Compliance with Ship Speed Regulations--Persistent High Risk of Ship Strikes to North Atlantic Right Whales in Charleston and Savannah Seasonal Management Area

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Abstract

North Atlantic right whales *(Eubalaena glacialis)* are endangered under the Endangered Species Act, depleted under the Marine Mammal Protection Act, a Species at Risk under Canadian law, and listed Critically Endangered by the International Union for Conservation of Nature. Population numbers have declined since 2010 to approximately 410 individuals, with approximately 100 reproductive age females in existence. Crucially, the number of females is declining faster than the number of males. Primary threats to the species are serious injury and mortality from entanglement, vessel strikes and declining reproductivity related to entanglement and ship strikes. To protect them from ship strikes, NOAA's "*Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales"* mandates that all regulated vessels 65 feet or longer must travel at 10 knots or less off of Charleston and Savannah between November 1 and April 30 each year, to reduce the threat of vessel collisions with endangered North Atlantic right whales (NARW). It is generally accepted that these federally implemented, mandatory speed restrictions have achieved a statistically significant reduction in ship strike injury and mortality, and that the rule has been effective in reducing right whale ship strike injury and mortality.

This report presents an analysis of ship speed compliance with NOAA's 2008 *Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales* by regulated vessels at the port areas of Charleston, South Carolina and Savannah, Georgia. The geographical region for our study was the Mid-Atlantic Seasonal Management Area (MAUS SMA) off the ports of Charleston and Savannah, intended to protect the migratory route for maternal whales (and others) enroute to and from the Southeast U.S. calving grounds (SEUS).

Within the language of the speed regulation, there is a navigational safety exception provision (NSEP), a discretionary management feature, which permits ship operators to exceed the speed limit in inclement weather, but which appears to have been utilized in nearly every transit in

our study, thereby suggesting that the NSEP is undermining the effectiveness of the regulation. Our findings indicate that the compliance with the mandatory 10 knot speed restriction in the Charleston and Savannah port areas approached zero during our study timeframe. We see high ship speed distributed along 16-miles of the Charleston entrance channel, entirely within the SMA, with Charleston pilots at the helm. This report, therefore, contrasts the effectiveness of the SMAs generally with our analysis of the MAUS SMA at Charleston and Savannah. We suggest that self-regulatory compliance will not alone achieve policy and management objectives to reduce the incidence and severity of ship collisions with right whales in this critical section of the MAUS SMA. Modification to the rules, developed with specific, accurate information and stakeholder input, monitoring and enforcement, may allow regulators to achieve previously elusive policy and management objectives.

Introduction

Right Whales at Charleston and Savannah Port Areas

The seasonal right whale migration intersects the Charleston and Savannah entrance channels, subject to mandatory federal speed restrictions between Wilmington, North Carolina and Georgia, between November 1 and April 30 each year, to reduce the risk of ship strikes to North Atlantic right whales. These mandatory speed restrictions are designed to reduce the risk to migratory whales passing those port areas enroute to calving and nursery grounds on the southern Georgia and Florida coasts, and to those same whales passing again enroute to Northern latitudes with nursing calves in the spring each year. Each mother-calf pair represents one of the approximately 100 reproductive females in existence, at a critical phase of their reproductive cycle. To avoid continued losses and sliding ever closer to extinction, right whales tending calves, in close proximity to shore and near the surface, must be protected from ship strikes. The pattern of pregnant females as first-to-arrive and mother-calf pairs as last-to-leave allows us to focus our report on that subset of the population. Krzystan et al., 2018).

The entrance channels for the ports of Charleston and Savannah funnel traffic into the busiest containership port region on the East coast (figure 2). Unlike other port areas in the SMA system, with deep approaches from the ocean, the ports of Charleston and Savannah must be approached through federally dredged and maintained channels. Ships must stay in the channels to avoid grounding, and pilotage is compulsory. As inbound ships approach pilot boarding areas, seaward of the entrance channels, they slow to pick up a pilot, responsible for navigating each ship through the entrance channel and into port. Outbound ships follow the same procedure, disembarking the pilot at pilot boarding areas seaward of the entrance channel. This report is focused on ship speed under pilotage, in the entrance channels.

