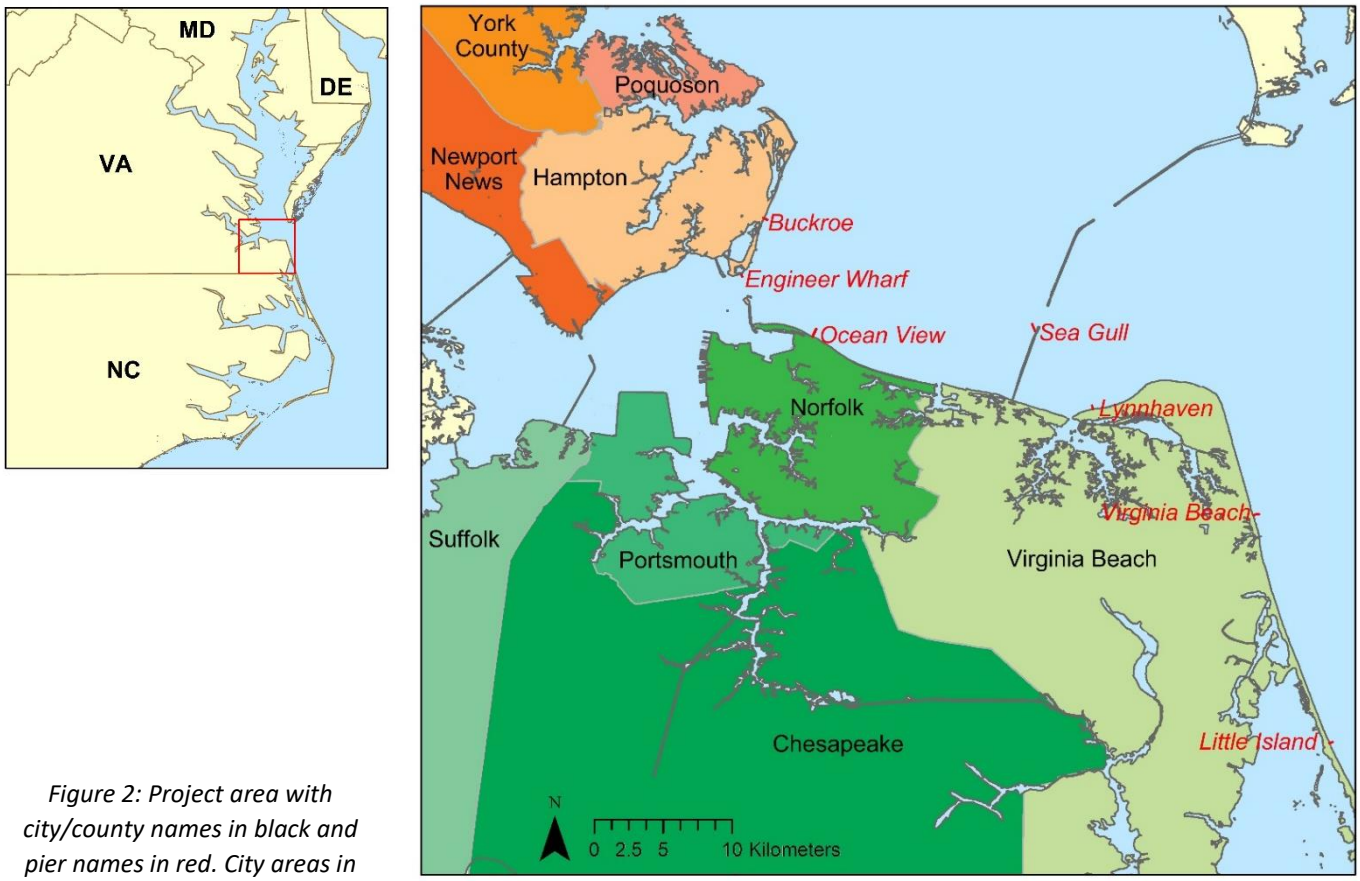


Figure 2: Project area with city/county names in black and pier names in red. City areas in hues of green are included in Southside Virginia, and those in orange hues make up the Peninsula region. The Sea Gull pier was attached to the first island of the Chesapeake Bay Bridge Tunnel until its closing in 2017.

anglers using surveys adapted from National Oceanic and Atmospheric Administration (NOAA) Fisheries Service surveys originally developed for use in Mississippi. The surveys allowed VAQS to gauge past responses to hooked turtles and found that while turtles had regularly been caught at every pier, few incidents were reported. Overall, the recreational fishing public supported helping hooked sea turtles and reporting these occurrences in the future.

As of 2017, the Virginia Pier Partner Program included seven “Pier Partners,” local piers that support the program’s mission to document as many hooked turtles as possible and safely retrieve those animals for responsible de-hooking and evaluation. The piers agreed to display program signage instructing anglers on how to respond to hooked turtles, equipment, including lift nets, for carefully landing turtles, and rescue boxes to contain animals until they were picked up by VAQS responders. The Pier Partners are located in two general areas in the Hampton Roads region of southeastern Virginia, “Southside” and the “Peninsula” (Figure 2).

The Southside fishing piers include four piers in Virginia Beach (Little Island, Virginia Beach, Lynnhaven, and Sea Gull), and one in Norfolk (Ocean View). Little Island and Virginia Beach are located on Atlantic Ocean-facing beaches, Lynnhaven and Ocean View are located in the

southern Chesapeake Bay, and Sea Gull is located on the first island of the Chesapeake Bay Bridge Tunnel. As of 2018, Lynnhaven is permanently closed, and Sea Gull is temporarily closed during current bridge tunnel construction. Little Island is operated by the City of Virginia Beach Department of Parks and Recreation. The remaining Southside piers are/were privately owned. All except the Sea Gull pier had gated entrances and continual staffing. There was no staff at the Sea Gull pier and anyone who paid the toll to access the private bridge-tunnel, could also access the pier.

The Peninsula fishing piers include Buckroe and Engineer Wharf, both of which are operated by the city of Hampton and are located on the Chesapeake Bay. Buckroe has a pier office and constant staffing when open, while Engineer Wharf is an unstaffed pier with no office to keep rescue supplies.

Since 2014, the Virginia Pier Partner Program has been hugely successful in increasing reports of hooked sea turtles by recreational anglers, and the circumstances under which sea turtles are hooked by the fishing public have greatly improved. Hooked turtles in Virginia seldom exhibit underlying health concerns secondary to the hook interaction, though secondary hooks were observed in 14% (n=17) of rehab cases. As the number of reports and turtles admitted for examination have climbed, VAQS' main goals are to continue data collection to inform protected marine species managers of the recreational fishing issues, streamlining sea turtle exam and assessment protocols to mitigate the burden of increased admissions, and providing increasing opportunities for Pier Partner volunteers to assist with hooked turtle response and maintaining relationships with local piers.

Project Goals & Objectives

The goal of this project was to develop mitigation measures that will minimize the impact of recreational hook and line fishing on sea turtles in Virginia. Recreational fishing from piers was targeted because it represents a high density of recreational anglers that are easily accessible for targeted outreach efforts, and because most of the hooked turtle reports received by VAQS have been from anglers at piers. We proposed three objectives to achieve this goal. First, we educated the recreational pier fishing community to increase reporting of hooked sea turtles and encourage proper response to these interactions through the Virginia Aquarium Pier Partner Program. Second, we expanded collection and analysis of data collected from piers and pier-caught sea turtles to better understand the nature of these interactions for mitigation. Third, we streamlined response to hooked turtles by developing more efficient response protocols and testing technology that can allow detection of ingested hooks without veterinary assistance, thus allowing for rapid release of otherwise healthy turtles.

Methods, Results & Discussion by Objective

Objective 1: Increase outreach presence at piers to fill angler survey data gaps

One of the primary objectives of the Virginia Aquarium Pier Partner Program is to communicate with recreational anglers who fish at partner piers. Messaging in the form of permanent signage on piers, tackle box stickers and surveys conducted by pier partner staff and volunteers are the primary tools of communication.

Prior to 2017, the Pier Partner Program conducted 1,088 surveys at partner piers. In 2017, an additional 948 surveys were conducted for a total of 2,036 surveys. Surveys were conducted primarily from May to October with additional surveys in April and November (Table 1). The goal of collecting at least 200 surveys per month was achieved for the May to October time frame.

Table 1: Number of surveys conducted by the Pier Partner Program from 2014-2017

Pier	City	Water body	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Pier Totals
Buckroe	Hampton	Chesapeake Bay	10	41	40	61	38	59	56	-	305
Engineer Pier	Hampton	Chesapeake Bay	3	22	31	38	20	21	25	-	160
Little Island	Virginia Beach	Atlantic Ocean	-	48	49	61	40	74	54	-	326
Lynnhaven	Virginia Beach	Chesapeake Bay	-	34	61	50	88	51	61	-	345
Ocean View	Norfolk	Chesapeake Bay	30	51	50	50	63	43	55	16	358
Sea Gull	Virginia Beach	Chesapeake Bay	-	30	30	30	-	30	11	20	151
Virginia Beach	Virginia Beach	Atlantic Ocean	28	57	65	79	77	43	42	-	391
Month Totals			71	283	326	369	326	321	304	36	**2036**

More than 1,600 (79%) of the 2,036 individuals or groups surveyed identified themselves as Virginia residents. Virginia anglers listed 115 different cities and counties as their primary residences, but the majority claimed the Southside region (n=872; 43%) or the Peninsula (n=289; 14%) as their primary area of residence (see Figure 2). Outside of these areas, Virginia residents in the vicinity of Richmond (Richmond, Petersburg, Midlothian, Chesterfield, Louisa, & Goochland) accounted for an additional 139 (7%) respondents.

The majority of Virginia anglers who provided information on their fishing frequency were most likely to say they fished *weekly* as compared to *daily*, *monthly* or *yearly*. *Weekly* fishing frequency was highest on all of the piers and ranged from 36% (117 of 322) of responders at the Ocean View Pier to 66% at the Engineer Wharf Pier (101 of 152). Anglers who described themselves as new to fishing or *just started* were less common, varying from a low of 3% (4 of 156) at the Engineer Wharf Pier to 18% (26 of 144) and 19% (57 of 307) respectively at Sea Gull and Little Island Piers.

Frequency of fishing varied less by month than by pier with *weekly* fishing frequency highest in all months from May to October. Surveyed anglers were slightly more likely to describe themselves as *just started* in August (15%; 45 of 305) and less likely in September (8%; 23 of 295), June (9%; 30 of 320) and October (9%; 26 of 287).

Overall, 26% (530 of 2,029) of all anglers who provided an answer to the question reported that a sea turtle had been seen while fishing, 13% (261 of 2,031) reported seeing one caught and 4% (83 of 2,032) reported catching a sea turtle while fishing. While there was a range of answers by pier and month, there were no differences temporally or spatially. However, anglers who reported fishing with greater frequency (i.e. weekly or daily) reported more incidents of seeing (39%; 364 of 922) and catching sea turtles (6%; 59 of 927).

These data suggest several things about anglers who fish from piers in southeastern Virginia. First, most pier anglers are local to the area and fish regularly. Second, while these data suggest the majority of pier anglers have infrequent interactions with sea turtles, reports of hooked sea turtles by pier anglers has increased in each successive year of the Pier Partner Program (see next section). Outreach to this community, therefore, has been effective and should continue. Moreover, these data suggest that more targeted outreach to anglers who fish frequently (i.e. daily or weekly) may be most effective, and focused education and outreach for this group is warranted.