The Charleston entrance channel (CEC) and the Savannah entrance channel (SEC) are long and narrow, and cut through shoals as the ships approach the coast. The CEC is 17 miles long and 1000 feet wide. The SEC is 14 miles long and 600 feet wide. Congressionally approved and federally funded dredging in both channels for greater channel depth (but not channel width) has increasingly accommodated Post Panamax vessel traffic in these port areas, creating efficiencies of scale and windfall profits for stakeholders. Post Panamax ships are the largest class of container ships, built for the Panama Canal expansion and increasingly accommodated by major ports. Typical dimensions for post-Panamax container ships are 1155 feet overall length, 141 feet beam and 47.5 feet draft. While channel depth has been periodically increased under the supervision of the United States Army Corps of Engineers, channel width has remained unchanged since it was established (Charleston was dredged to 1000 feet wide in 1926). Type C-Class cargo ships, typical in the 1930’s, were 417-492 feet length overall, when the channel width was established at its current dimension.

Charleston Entrance Channel

The Seasonal Management Area at Charleston is the main focus of our analysis, but many observations pertaining to Charleston may be applied to Savannah as well. The Charleston entrance channel (CEC) is currently undergoing dredging to extend it to 20 miles. There are no turns in the CEC, therefore challenges that can arise from turns are not a factor. The channel is nominally 1000 feet wide, but because of the shoulder contour of the channel, Post Panamax ships have 800 feet in width to navigate within; the nominal width of the channel was reduced in order to cut costs, a pattern in the USACE planning and design process noted by the Society of Naval Architects and Marine Engineers (Gray et al., 2002).

Compliance at Savannah is comparable to Charleston. The ports are adjacent to one another, separated by 102 miles (US Coast Pilot, Volume 4). The sum of container ship calls at these two ports constitutes the busiest container ship port region on the Atlantic coast, with the highest rates of Post Panamax ship traffic. The Savannah Pilots Association is responsible for navigating the 600-foot-wide SEC, which is configured with five distinct reaches, where channel alignment changes (Briggs et al., 2011). The channel sections are connected by bends or “doglegs.” (Webb, 2004).

Charleston and Savannah Coastal Pilots

The Charleston Branch Pilots Association (CBPA) and the American Pilots’ Association (APA) have advanced their concern that conditions in the CEC prohibit them from complying with the regulated speed of 10-knots, and that adherence to the 10-knot speed restriction may cause the loss of navigational control (Cameron 2014; American Pilots Association, 2014). Although the National Marine Fisheries Service (NMFS) denied the APA’s petition for exclusion from the speed rule (National Marine Fisheries Service, 2015), it offered the crucial guidance that the existing regulation gives pilots discretion to deviate from the speed restriction under the navigational safety exception provision, thereby establishing an operational framework for non-conforming pilotage in the Charleston and Savannah SMAs.

The pilots are required to make a ship log entry identifying the reason for invoking the navigational safety exception, and access to those records would be instructive; our analysis of wind speed and other relevant data does not support adverse weather conditions as a credible reason for noncompliance in most cases. Certainly, when inbound and outbound Post-Panamax containerships meet in the channel, the margin for error is reduced, and results in navigational challenges. When wind conditions are adverse, i.e. 30 miles per hour, navigational safety becomes a concern, but as we will show, these conditions, (Post Panamax ships, two-way traffic, and high wind speed), occur infrequently individually and very infrequently together. It is therefore arguable that these conditions cannot explain the high rate of noncompliance and cannot be justifiably applied to the majority of transits.