Objective 2: Adapt response and rehabilitation protocols to include methods for assessment and release of hooked turtles at fishing piers

From 2008-2017, VAQS admitted 145 turtles that were hooked by recreational anglers. Since the species dynamics and nature of hooked turtle admits shifted with the advent of the Virginia Pier Partner Program in 2014, unless otherwise stated, the data presented below are for the 125 turtles admitted from 2014-2017 (Table 2).

Table 2: Numbers of hooked turtles reported and admitted into rehab at Virginia Aquarium from 2014 to 2017.

Year	Loggerhead	Kemp's ridley	Green	Total Admitted into Rehab
2014	1	14	1	16
2015	6	28	1	35
2016	2	36	1	39
2017	5	30	0	35
Total	14	108	3	125

The steady increase in hooked sea turtles retrieved for rehabilitation (rehab) since 2014 necessitated changes in protocols to manage the patient burden on VAQS resources. Although many of the Kemp's ridleys, the most common species hooked in Virginia, admitted into rehab post-hooking appeared to be healthy, the prevalence of secondary hooks (hooks not reported by the angler and, presumably, from a different, prior interaction) and occasional underlying conditions (recent trauma, infection, etc.) provided VAQS with incentive to continue conducting

thorough exams on all hooked turtles. As a result of continually increasing patient numbers, however, VAQS has had to streamlined exam and release protocols to identify otherwise healthy Kemp's ridley turtles with no secondary hooks, by evaluating species-specific parameters for body condition, packed cell volume (PCV), total protein and behavior so otherwise healthy animals spend less time in rehab and require fewer resources overall. VAQS staff worked with the Aquarium's veterinarian to reassess the importance of various blood chemistry data to inform release criteria and calculated body condition index (BCI) to quantitatively assess the health status of hooked turtles. VAQS also tested the efficacy of metal detectors to determine the presence of ingested hooks without radiographs.

Demographics of hooked turtles admitted into rehab in Virginia

The majority of hooked sea turtles recovered have been Kemp's ridleys, representing 86% of all turtles retrieved from the piers for exam. Additionally, 14 loggerheads and three green turtles were admitted. All of the turtles admitted during this time were juvenile animals, with median straight carapace lengths (SCL) 25-29 cm for Kemp's ridleys and 55-59 cm for loggerheads (Figure 3). The average straight carapace length (SCL) of hooked Kemp's ridleys and loggerheads

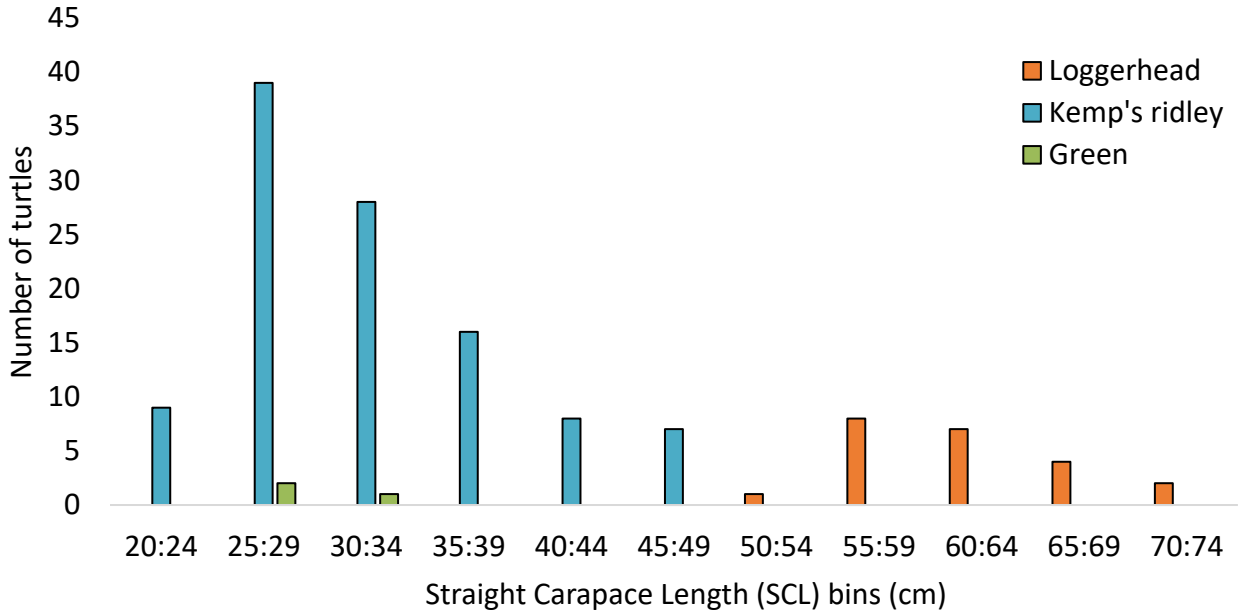


Figure 3: Straight carapace length (SCL) of sea turtles hooked by recreational fishers from 2014-2017. All turtles during this period were juvenile animals.

was also smaller and less variable than that of non-hooked stranded conspecifics within the same time frame. Hooked Kemp's ridleys measured an average of 32.0 ± 6.6 (SD) cm, while non-hooked Kemp's ridleys measured 36.4 ± 10.2 cm (Table 3). Even more dramatically, hooked loggerheads measured an average of 54.5 ± 4.5 cm, while non-hooked loggerheads measured 72.4 ± 15.35 cm. Hooked and non-hooked green turtles were very similar, but there were only two hooked green turtles, so this result may not be real.

The size disparity for these animals is most likely due to the fact that larger turtles (loggerheads and large ridleys) are much more difficult to land and frequently break the line, and so are not recovered for exam. Of the 59 turtles that were not recovered for exam, 35 were unidentified, but anecdotal evidence suggests that many of these turtles could be either large Kemp's ridleys or loggerheads. Eighteen of the remaining turtles were identified as loggerheads, and six were identified as Kemp's ridleys.

Table 3: Mean and standard deviation of hooked and non-hooked turtles by species (SCL= straight carapace length notch-tip)

	Average SCL (cm)			
Species	Hooked	Count	Non-Hooked	Count
Kemp's ridley	31.96 ±6.64	105	36.44 ±10.22	135
Loggerhead	59.49 ±4.46	14	72.4 ±15.35	231
Green	28.0 ±2.72	3	28.65 ±2.76	78

Of note in 2017, reports for April and August-November represent the highest numbers of hooked turtles for those months on record. Additionally, the total number of reports for 2017 (n=57) was the highest on record followed by the 2016 total of 55 reported hooked sea turtles. The number of hooked loggerhead reports (n=16) was also the highest recorded. Eight of these interactions occurred in the August-October timeframe which contributed significantly to the unusually high late summer and fall numbers.

However, the average annual number of hooked turtle reports may be reaching a plateau, with an average of 53 ± 5.3 reports from 2015-2017 (Figure 4). These data could suggest that pier outreach efforts are reaching saturation with the original target audience and both the messages and intended target audience should regularly be reviewed and refined as needed.

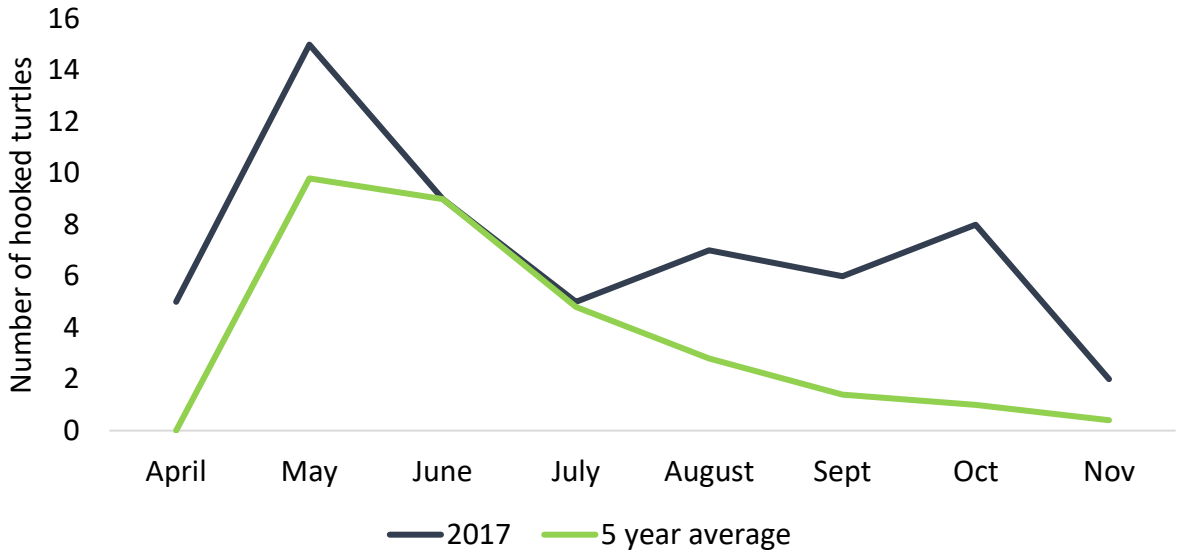


Figure 4: Hooked turtle reports in 2017 compared to the 5 year average of reports from 2012-2016. Reports for 2017 were the highest on record for the year as well as for April and August-November.

Nature of Hook Interactions

Of the 125 turtles admitted from 2014-2017, 17 turtles (14%) were confirmed to have more than one hook, including two animals that had three hooks. In all but one case, these *secondary* (and tertiary) hooks were not involved in the reported interaction and must have occurred prior to the interaction for which the turtle was recovered. Though only 14 loggerhead turtles (11% of total admissions) were admitted into rehabilitation during this time period, six were found to have secondary hooks. In 2013, prior to the Virginia Aquarium Pier Partner Program, seven turtles were admitted post-hook interaction, and all were loggerheads. Five of the seven loggerheads had secondary hooks. Detection of secondary hooks is the main reason why currently all turtles recovered by anglers, regardless of their apparent condition, are admitted into rehab. VAQS believes that no turtle should be released with a hook in its body if there is way to detect and remove it, especially if that hook is embedded in tissue. Regardless of cause of stranding, fresh dead loggerhead turtles with hooks present were in poorer body condition than turtles that died from acute vessel strike or drowning from fishery entanglement (Barco et al. 2016). Developing the ability to detect secondary hooks in turtles in the field is one goal of this project and is discussed further below.

Hook interactions with turtles were categorized as *fair* when the turtle was hooked in the mouth or esophagus, apparently while trying to bite at the bait, or *foul* when the turtle was hooked in another area (usually a front flipper). VAQS has also recorded a few interactions where a turtle was entangled in twine from a fishing rod but not hooked. In the case of foul hooking and entanglement, it is unclear if the turtle was attempting to bite at the hook or if it randomly encountered the gear. More than three quarters (76.8%) of the admitted turtles were

reportedly fair-hooked (n=96), while 17.6% were foul hooked (n=22), hooked. The frequency of secondary hooks was very similar between the two groups, with secondary hooks present in 14.6% of fair hooked turtles and 13.6% of foul hooked turtles. When only one hook was present, foul hooked turtles spent considerably less time in rehab (14 ± 9 days) compared with fair-hooked turtles which spent an average of 43 ± 61 days. However, few turtles with unusually long stays in rehabilitation skew the average duration of fair hooked sea turtles. (The three cases that remained in rehabilitation in 2016 and 2017 all developed osteomyelitis infections, requiring extensive antibiotic therapy.) Overall, more turtles are spending less time in rehabilitation each season, with the median rehabilitation time decreasing from 1-2 months in 2014, to 2-3 weeks in 2015, to 1-2 weeks in 2016 and 2017 (Figure 5).

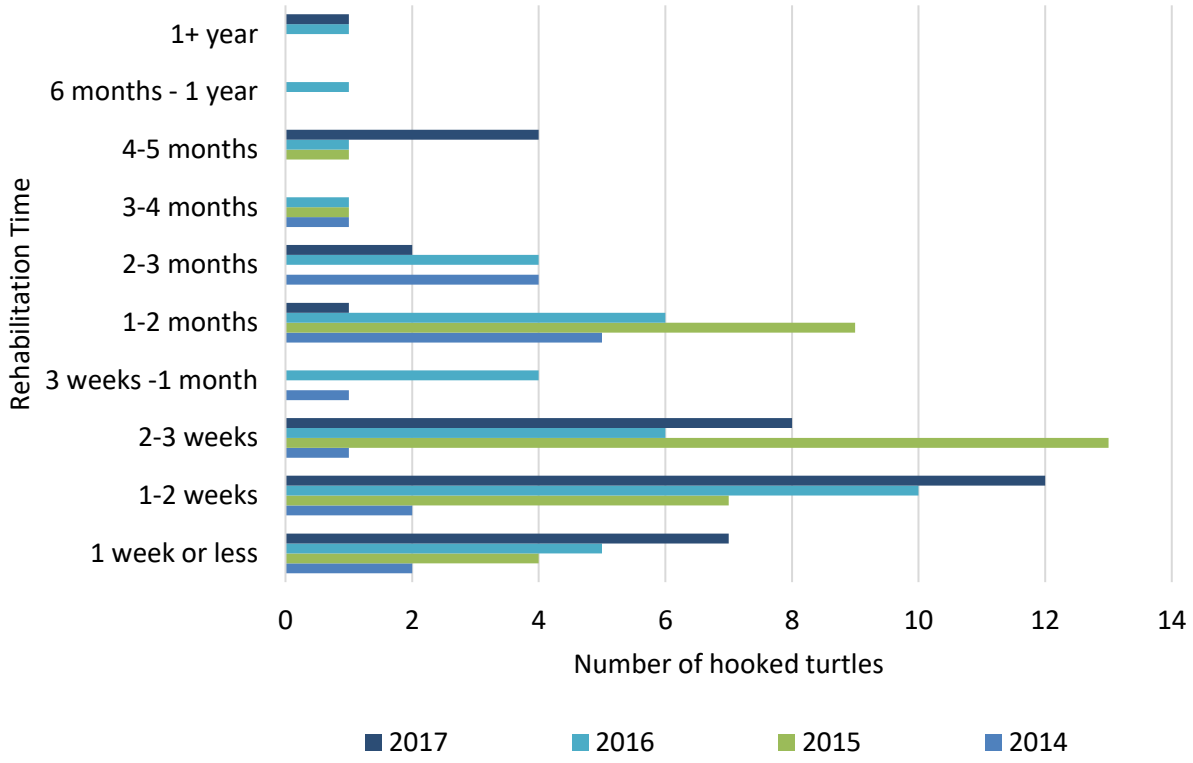


Figure 5: Time spent in rehabilitation for hooked sea turtles. Since 2014, more turtles have experienced shorter rehabilitation durations.

Blood Data Research

Sea turtles are not present annually in Virginia. Stranding and tag data suggest that they migrate into the Chesapeake Bay in May, when surface water temperatures reach approximately 20°C and leave in October/November when water temperature falls (Barco & Lockhart 2016, Mansfield et al. 2009, Swingle et al. 2017). Most hooked turtles in Virginia are reported early in the year, often before other sea turtle strandings occur. Upon admission, many of these animals appear healthy, but present with hypoproteinemia, meaning that their blood albumin levels are below the standard acceptable level for release (1.0 g/dL), as well as

below the mean published albumin level for wild Kemp's ridleys (1.3 g/dL) (George 1996). Anecdotally, wild, apparently healthy Kemp's ridley turtles captured at the same time as hooked turtles were recovered tended to exhibit similarly low albumin values. Blood parameters for the wild caught turtles was conducted post-release since albumin levels are difficult to determine in the field and was not required by the research permit as a pre-release value to be checked for wild caught turtles. Due to the disparity between the published normal range of albumin values (George 1996) and the low values collected from otherwise healthy hooked and apparently healthy wild turtles, analysis was needed to reevaluate albumin level as a release criterion.

VAQS conducted an assessment of three groups of Kemp's ridley turtles to determine the significance of observed hypoproteinemia. The groups were: hooked turtles, wild-caught turtles (captured as part of research activities), and stranded turtles. This analysis indicated no statistical difference between albumin levels in wild caught turtles and hooked turtles ($t=1.1229$, $p=0.31$; Rose et al. 2016). When the albumin levels for hooked Kemp's ridley turtles were analyzed using a Kruskal-Wallis test by the month of the capture, the albumin level was statistically different among the months of capture ($X^2=21.0563$, $p<0.0001$), and the mean albumin level increased from spring (May & Jun) through summer (Jul-Sep) then seemed to decrease slightly in the fall (Oct-Nov; (Figure 6).

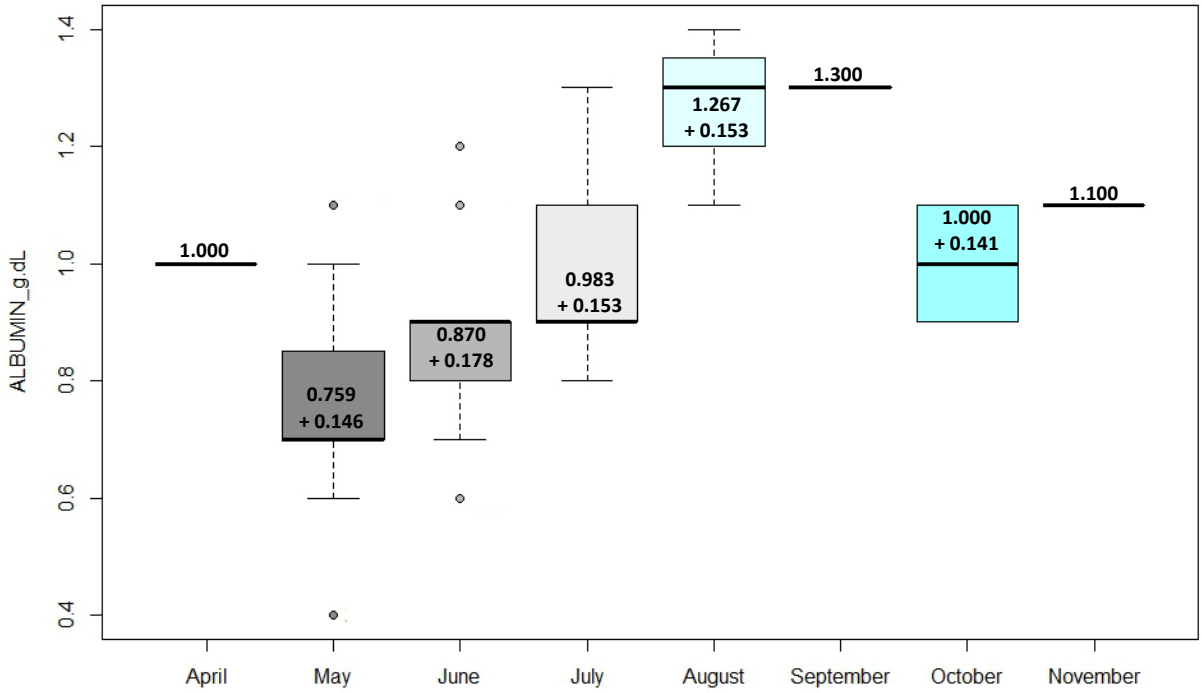


Figure 6: Albumin levels for hooked Kemp's ridleys from 2014-2016 increased through the spring and summer months, decreasing slightly in fall. The recommended albumin value for release of rehabilitated turtles is 1.00 g/dL (dashed red line).

A non-parametric Tukey and Kramer post-hoc rank comparison test confirmed that spring albumin values in hooked turtles was statistically different from summer (p=0.0001) but not fall (p=0.0744), and fall and summer were not different (p=0.9955; Pohlert 2014).

Blood PCV and total protein did not vary significantly over the course of the season or between wild and hooked turtles. These results suggest that release criteria using a minimum albumin value of 1.0 g/dL may be inappropriate in temperate areas for recent migrants. Instead, albumin levels appear to vary naturally across the course of the seasons in Virginia, so other seasonally stable parameters, such as PCV, for which there are species-specific acceptable values, may be more appropriate for evaluating health regardless of seasonality.

Body Condition Index (BCI)

In addition to the blood data comparisons between hooked, wild-caught, and non-hooked stranded Kemp's ridley turtles, VAQS also investigated body condition index (BCI) as a parameter for general health assessment (Rose et al. 2017). Otherwise healthy hooked Kemp's ridleys admitted into rehabilitation from 2014-2017 were used to calculate mean body condition. The standard body condition equation for turtles is as follows (Norton & Wyneken 2015):

$$\text{BCI} = [\text{weight (kg)}/\text{straight carapace length (cm)}^3] \times 10{,}000$$

Using a Wilcoxon rank-sum test, hooked Kemp's ridley turtles (n=74) had a significantly higher mean BCI of 1.460 (±0.114 SD), as opposed to non-hooked stranded turtles of the same species (n=38) which had a mean body condition score of 1.352 (±0.129; p>0.0001). The wild group was not included because it was data deficient for mass and straight carapace length. A Kruskal-Wallis test indicated no effect of month on BCI (X^2=13.454, p=0.1431) for all Kemp's ridley turtles in rehab combined, nor for hooked and non-hooked as separate groups (hooked, X^2=8.9313, p=0.2576, stranded, X^2=10.23, p=0.2493).

BCI is an effective assessment tool for evaluating hooked sea turtles for release. Interestingly, although not significant, there was a trend for BCI to vary seasonally with April being the month with the lowest average BCI (1.35 ±0.02; Figure 7).