U.S. Army Corps of Engineers

Since 1926, when the Charleston entrance channel was established at its current 1000-foot width, the US Army Corps of Engineers (USACE) has dredged the entrance channel longer and deeper, but not wider, to accommodate increasingly larger vessels. In 1996, USACE extended the entrance channel from 11.36 miles to 16.3 miles (USACE, 1996), and dredged the channel depth from 42 feet to 47 feet, maintaining channel width of 1000 feet. The most recent project, the largest and most expensive dredging project in USACE's history, will extend the channel to 20 miles in length, to 52 feet in depth but will maintain the 1000-foot width established almost 100 years ago. This pattern and the consequences of dredging channels deeper but not wider were the subject of extensive discussion at a 2002 meeting of the Society of Naval Architects and Marine Engineers (Gray et al., 2002). Historical size comparisons (figure 17) illustrate the increase in ship dimensions since 1960.

Because the width of the channel is relevant to the navigation safety issues identified by USACE and Charleston pilots, it is perplexing that a widening alternative did not emerge to address the issue during the scoping, feasibility, consultation and planning phases of the current dredging project. The USACE and Charleston pilots engaged in formal consultation during the planning and testing phase of the project to evaluate channel dimensions in Charleston harbor, but we see no evidence that they were concerned about entrance channel width modifications to address navigational safety concerns. Any consideration of entrance channel width modifications was discarded early in the planning stage and was not revisited. This points to a disconnect between navigational concerns and appropriate remedies, despite projections of rapidly increasing volume of Post Panamax ships calling at Charleston (figure 18). USACE forecasts a 66% increase in the number of vessels calls at Charleston between 2022 and 2037, with the proportion of Post Panamax ship increasing year by year (figure 19).

The dredging project's *Final Integrated Feasibility Report and Environmental Impact Statement, June 2015* (FIFR) documents NMFS' consultation and conclusions pertaining to the Charleston Post 45 Project (USACE, 2015). Appendix F2 of the FIFR is the *National Marine Fisheries Service: Biological Opinion*, 132 pages in length. NMFS concluded that the dredging project was not likely to jeopardize right whales. We find no mention in the FIFR or appendices of the ship strike risk posed by persistent high rates of speed by ships in the entrance channel within the SMA, or the risk posed by a constant increase in size, speed and volume of ship traffic which the dredging project facilitates. As a congressionally approved and federally funded project, the federal and state agencies involved have specific obligations under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) with respect to right whales. Seen through the lens of the MMPA and ESA, the impact of essentially unregulated ship speed across the seasonal management area, facilitated by federally funded entrance channel modifications is a problem.

USACE Navigation Simulation of Charleston Entrance Channel

In order to gain better insight into the pilots' resistance to the ship strike regulation, and explore potential remedies, we looked to a navigation study USACE performed to evaluate different channel alternatives for Post Panamax container ships calling at Charleston. The *Charleston Harbor Deepening and Widening Study, South Carolina*, (Webb et al., 2019) was conducted in 2016 and published in 2019. It simulated environmental forces acting on simulated ships, including high wind speed and ship-to-ship interactions. Simulations of the entrance channel involved container ships of Post Panamax Generation 3 class, the largest Post Panamax vessels calling on Charleston. The study established an outer boundary for the Charleston pilots that form an objective, but restrictive basis for invoking the navigational safety provision, under worst case conditions, i.e. a combination of maximum ship size, two-way traffic, and strong wind conditions. It is worth noting that by the time the simulations were run, the decision had been made that the entrance channel would not be dredged to a wider dimension (Webb et al., 2019).

In the course of the simulations, the Charleston pilots operated the ship's rudder and throttle in a manner similar to a ship in real life. Environmental forces acting on the ship during the simulation included wind speed and direction and ship-to-ship interactions. Conditions were chosen to provide a maximum credible worst-case scenario, i.e., the worst conditions under which the port operates on a regular basis. The report notes that the exercises simulated extreme conditions that pilots may not often encounter. In fact, we did not observe these extreme conditions in the data.