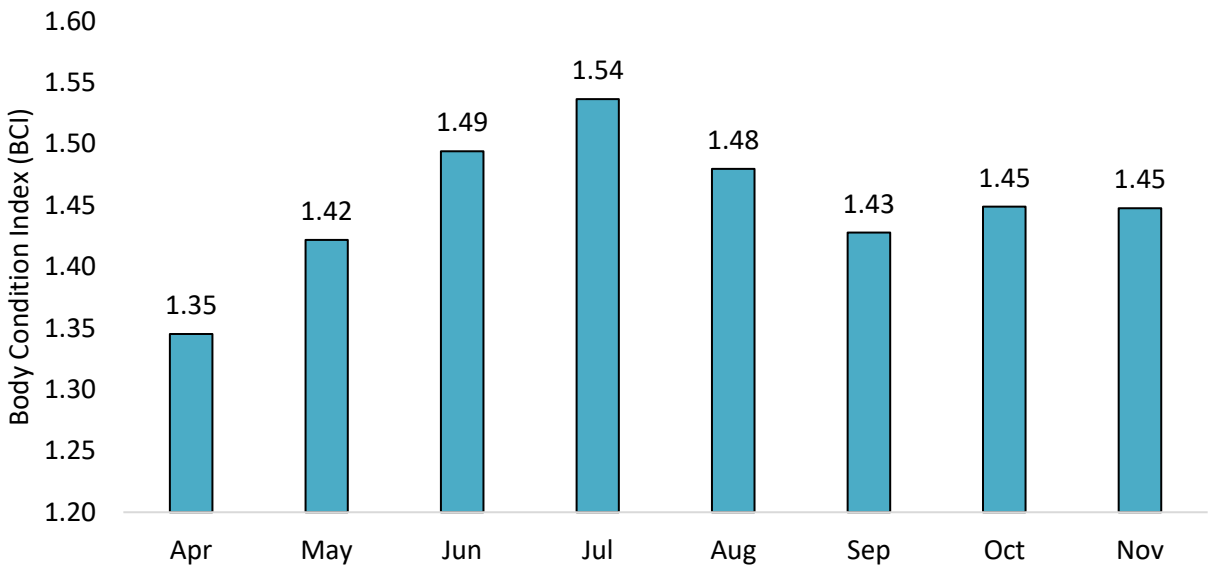


Figure 7: Average body condition index (BCI) of hooked Kemp's ridley turtles, 2014-2017. BCI was lowest in April and May, increased until July, and fell in August and September.

Development of Immediate Release Criteria Protocol

From analysis of blood, BCI data and other patient intake data, VAQS compiled a framework of "immediate release criteria" for hooked Kemp's ridley turtles. This protocol, developed in 2017 and approved by the VAQS veterinarian, allows staff to assess hooked Kemp's ridley turtles for release within 72 hours of a hook interaction without needing a veterinarian physically present for an exam. The criteria for immediate release are:

- Primary hook removed without use of sedation or significant mouth manipulation
- Radiographs confirming no secondary hooks present
- Total protein (measured in-house) within normal limits
- PCV ≥ 20% (measured in-house)
- Body condition index > 1.351 (2014-2017 average BCI – 1 standard deviation)Mucous membranes pink with no visible lesions
- Turtle is bright/alert/responsive (BAR)
- Absence of significant injuries/lesions
- Eyes clear with no visible lesions
- Low (0-25% carapace and skin coverage) epibiota presence

These criteria utilize slightly different quantitative measures for pre-release assessment. Hematocrit and total protein, which have been shown to remain consistent throughout the stranding season in healthy animals, are the only blood values considered when a turtle meets the rest of these criteria. Additionally, BCI is another measure that has not previously been considered for release assessment, but it is a helpful tool to objectively quantify body condition, a parameter associated with overall health status (Barco et al. 2016).

This immediate release criteria was developed in 2017, and, in 2018, has successfully facilitated prompt release of turtles that were lightly hooked and in overall good condition. Any turtle that is deeply hooked, exhibits significant lesions or injuries, or otherwise does not meet the diagnostic criteria must be examined and approved for release by a veterinarian.

Using metal detectors to detect hooks in sea turtles

Since one of the primary reasons to admit an apparently healthy hooked sea turtle into rehab is to take a radiograph to visualize whether secondary hooks are present, VAQS decided to determine whether means exist to reliably detect hook presence. Handheld, security metal detectors may serve as a relatively inexpensive field tool to determine the presence of hooks in sea turtles, but a true study of their efficacy has not been published. To study the accuracy and precision of metal detectors, VAQS evaluated three models made by two different manufacturers. The first model, the Garrett Super Scanner (SS) was recommended by NOAA Fisheries personnel. The second model, the Garrett Pro Pointer (PP) was recommended by Garrett technical specialists who VAQS made enquiries with, and the third, the Adams Electronics ER3000 (AE) is self-proclaimed as being "...*specifically designed for the detection and location of tiny foreign metal objects that have been...ingested deep within...body cavities.*" The website also states that the ER3000 reaches a "...*new level of performance for super high sensitivity metal detection, giving the user the ability to detect objects that were previously impossible to detect with a standard hand held metal detector*" (Adams Electronics 2018).

Metal detector trials were divided into three categories, bare hook distance detection, carcass trials to determine best practices and detector limitations, and scanning live hooked sea turtles to determine accuracy of detection. Bare hook distance detection was used to compare the distance at which each device was able to detect hooks of different sizes. Hooks were placed in a location with no other metal objects nearby and each device was placed at distance where the hook was not detected then consistently moved toward the hook until the hook was detected by way of an audible signal. Each hook/device combination was repeated three times on different days by the same person. The trials included 19 hooks (6 circle, 13 J hooks) that had been removed from live turtles. The AE device detected bare hooks from a significantly greater distance (6.9 ± 1.3 cm) than the two Garrett detectors (PP = 3.8 ± 1.0 cm; SS = 3.5 ± 0.8 cm) which were similar (X^2=38.91; df=2; p<0.0001; p-values from Tukey-Kramer post-hoc: AE-PP<0.0001; AE-SS<0.0001; PP-SS=0.48; Figure 8).

Metal detection scans in carcasses evaluated efficacy of presence/absence detection using multiple scanning techniques with all three detectors. In total, 102 test scans were completed on two carcasses with eight different hook-location combinations and an additional four with no hook present to determine proper scanning technique. The SS was eliminated from live trials due to inconsistent performance during the carcass test scans. The PP and AE were used for

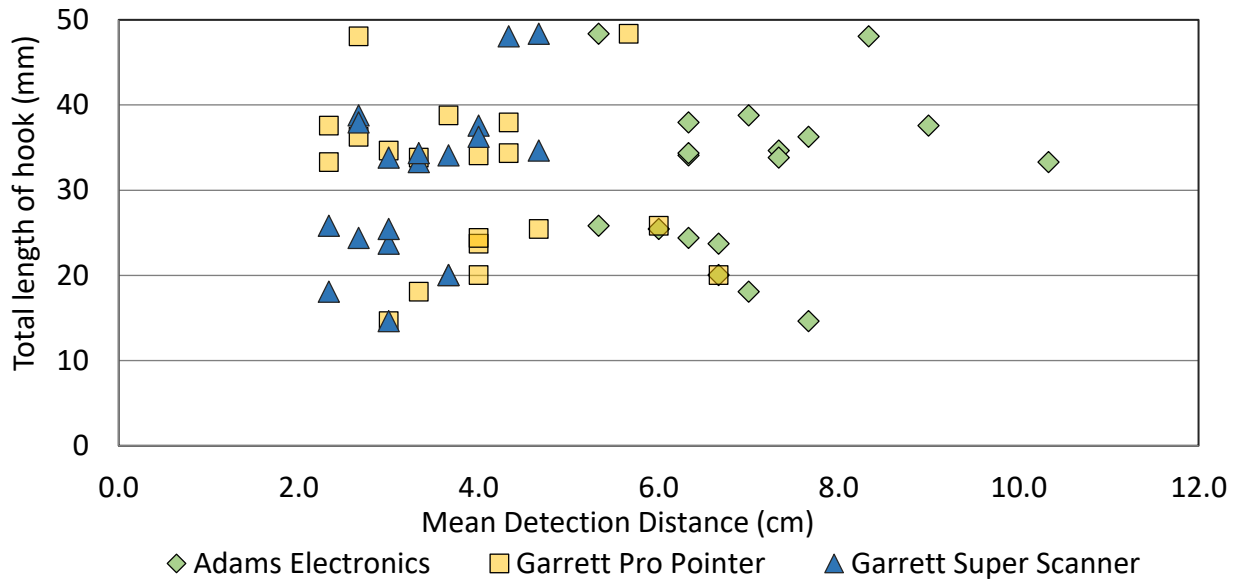


Figure 8: Distances at which hand held metal detectors detected hooks of different lengths.

metal detecting hooks in live sea turtles and protocols and a brief training were provided to people conducting live scans (scanners). Of particular concern was setting the sensitivity of the AE and PP devices. Protocols required sensitivity to be tested before each trial to make sure the device sensitivity did not attenuate over time.

Twenty-eight live sea turtles were scanned post-hook interaction multiple times by different people (scanners) for a total of 188 scans. Of the 28 turtles scanned, 18 had ingested hooks, while the remaining 10 were free of hooks (presumably removed by the angler). Presence/absence of hooks was groundtruthed via radiograph. If scanners were unaware of whether a hook was present in the turtle when they used the metal detectors, they were labeled as 'hook blind' for the trial. If the hook or trailing twine was visible or the scanner had knowledge of whether a hook was present, that individual was not considered 'hook blind.' Each scanner used both detectors on each turtle, and a coin was tossed to determine which detector was used first. If a scanner was 'hook blind,' during the first trial, that individual was considered 'scan blind' (i.e. not aware of the results of a previous trial). The scanner was not 'scan blind' when using the second detector or when observing someone else scanning the same turtle. A detection was considered 'correct' when the scanner accurately determined whether a hook was present in the turtle, and 'incorrect' if a false negative or false positive was scored. Scanners also commented on any difficulty during the trail and were asked to use a turtle outline to sketch the location of a hook if detected. There were no differences in correct determinations based on scanners' hook blindness or the order in which the devices were used, so all data were pooled for other analyses.

During the 118 trials in which a hook was present, use of the AE resulted in 89% correct detections, and the PP in 98%. During the 70 trials with no hook present, use of the AE resulted in 89% correct detections and the PP in 86%. The PP resulted in 0.9% (1 of 54) false negative scores (failure to detect a hook was present) and the AE resulted in 10.9% (6 of 55) false negative scores. There was a weak significant difference in the number of false negative scores) between the two devices (X^2=3.72, df=1, p=0.054) but all of the false negatives occurred on the same large loggerhead turtle which, following final carcass trials, was likely too large for either device to be effective. The ultra-sensitivity of the AE resulted in more false positive signals during 49% of the trials compared with 37% using the PP, but scanners quickly adapted to these signals and only made false positive errors in 9% of the PP scans and 14% of the AE scans. The difference between the two devices was not significant (X^2=1.28, df=1, p=0.26).

Use of the AE was more awkward because of its size, and any sudden movement resulted in false positive signals. If the AE touched the turtle it also emitted signals. Thus, interpretation of the signals emitted by the AE was considerably more difficult, and the learning curve for effective use of the scanner was more steep than for the PP. False positive beeps in the AE could have been reduced by adjusting the sensitivity during each trial, but with no way to quantify sensitivity that would have introduced a variable that could not be controlled. Instead, the detector was set to a specific level recommended by a company technician.

The PP was most effective when it was touching the turtle which allowed for consistency among scans. The PP could be held parallel to the scanned object for a broader area of detection or the distal end of the device could be pointed at an area for a narrower detection zone. This ability made detection of hooks that were deep in the esophagus easier with the PP because the more targeted end could be directed through the skin of the neck toward the deep esophagus. The PP also had a simpler sensitivity setting than the AE with three settings that were relatively easy to distinguish from each other. Finally, the PP is waterproof (facilitating better cleaning between trials and less risk for damage during use in an aquatic setting), is smaller than the AE, and is approximately 1/4 the cost of the AE ($125 for the PP on Amazon, $495 for the AE, only available from the manufacturer in the UK) making it the clear choice between the two devices for this application. Thus, final carcass trials to determine hook and turtle size limits were only conducted with the PP.