Two-way traffic was simulated by pilots controlling identical vessels (Webb et al., 2019) in two separate simulated ship bridges. The simulated vessels were in visual, radio, and radar contact with each other. The design ships were Post Panamax Generation 3 container ships, dimensions 1201 (L) x 160 (W) x 49.9 (D) feet. The simulations were designed to combine the main factors that pilots identified as impacting navigation in the entrance channel: two-way traffic, high wind speed, and maximum ship size. Of twelve simulation runs involving two-way traffic in the entrance channel, five were restricted to a vessel speed of 10 knots, and seven were unrestricted for vessel speed. All simulation runs were conducted with 30-knot wind speed modeled from northeast or south-southwest. When ship speed was restricted to 10 knots, there was an increase in effective beam due to "crabbing" and a decrease in steerage. The report notes that while two-way traffic was viable at slower speed, ships did not handle as well (Webb et al., 2019). The pilots were better able to control their ships, and to meet and pass safely, with simulated vessel speed between 13 and 14 knots. The report notes that, subject to a simulated wind speed of 30 miles per hour, when "the ship's speed was restricted to 10 knots, there was an obvious increase in the ship's effective beam and a decrease in steerage (Webb et al., 2019)." The USACE report shows a comparison plot of unrestricted and restricted runs (figure 7).

Crucially, the simulation study did not include typical conditions, i.e. one-way traffic, and wind speed lower than 30 miles per hour. A more nuanced study could reveal navigational safety thresholds that would be used to inform Vessel Traffic Services (VTS) at Charleston, to coordinate ship traffic and receive feedback from pilots on the water. Under adverse conditions, the VTS could enable one-way traffic instructions to the pilots, for navigational safety reasons.

Methods & Results

Selection of Study Area and Season

The Charleston Seasonal Management Area was our initial area of interest; we conducted a brief analysis of the Savannah SMA for comparison and found broad similarities between the two areas. Both entrance channels exhibited compliance rates approaching zero. Sighting data from both areas indicate the seasonal presence of right whales within ten miles of the coast, significantly including mothers and nursing calves. The November-April period was selected because it corresponded to the SMA time frame. For VPRs, we defined the entrance channel coordinates using the United States Coast Guard Navigation Center, District 7 Light List. Using the SMA time frame and entrance channel coordinates, we obtained vessel position reports (VPR) from Vessel Finder, using a time resolution of 10 minutes, minimum vessel size 65 feet, minimum vessel speed 2 knots (Lang et al., 2020). In our study, the average ship size at Charleston was 886 feet in length overall (LOA), maximum length 1204 feet; the average number of transits, defined as a complete inbound or outbound passage of the entrance channel, was 10.26 per day.

Vessel Speed Data

The study was initiated to analyze ship speed and calculate rates of compliance. It was immediately apparent that the highest rates of speed correlated with the entrance channel and pilotage. The sample area was further refined to exclude the pilot boarding area and the slow steaming speed associated with taking on and discharging the pilot. The data indicate that from March and April 2017-2018, ship speed averaged approximately 15 knots, and that these noncompliant speeds were distributed evenly along the length of the CEC over a distance of 15 nautical miles, from pilot boarding area “A” to the jetties at the Charleston harbor entrance. We defined transit speed as the maximum speed over ground obtained per ship, per transit—there was typically one inbound transit and one outbound transit per port call. Our decision to define transit speed as maximum speed obtained per transit pertains to the relationship between ship speed and ship strike risk. It is analogous to the way speed violations are reported during traffic stops on public roads, where the maximum speed is what is important, and not the speeds observed leading up to that maximum speed. Based on the time stamps from our April 2017 and April 2018 data, approximately 87.5% of all positions data was at taken at speed exceeding the speed rule, which tells us that non-compliant speed is uniformly high along the length of the CEC; in other words, the transit speed calculations found in this report do not represent brief periods of high speed set against a background of compliant speed.