The greatest concern over the use of metal detectors in the field is a high percentage of false negative scores, or scoring a turtle as hook free when there is a hook present. Use of the PP resulted in only one false negative in trials with live turtles, most of which were relatively small Kemp's ridley turtles. For the second set of carcass trials, the objective was to determine the minimum hook size that could be reliably detected (false negative rate <10%) in the shallow and deep esophagus, where it could not be easily visualized. First we tested a series of hooks in a turtle carcass that was close to the mean size of previously hooked Kemp's ridley turtles. To consistently identify a shallow- and deep- esophagus depth for different sized carcasses, the

distance from the cranial edge of the carapace to the tip of the snout of a carcass was measures when the neck was relaxed (but not stretched). The shallow-esophagus hook was positioned so that the cranial edge of the hook started at half the distance from the snout to the carapace edge. The deep esophagus hook was placed so that its cranial end was the same distance distal from the carapace edge or as deep as it could be placed without using undue force. A straight stick with a piece of Tyvek tubing was used to position the hook the appropriate distance down the esophagus and monofilament held the hook in place on the stick.

The first turtle that was used was a 32.8 cm SCL green turtle which was closest the mean hooked Kemp's ridley size of 32.0 cm (see Table 3). Beginning with the smallest hook VAQS has recovered from a turtle, scanners tested the PP at both the shallow and deep esophagus locations. Scanners who were not blind to hook presence readily detected the smallest hook at both locations. Five scanners were asked to blindly scan the same turtle three times. Each scanner was asked whether a hook was present and where it was with: 1) the smallest hook in the deep esophagus, 2) a slightly larger hook in the shallow esophagus, and 3) no hook in the turtle. The order in which the three scenarios were presented were randomly chosen for each scanner. Two scanners had some experience with the PP and the other three had no previous experience. All but two scans resulted in the correct decision of whether a hook was present and where it was located. The two incorrect scans both involved the small hook deep in the esophagus. The small hook was 15 mm long, 10 mm wide at the widest point and had a wire diameter of 0.75 mm. It weighed less than 0.05 g and did not register on the most sensitive scale which was accurate to 0.1 g. The hook placed mid-esophagus was 45.5 mm long, 13.5 mm wide and was made from wire that was 1.1 mm in diameter. It weighed 0.4 g. Although the smallest hook was only detected in 60% (3 of 5) of the trials, it was well below one standard deviation of the average sized hook removed from turtles (see Table 5) in every measurement and represents a size seldom recovered from hooked turtles. The second hook was within one SD of average hook dimensions and was easily detected.

Using the second carcass, a large Kemp's ridley that was 46.7 cm SCL. None of the scanners who knew when and where hook was placed could detect a hook in the deep esophagus smaller than 1.5 SD above the mean hook size. Because a number of turtles have presented with imbedded hooks deep in the esophagus, the inability to detect hooks of average size in the deep esophagus of a larger turtle is disappointing. Thus, while accurate in turtles less than 30-35cm SCL, the PP may not be reliable in larger turtles until more research can be conducted.

Objective 3: Data Collection and Analysis

Information summarized under this objective includes three sources of data: 1) survey data collected at Pier Partner piers, 2) data collected from interviewing anglers who caught sea turtles, and 3) data from hooks removed from turtles that were rehabilitated at the Virginia Aquarium. Analysis and comparison of these three data sources offer some insight into

voluntary mitigation measures that may reduce the incidence and/or severity of interactions between sea turtles and recreational hook and line gear.

General pier fishing data summary

Survey data provide general information on fishing practices at local piers. Six bait types represented 94% of the primary bait described as being used by pier anglers. These included, in order of greatest use, squid (28%), cut fish (20%, various species), bloodworms (17%), shrimp (14%), artificial bait (10%, 'flavored' substance placed on a hook-not lures), and live fish (6%, various species). Of the six primary bait types, squid was the most common in all months except Oct. where bloodworms and cut fish dominated (Figure 9). By pier, number of surveys collected and bait use showed higher variation than bait used over time (Figure 10). Squid was the most

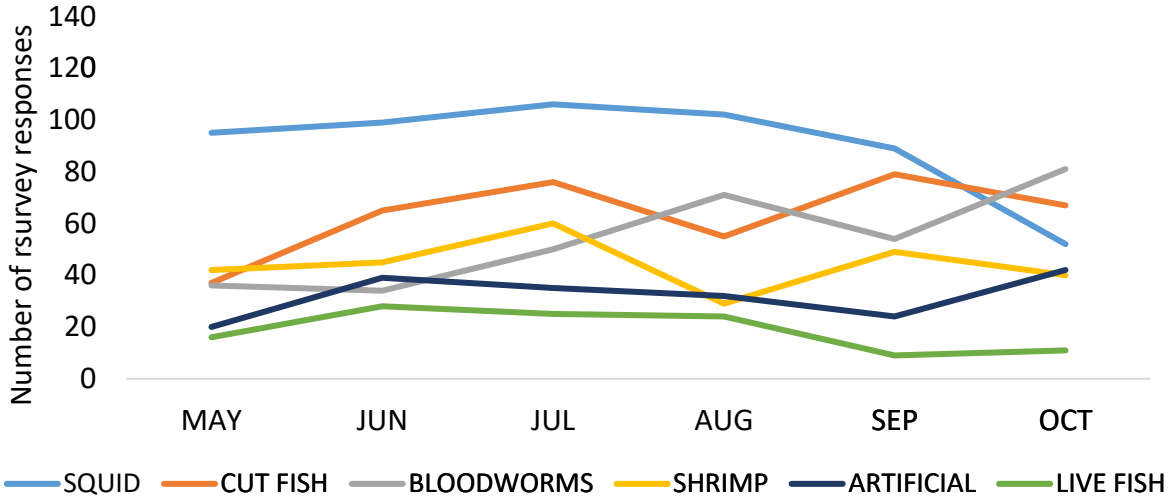


Figure 9: Monthly frequency of primary bait types used by anglers surveyed on piers.

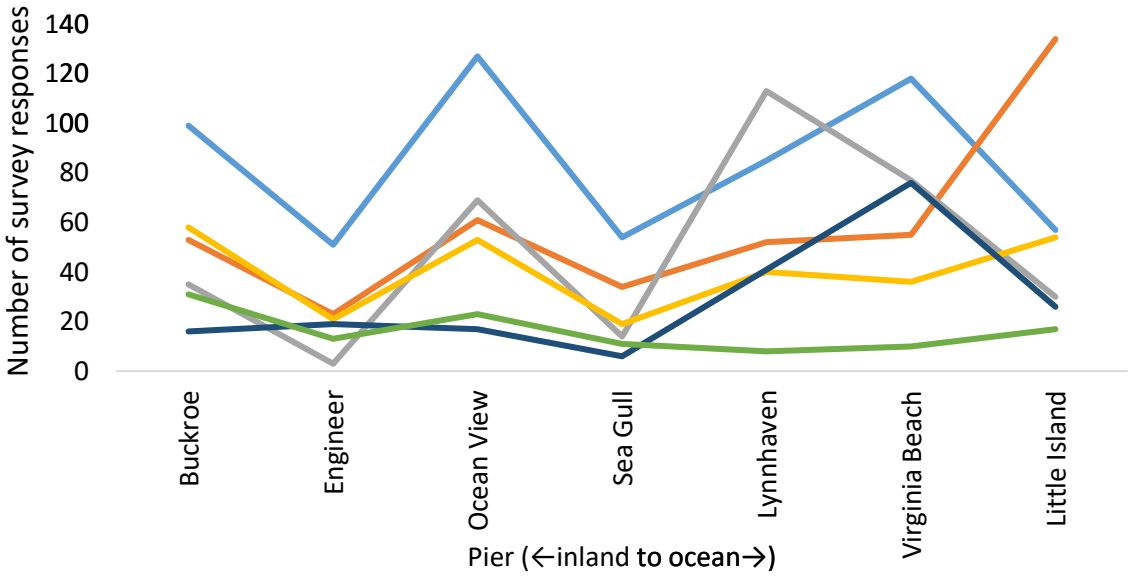


Figure 10: Frequency of primary bait used by pier (Legend is the same as Fig. 9).

common bait used on all piers except the Lynnhaven Pier where bloodworms were most common. Bait type use was significantly different (F_5=18.2; p<0.0001). Tukey's posthoc analysis

showed that squid was used more than all other bait types except cut fish. Cut fish, shrimp and bloodworms were used in similar numbers, and artificial bait was used in similar numbers to shrimp and bloodworms. Live fish was used less than all other bait except artificial bait. There were no differences in bait type used by month ($F_{5,5}$=1.00; p=0.419).

A two-way ANOVA was conducted with pier and the common bait types as factors. The results suggested that bait types were used in significantly different numbers and there are also significant differences in bait types used among the piers. There was also significant interaction between pier and bait type (Table 4).

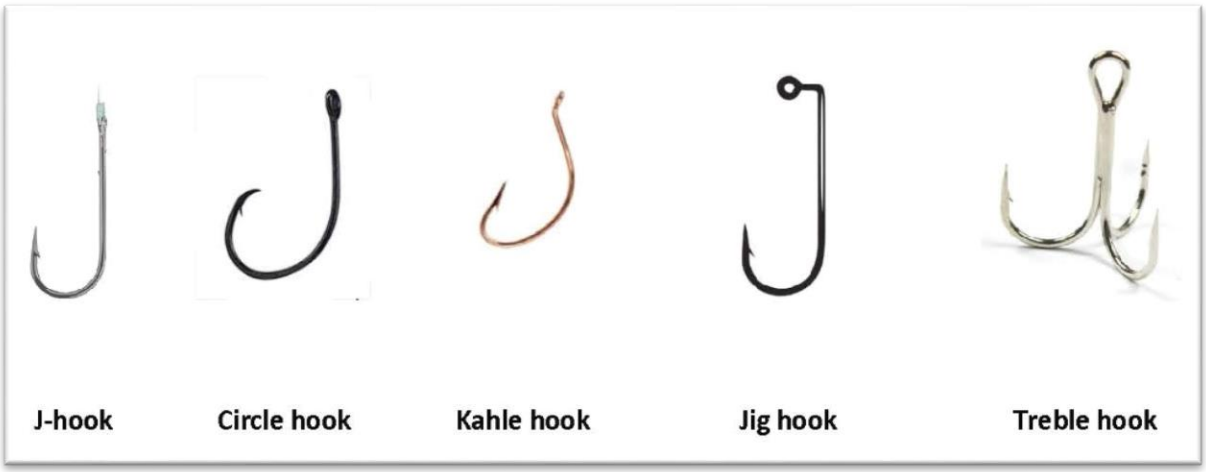
Tukey's posthoc pairwise comparison of bait types by pier indicated that the distribution of bait types used at the Engineer Wharf pier were different from bait used at Ocean View, Lynnhaven, Virginia Beach and Little Island piers, and that the Lynnhaven and Virginia Beach piers were different from Sea Gull and Engineer Wharf piers.

Table 4: Results of Two way ANOVA showing significant differences among bait type by pier.

Variable	Sum of Sq.	Df	F	p value
bait type	2870.9	5	29.930	<0.0001
pier	1156.2	6	10.045	<0.0001
bait:pier	2500.9	30	4.345	<0.0001
Residuals	3913.5	204		

Hook types are discussed in detail in the section below on 'hooks recovered from sea turtles.' Hook type was self-reported by anglers who were surveyed, but surveyors used a hook identification card to facilitate proper identification (Figure 11).

Figure 11: Example of the hook identification card used by volunteers to provide a visual cue for hook type for anglers during pier surveys.



Overall, J hooks were used by 80% (1,622 of 2,019) of anglers who responded to the question. Circle hooks were the second most common hook reported and made up 16% (326 of 2,019) of

responses. Both J and circle hooks were most commonly used with squid as bait, but distribution of other bait types differed between the two hook types. Using a Chi Square test, bait used on the two hook types differed significantly (X^2=51.97; df=4; p<0.0001; Figure 12).

Posthoc comparison using methods explained by MacDonald and Gardner (2000), with a Bonferroni corrected p value=0.005, indicated that significance was due to the difference in use of live fish between the two hook types (p<0.0001 for all two-way comparisons between live fish and other bait types).

Use of J and circle hooks also differed significantly among the piers (X^2=36.560; df=6; p<0.0001) with posthoc comparison indicating that the Lynnhaven pier differed significantly from Little Island (p<0.0001), Sea Gull (p<0.0001) and Virginia Beach piers (p<0.0001) using a Bonferroni corrected p value of 0.003 (MacDonald and Gardener 2000).

There were 23 different target species identified among 2,036 responses, and a 24th non-specific category (e.g. anything that can be caught), was by far the most common. The five most common target categories included *non-specific* (58%; n=1,188), *croaker* (10%; n=211), *spot* (7%; n=150), *cobia* (6%; n=114) and *drum* which included both red and black drum (6%; n=113).

Hook type differed significantly among the target categories (X^2=173.234; df=4; p<0.0001; Figure 13). Anglers who targeted cobia and drum were identified by posthoc analysis as using significantly different hook types (greater use of circle hooks) compared with other target categories (all pair-wise combination of cobia or drum p<0.0001 except cobia/croaker where p=0.0004, for all other combinations p>0.01; Bonferroni corrected p=0.005).

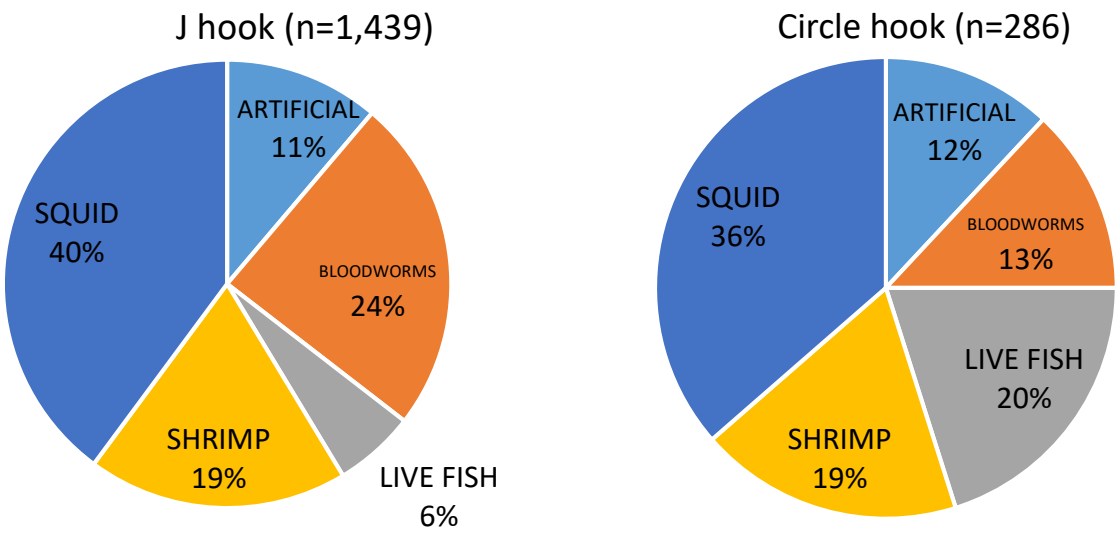


Figure 12: Comparison of bait types used on the two most commonly reported hook types. Bait type used was significantly different between hook types, with the primary difference being the use of live fish.

Looking specifically at anglers who reported they were targeting cobia and drum, cut fish was the most common bait type for both target species (49%, 56 of 114 for cobia; 60%, 68 of 113 for drum). Live fish was also commonly used by anglers targeting cobia (36%, 41 of 114) all other bait categories represented less than 7% of the bait type used.

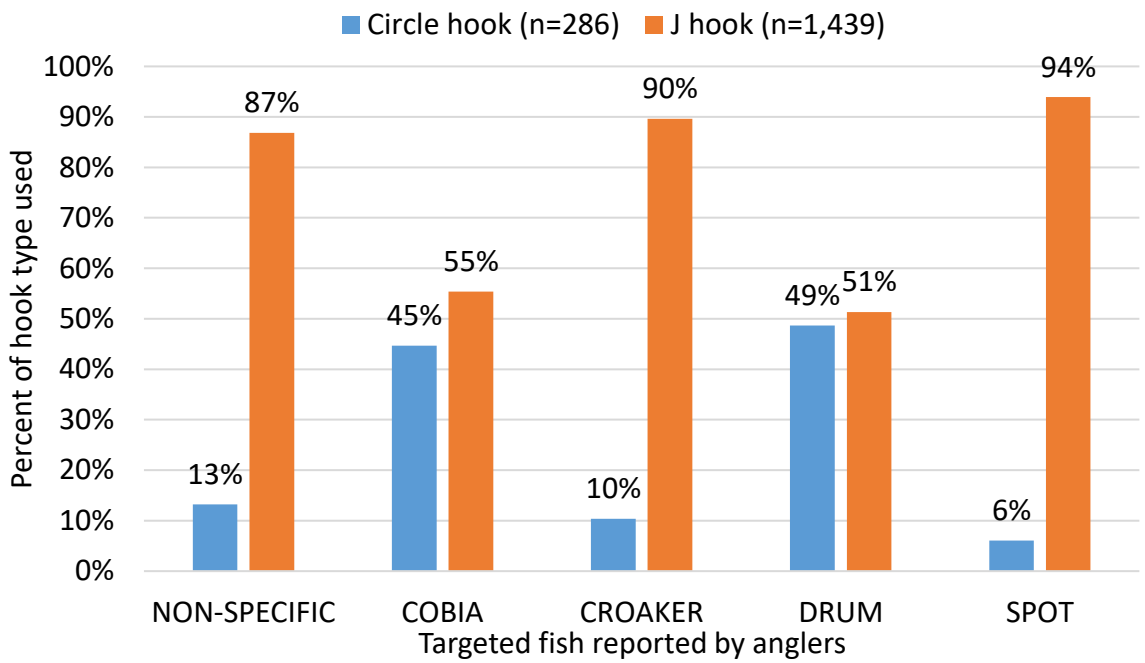


Figure 13: Ratio of hook type used for highest reported target categories

Sea turtle interaction data summary

In addition to the pier angler surveys collected, angler interviews were attempted with all anglers (primarily pier anglers, but also those fishing from shore, a boat, etc.) who reported a hooked sea turtle, from 2014-2017. Of the 190 interactions, we were able to interview the individual who actually caught the turtle for 91 (48%) of the interactions. Interviews included 74 from Pier Partner piers, two from other piers, three where turtles were hooked from boats, five hooked from the surf at ocean and bay beaches, and seven hooked from other structures such as boardwalks, bulkheads, docks and jetties. Kemp's ridley turtles (73 of 91) were the dominant species reported followed by loggerhead turtles (17 of 91). There was also one angler who hooked a green turtle. For the summaries below, we only analyzed interviews where the turtle was fair hooked (as opposed to *foul* or 'accidentally' hooked, for example in a flipper) at a Pier Partner pier and where we had details on the hook, target species and bait used by the angler (n=60).

Squid (45%, 27 of 60) was the bait on which most turtles were hooked, followed by cut fish (37%, 22 of 60), and shrimp (8%, 5 of 60). There were three incidences of turtles being hooked on cut crab, two on whole dead fish, and one on artificial bait. Several anglers listed more than one target species s/he was attempting to catch. If 'anything' was listed, that record was

recorded in the non-specific target category. If one of the species listed was more common than others, the record was included only in the more common category. Four anglers listed both cobia and drum as target species, and to aid in analysis, two records were added to each species. Using the methods described above, most of the anglers who hooked turtles were fishing for anything they could catch (46%, 30 of 65). When a primary species was targeted, croaker (18%, 12 of 65), cobia (17%, 11 of 65), and drum (12%, 8 of 65) the most common species listed.

Hooks recovered from sea turtles data summary

From 2014 to 2017, we collected 96 hooks from live sea turtles in Virginia. When the hook was intact and did not appear to be misshapen, we measured hook length (from eye to bottom of curve with shaft perpendicular to calipers), maximum width (with shaft parallel to calipers), maximum diameter of wire with digital calipers accurate to 0.01 mm (Carrera Precision CP5905) and mass with a digital platform scale accurate to 0.1 g (My Weigh Palmscale 7.0). Hooks weighing less than 0.1 g were recorded as 0.05 g. Before weighing, debris and twine were removed from each hook, but rust was not. The mean and median dimensions of hooks is shown in Table 5.

We recorded whether the hook was offset (barb not in a parallel plane with shaft) for 82 hooks. Of these 74% (n=61) were not offset and 26% (n=21) were offset. One of the objectives of this project was to determine the type of hook (J, circle, Kahle, jig head or other) used by recreational anglers in general and when turtles were hooked. Although hooks are categorized by both shape and size, there is no industry standardization, and different manufacturers may categorize similarly sized and shaped hooks differently (ASMFC 2003). In its 2003 Special Report

Table 5: Dimensions of hooks removed from live sea turtles

Hook Dimensions	Count	Mean (mm)	St. Dev. (mm)	Median (mm)
Max width	59	20.61	9.27	16.60
Length	44	39.92	14.84	38.50
Diameter	71	1.69	1.33	1.35
Mass (g)	36	1.35	1.37	0.50

No. 77, the Atlantic States Marine Fisheries Commission (ASMFC) provides a definition of a circle hook as: "...*a non-offset hook with the point turned perpendicularly back to the shank*." The Wikipedia definition of a circle hook is similar, but instead of stating that the point be perpendicular to the shank, the definition states that the point is "...*sharply curved back in a circular shape.*" In a 2008 Florida Sea Grant publication, circle hooks are not specifically defined but are described as being either offset or non-offset (Sea Grant Florida 2008) which contradicts the ASMFC definition of a circle hook being a non-offset hook.

Interviews of 83 anglers who hooked sea turtles indicated that 67% (n=56) used J hooks, 22% (n=18) used circle hooks, and 2% (n=2) used treble hooks. Another 8% (n=7) of the anglers were not sure what type of hook they were using. Using the ASMFC definition, we found 11 of 79 (14%) hooks recovered from turtles met the ASMFC criteria for circle hooks. An additional four hooks (19% total) met the definition of a circle hook as defined on Wikipedia. None of these hooks were offset. There were 59 J hooks (75%). Of the 24 J hooks that were not bent or cut, 71% (n=17) were offset. The hooks removed from sea turtles also included four kahle hooks and one treble hook. This analysis included turtles that were foul hooked (usually in a flipper) as well as those that were hooked in the mouth/tongue or swallowed a hook. As the recovered hook data set grows, there will be an opportunity to compare hook type and size to location and severity of a hooking.

Despite the caveats of self-reporting and confusion over the definition of a circle hook, both the survey data and recovered hook data showed that the J hook and circle hook were the most common types deployed, and the analyses indicated that turtle interaction rates were very similar for both types of hooks. .