We discarded any vessels not subject to the speed rule, and all vessels crossing or deviating from the channel. It quickly became apparent that we would prioritize ships over smaller vessels and filtered out vessels with length overall of less than 150 meters. The average and maximum transit speed for the Charleston SMA, per vessel class are tabulated below. Vessel classifications are Post Panamax ships length overall (LOA) 966-1200+ feet, Panamax ships LOA 657-965 feet, Sub Panamax ships LOA 492-656 feet.

Month/Year	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019
Avg. Transit Speed (kn.)	Post Pan: 15.8 Pan: 15.9 Sub Pan: 14.4	Post Pan: 15.7 Pan: 15.8 Sub Pan: 14.0	Post Pan: 15.8 Pan: 16.1 Sub Pan: 13.9	Post Pan: 15.8 Pan: 15.5 Sub Pan: 13.5	Post Pan: 15.9 Pan: 16.0 Sub Pan: 14.5	Post Pan: 15.9 Pan: 16.1 Sub Pan: 13.9
Max. Transit Speed (kn.)	Post Pan: 18.3 Pan: 18.7 Sub Pan: 17.8	Post Pan: 18.7 Pan: 18.7 Sub Pan: 17.4	Post Pan: 18.9 Pan: 20.2 Sub Pan: 17.3	Post Pan: 19.3 Pan: 19.2 Sub Pan: 17.0	Post Pan: 19.0 Pan: 19.6 Sub Pan: 18.3	Post Pan: 18.3 Pan: 19.8 Sub Pan: 17.2

Table 1. Average and maximum transit speed for 2018/2019 Seasonal Management Area at Charleston

Month/Year	Feb 2017	Mar 2017	April 2017	Feb 2018	Mar 2018	Apr 2018
Avg. Transit Speed (kn.)	Post Pan: 15.7 Pan: 15.4 Sub Pan: 13.4	Post Pan: 15.5 Pan: 15.7 Sub Pan: 13.6	Post Pan: 15.7 Pan: 15.7 Sub Pan: 13.8	Post Pan: 15.4 Pan: 15.0 Sub Pan: 13.8	Post Pan: 15.0 Pan: 14.7 Sub Pan: 13.2	Post Pan: 15.4 Pan: 15.5 Sub Pan: 13.8
Max. Transit Speed (kn.)	Post Pan: 17.7 Pan: 18.3 Sub Pan: 17.1	Post Pan: 18.5 Pan: 18.7 Sub Pan: 17.3	Post Pan: 18.7 Pan: 18.6 Sub Pan: 17.1	Post Pan: 18.2 Pan: 18.8 Sub Pan: 17.2	Post Pan: 18.2 Pan: 17.3 Sub Pan: 17.5	Post Pan: 18.4 Pan: 18.8 Sub Pan: 17.3

Table 2. Average and maximum transit speed for February, March and April, 2017 and 2018 for Charleston

Vessel positions data for the CEC indicate a concentration of vessel speeds grouped around 15 knots, correlated with pilotage, and another grouping around 10 knots, corresponding to the same ships slowing to board or discharge the pilot at the pilot boarding area (figure 6).

Two-Way Traffic

The two-way traffic condition reduces available channel width from 1,000 feet (800 nominal) to 400-500 feet per ship, depending on ship class and draft. As noted, the pilots identify two-way traffic involving a pair of Post Panamax ships as a particular navigation concern. To determine the number of the transits that involved two ships meeting and passing, we filtered VPRs for all ships with Date/Time stamps within 10 minutes apart, for ships travelling in opposite directions in the Charleston entrance channel. The data set is available on the Maritime Whale website, Newman, O. (2019). [Meet/Pass Exploration].