Comparison of data sets

If turtle interactions with hook and line gear at piers is not due to random encounters as turtles migrate and forage, the variables most likely to affect the number of interactions are bait type, hook type and, perhaps, target species. If turtles discriminate between bait types, one might expect the presence of a preferred bait type to be higher in the data collected from turtle interactions compared with the data from the general angler population. Likewise, if one hook type is more likely to result in a hooking, one might expect the presence of that hook type to be higher in the data collected from turtle interactions compared with the data from the general angler population. Analysis of target species may provide a proxy for bait/hook combinations that are more likely to attract and/or hook turtles, such as larger hooks baited with cut bait (often fresh cut fish) when targeting cobia, bluefish or mackerel.

First, hook type was compared across the two groups. J-hooks and circle hooks were the primary gear used at fishing piers, reportedly used by 81% of anglers surveyed. J-hooks were slightly less frequent among hooked turtles, noted in 71% of the angler interviews, while they were reported as being used by 75% of anglers at fishing piers (Figure 14). This difference however was not significant. Circle hooks were the second most common hook in both groups, with slightly more hooked turtles interacting with circle hooks (20%) than reported in angler surveys (16%), but this difference was also not significant

Bait type was also compared between the angler interviews and angler surveys (Figure 14). Squid was the most commonly used bait in both groups, with 46% of hooked turtles reportedly caught with squid as bait, while 29% of anglers reported using squid as bait during pier surveys, suggesting a possible preference for squid by turtles. Cut fish was the second most common bait in both groups, with slightly more hooked turtles interacting with cut fish (23%) than

reported in angler surveys. Worms were used more often by surveyed anglers (17%) than seen among hooked turtle interactions (8%). Artificial bait was used by 10% of anglers surveyed, but no interactions between turtles and artificial bait were recorded in the angler interview data.

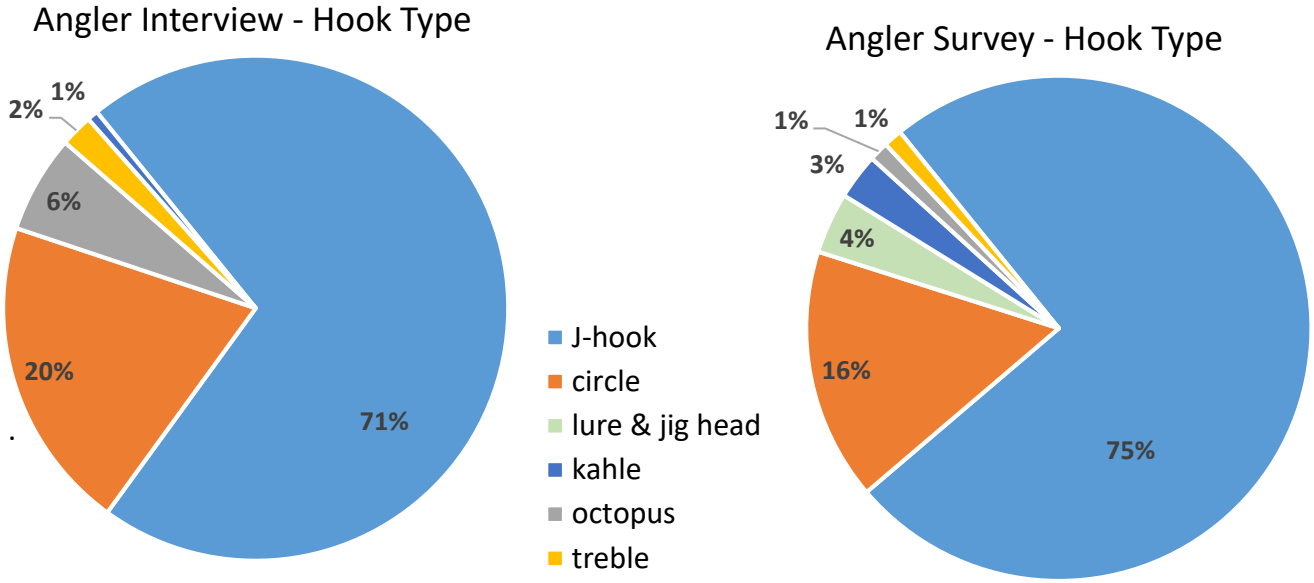


Figure 14: Comparison of hook type used by anglers who hooked turtles (Angler Interview) and the general pier fishing community (Angler Survey).

Overall there were no differences between bait types used by the two groups. When restricted to the months of April-June, when most turtles were hooked, however, there were significant differences between anglers who caught turtles and those were only surveyed (X^2=48.744;

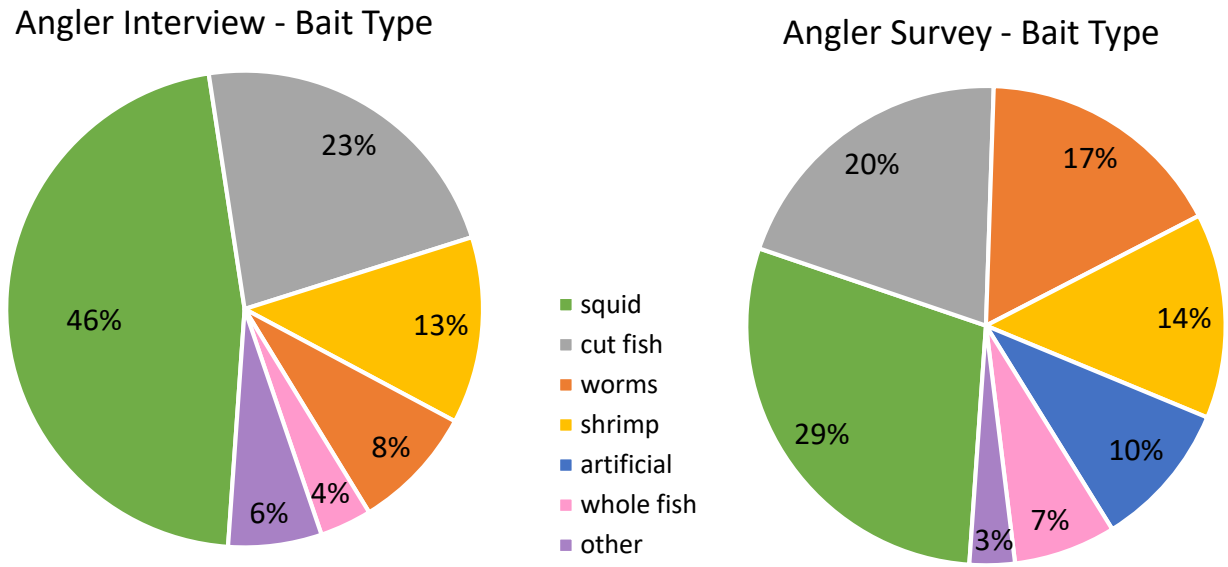


Figure 14: Comparison of bait used by anglers who hooked turtles (Angler Interview) and the general

pier fishing community (Angler Survey).

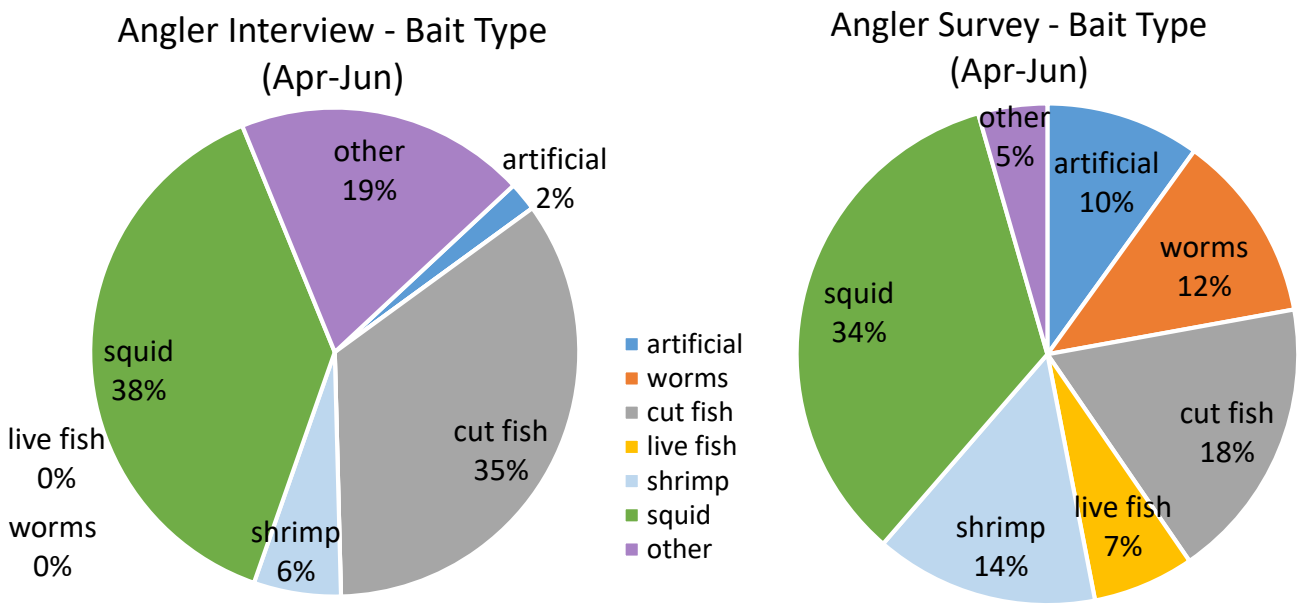


Figure 15: Comparison of bait used by anglers who hooked turtles (Angler Interview) and the general pier fishing community (Angler Survey).

df=6; p<0.0001; Figure 16). Posthoc analyses on the April-June bait data showed the greatest differences between the two data sets were the ratios of *squid* compared with *artificial bait* (p>0.0001 where the Bonferroni correct p value=0.002), *worms* (p<0.0001) and *other bait* (p<0.0001) each compared with *squid* (in each case there was a higher proportion of *squid* in the angler interview category compared to the survey category). In addition, the ratio of *shrimp* to *other bait* (p<0.0001) was significantly different with less shrimp in the angler interview category compared to *other bait*). Weaker, but still significant differences existed between the use of *cut fish* and *worms* (p=0.001) and *other bait* and *live fish* (p=0.0001) with the former category higher in the angler interview data for each. There were no anglers that caught turtles April-June who were using *worms* or *live fish* as bait.

The *other bait* category included three instances (of 6 total responses) of cut crab. Crab appeared as a bait type in 2.4% (16 of 673) and 1.6% (43 of 2,025) of the April-June and full survey data set respectively, and appeared in 5.6% (3 of 54) and 4.1% (3 of 74) of the April-June and full angler interview data sets respectively. The species was presumably blue crab, which is the most prevalent diet item in gastrointestinal tracks examined among dead stranded Kemp's ridley turtles in Virginia (Seney & Musick 2005, Seney et al. 2014).

Proposed Mitigation Measures for the Recreational Pier Fishery in Virginia

Although this project has significantly increased our knowledge of the recreational hook and line fishery on piers in Virginia, the data collected have not resulted in the development of effective enforceable policies to mitigate the number and/or severity of recreational hook and line interactions with sea turtles. This partially due to the fact that it focused only on seven of the 20 publicly accessible fishing piers in Virginia (https://www.vasaltwaterjournal.com/search_fishing_sites.php) and it did not include any private or military piers. The project's limited sample size may have to some degree precluded our ability to ascertain strong correlations between hook and line interaction rates and fishing methods and gear types.

The lack of enforceable policies is partially related to the lack of clear state and federal regulatory authority over the unauthorized take of protected species by the recreational fishery. There is precedence in the review of new or rebuilt piers and fixed structures as part of ESA Section 7 consultations through which incidental take may be authorized provided there is a federal nexus in the structure's permitting process. Aside from those specific examples, there is no blanket authorization for recreational take in any state. Instead, each state would have to apply for an Incidental Take Permit (ITP) from NOAA, undergo a review of all recreational fisheries in the state, and request authorization for the takes that are likely to occur. An individual pier, county or town may also apply for an ITP for human activities may result in takes at individual piers. The entity that applies for an ITP must have management authority over the activity. The process of estimating takes and obtaining an ITP is a rigorous and complicated process for state and municipal governments and warrants careful consideration.

Establish Angler Reporting Requirements and Procedures

We believe that the process of determining the scope of the problem is just beginning and that a more rigorous state-wide program should be implemented to better understand the number and severity of sea turtle takes by the recreational pier fishery. Currently, information on bycatch rates of non-target species, including state and federally listed species, is virtually non-existent because there are no reporting requirements in place for any of the recreational fisheries in Virginia. In fact, the data presented in this report probably represent the most comprehensive sea turtle interaction information available for Virginia despite its limited scope. Moreover, fishing effort and harvest rates of recreational fish species are largely underreported, which makes it difficult to measure the fishery's direct and indirect impacts on target fish and bycatch populations, and heavily fished habitats. As such, there is a real need for more comprehensive recreational fishery baseline data (Cooke and Cowx *et al.* 2004) including information on reported incidental takes of protected species. The most effective way to gather the data necessary to assess recreational fishery impacts on sea turtles is to establish a real time reporting system that requires, but does not penalize, recreational anglers to report incidental takes of sea turtles. We recommend implementing and developing a pilot reporting system that is limited to the recreational pier fishery for the following reasons: (1) incidental

take of sea turtles by the pier fishery has been well established in Virginia; (2) immediate reporting of hooked turtles will help ensure proper response, rescue and treatment actions will be taken to minimize lethal take; and (3) because piers offer easy access from land, response time and logistics involved with the recovery and transport of turtles requiring medical attention are greatly reduced. The VDGIF will work with the Virginia Marine Resources Commission (VMRC) and VAQS to develop reporting procedures and guidelines and determine how the data will be stored, analyzed and disseminated.

Pursue Stable Funding Sources for a Permanent Response, Recovery and Rehabilitation Program for Hooked Sea turtles

The establishment of a permanent response, recovery and rehabilitation program is vital, given the increasing trend in sea turtle hook and line interactions documented by the Virginia Pier Partner Program. Such a program requires a secure funding source. The Virginia Saltwater Recreational Fishing Development Fund (VSRFDF; Code of Virginia § 28.2-302), which is administered by the VMRC and funded through the sale of saltwater fishing licenses, accrued in excess of 2.5 million dollars in fiscal year 2017 (December 12, 2017 Memorandum from VMRC to Virginia Chairmen of the House Appropriations and Senate Finance Committees). Currently, monies from the VSRFDF are to be used solely for the following purposes: conserving and enhancing finfish species taken by recreational anglers; enforcing all recreational saltwater licensing provisions and regulations (§§ 28.2-302, 28.2-302.1, and 28.2-302.6 through 28.2-302.9); improving recreational fishing opportunities; administrating the Virginia Saltwater Sport Fishing Tournament certificates program; obtaining necessary data and conducting research for fisheries management; and creating or restoring habitat for species taken by recreational fishermen (Code of Virginia § 28.2-302.3). At this point, VSRFDF funds cannot be authorized for the purposes of data collection, recovery or rehabilitation of incidentally captured protected species by recreational anglers. A change in the legislative language would be required before such efforts could be supported by the VSRFDF. The VDGIF will contact the VMRC to assess the feasibility of such an undertaking. If both agencies agree that it is worth pursuing, VDGIF will collaborate with the VMRC to develop the appropriate justification and legislative language. If both the VDGIF and the VMRC agree it is not worth pursuing, the VDGIF will reach out to other states experiencing similar take issues by pier anglers with the hope of securing regional funds that will be equitably split among partnering states.

Develop and Implement Best Management Practices for the Pier Fishery

The VDGIF will work with the VAQS and the VMRC to develop and implement best management practices (BMP) for pier owners and recreational anglers designed to minimize both non-lethal and lethal takes of sea turtles by pier anglers. One practice that can be recommended to pier owners is to discourage anglers from dumping bait and fish remains into the water by providing some other means of disposing of fish remains. The VDGIF will collaborate with the VAQS, VMRC and pier owners to develop an effective alternative that does not place undue burden on pier owners. If successful, this measure may go along ways towards making piers less attractive to sea turtles. Another BMP is to require pier owners to have sufficient number of trash cans

and fishing line recycling bins available for the proper disposal of trash and fishing line; thus reducing the potential for sea turtles and other wildlife to ingest or become entangled in ghost gear or debris. Some other examples of non-controversial BMPs may include: pier owners posting sea turtle response guidelines and contact information for local stranding response networks; pier owners providing lift nets for the safe retrieval of hooked sea turtles; and recreational anglers using personal lift nets to retrieve hooked turtles safely.

The most important step in mitigating severity of injuries to sea turtles is effective education and outreach. General familiarity with rescue procedures, and prompt reporting has already resulted in well over a hundred sea turtles, most of them critically endangered Kemp's ridleys, being released hook-free. The VDGIF will work with the VMRC and VAQS to provide all permitted recreational fishing piers the most current reporting and response guidelines.

Lift net usage is an essential component of hooked sea turtle rescue and should be incorporated in the list of BMPs. While participating piers in the Pier Partner Program have been provided a lift net by the VAQS, these nets are usually kept in the pier offices and pier staff are often not able to leave cash registers unattended to deliver nets to anglers. The lift net BMP should encourage the placement of the net in a public area, but within sight of pier staff so that fishers can access the nets as needed. The use of personal lift nets allows anglers to have an even more prompt response to a hook interaction by confining the turtle in the net immediately and reducing tension on the hook; thus, minimizing the likelihood of a severe injury. Securing the turtle in a lift net before it is able to break the line also increases the chance of successful hook removal. Workshops targeting at pier anglers who fish often, perhaps season pass holders, may be an effective way to ensure "trained" anglers are available on piers in the event that a sea turtle is hooked. Securing a donation of lift nets to be given to workshop attendees free of charge may increase workshop attendance.

One of the most valuable aspects of the Virginia Pier Partner Program has been the collection of detailed data on fishing methods and gear deployed by recreational anglers and reported sea turtle interactions. Unfortunately, the nature of the data did not lend itself to offering clear guidance on the type of bait and gear to deploy or avoid for the benefit of sea turtles. More study is required across a broader geographic scale that also incorporates pier and environmental parameters (e.g., length of pier, mean and maximum water depths, mean salinity, etc.) before such recommendations can be made. This is especially true for hook type, which was the most difficult variable to assess because there is no industry standardization with regard to hook shape and size as evidenced by the considerable variability in the dimensions of hooks recovered from hooked turtles (see Table 5). One non-controversial BMP that could easily be implemented by pier owners is requiring anglers to use corrodible (non-stainless steel) hooks to reduce prolonged, serious injuries to sea turtles and other wildlife prone to ingesting hooks. According to several local tackle shops, the use of corrodible hooks is gaining considerable acceptance within the recreational fishing community. Another possibility would be to provide warnings about the use of high strength micro-braided fishing line which is marketed as being extremely strong and resistant to degradation. Below are a few additional

suggestions to consider and perhaps discuss with other sea turtle researchers and managers that are trying to address the issue of hook and line interactions.

Diet studies conducted on stranded Kemp's ridley and loggerhead sea turtles have shown fish to be a regular part of the diet of both species in Virginia (Barco et al. 2016, Seney et al. 2014, 2015). Analyses of the survey and interview data suggest that there are measures that may reduce the number of hook interactions, especially in bait choice. Any suggested restrictions on bait type, however, are likely to be unpopular with anglers, and there is no information on whether cost effective, turtle friendly alternatives exist. Restricting the use of blue crab as bait would be a simple measure; however, this would yield little benefit since it is not a preferred choice among anglers to begin with. Encouraging the use of artificial bait, worms and lures over squid may have a greater effect, but all of the former choices are substantially more expensive than squid.

Additional, but impractical measures are clear from the study. The majority of sea turtles are hooked in May and June, so avoiding pier fishing during these months would certainly reduce annual hook and line interactions. Additionally, avoiding fishing when turtles are seen swimming near the pier is another alternative, but would require an independent observer in order to be effective. An easy, but less effective alternative would be to provide anglers with outreach materials that include tips such as: (1) Reel in your line or change location if a sea turtle is near or shows interest in your bait and (2) Never cast in the direction of a sea turtle.

Summary

Since the number of hooked turtles reported to VAQS started increasing in 2013, VAQS has strived to improve communication with the recreational fishing community as well as response and rehabilitation for hooked turtles. The data reported for this project represent some of the first studies to better understand the issues surrounding interactions between the recreational hook and line fishery and sea turtles. Positive outcomes of the project have included the success of the Virginia Aquarium Pier Partner Program and continually improving relationships with pier owners and recreational anglers as well as blood data and body condition research that influence how VAQS interprets patient health for all admitted sea turtles.

Promising metal detector trials suggest that these tools may be used as an important means of field assessment especially for smaller turtles, which can facilitate immediate field release of otherwise healthy animals. The increase in turtles admitted for exam, while overwhelming, has provided us with a substantial dataset to better understand hook interactions using a scientific approach, though more data and analyses are needed.

Unfortunately, many aspects of sea turtle interactions with hook and line gear are difficult to control and therefore difficult to mitigate. From a regulatory aspect, there has been little to no regulatory control outside of licensing and catch limits. Outreach and voluntary behavioral changes are the most likely measures to be accepted by this community. Continued involvement by VAQS including rehabilitation efforts are likely to be required in order to

provide effective mitigation for hooked turtles. However, on-going funding for increased rehabilitation efforts that have resulted from a successful outreach campaign has been difficult to obtain in Virginia.

From a veterinary perspective, studies to develop and test improvements in hook removal techniques, measurement of stress levels and stress reduction techniques, use of prophylactic anti-biotics, pain management, and effects all of the above have on time in rehab and post-release success are needed. From a scientific perspective, studies on interaction with recreational hook and line fishing that mimic commercial studies in the longline fishery on stress, use of circle hooks, bait type, and studies that address both habituation and use of deterrents are needed. Circle hooks deployed in commercial long-line gear have been shown to reduce both capture and deep-hooking in loggerheads and leatherbacks (Sales et al. 2010). A recent review of the effect of hook and bait type on sea turtle catch rate in pelagic long-line fisheries was recently published (Gilman & Huang 2017). The above publications, however, cannot be directly transferred to recreational hook and line gear because of differences in habitat, target species and turtle bycatch species (Kemp's ridley turtles are rarely, if ever, taken on pelagic long-line gear).

The next steps for the Virginia Pier Partner Program include further data collection and analysis. In lieu of intensive pier surveys, brief surveys to gauge hooked sea turtle reporting and effectiveness of signage and other messaging will continue. VAQS will continue to develop and test improvements in hook detection, hook removal, turtle behavior around piers and other areas of intense fishing as well as post-release monitoring of immediately released and long term rehabilitation cases.

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