Of the 910 transits between February 1-April 30, 2019, 26.9% involved two-way traffic (figure 11); the remaining 73% were one-way transits, which do not meet the USACE simulation definition of an adverse condition. Therefore, with the rare exception of high wind, mechanical failure, or other unusual conditions impacting safe navigation, the deviation provision was not applicable, according to the conditions specified in the USACE ship simulation described above.

In fact, none of the transits in our data satisfied all three conditions--Post Panamax vessels, 30 mile per hour wind speed, and two-way traffic. Instead, the evidence indicates that non-compliance with the speed rule was the norm under all conditions, invoked most often for one-way traffic, and in light to moderate wind. The table below shows a breakdown of two-way traffic for the three months analyzed, and subdivides each month for Post Panamax and sub Post Panamax ships.

Month/Year	Feb 2019	Mar 2019	Apr 2019
Two-way transits, all classifications	33.1%	31.7%	17.0%
Two-way transits, per classification	Post Pan: 13.7% Sub Post Pan: 19.4%	Post Pan: 15.9% Sub Post Pan: 15.8%	Post Pan: 7.3% Sub Post Pan: 9.7%

Table 3. Percentage of two-way transits in Charleston entrance channel, February-April

Clearly, there are circumstances when deviation from the 10-knot speed limit is warranted. Container ships, car carriers and cruise ships have large windage areas that can complicate ship controllability in narrow channels (Gray et al., 2002). Navigating these ships in two-way traffic within the confines of the channel, subjected to high wind speeds, the pilots can reasonably argue that they must deviate from the speed restriction for safety reasons. That said, it is worth noting that wind speed of 30 knots or higher was recorded less than 10% of the time during the study period, and that two-way traffic represented just 27% of all transits. We suggest a shift from two-way traffic to one-way traffic if and when necessary to improve margins of error for the maneuvering and station keeping ability of ships, to protect right whales in accordance with the speed regulation, as opposed to the high speed, high risk, habitual non-compliance observed.

Yaw Analysis

The Charleston pilots identify excessive yaw (crabbing) as the principal concern limiting their ability to comply with the speed regulation. Our focus on yaw, with data from Post Panamax ships, uses the maximum ship class in the forecasted fleet, per USACE guidelines (Gray et al., 2002). Yaw analysis was limited to the area within the CEC, to capture channel bank effects and confined propeller/rudder dynamics (Gray et al., 2002).

We defined yaw as the difference in angle between course and heading, using VPRs in 1-minute time resolution for both compliant speed and for transit speed. Lang, J. (2020). [Vessel Movements Report], available on the Maritime Whale website. There were 43 VPRs in February 2019 that met the condition for vessels with at least one position at compliant speed and one at non-compliant/transit speed (26 positions at 8-10 kn, 17 positions at >10 kn), allowing us to make same-ship, same-transit comparisons for yaw.

The pilots' *Navigation Update* illustration of "crabbing" in the channel (figure 12) identifies 10 degrees of yaw as a particular navigational concern. In February 2019, the reality was an average yaw angle of 1.6 degrees for ships traveling between 8 and 10 knots (average ship speed 9.2 knots). Vessel positions data for the same ships, during the same transit at non-compliant/transit speed (average ship speed 14.8 knots), indicate the average yaw angle was 1.2 degrees, a difference of only 0.4 degrees. The 10 degrees of yaw cited in the *Navigation Update* was not in evidence. Wind conditions from the National Data Buoy Center, Edisto Buoy, Station 41004 showed an average wind speed of 14.5 miles per hour for the period, with average wind gust speed of 18.1 miles per hour, and an average wind direction of 212 degrees True, typical for the area.

We did not see Post Panamax ships being swept into extreme yaw angles (figure 13). According to a report by The Society for Naval Architects and Marine Engineers, the width of one-way channels should be between 4-5 times the maximum beam of ships expected to use it (Gray et al., 2002). The widest beam is 158 feet for the Post Panamax ships in our yaw analysis. With 800 feet of channel width to navigate within, the channel is therefore 5.06 times the maximum beam of the largest ships expected to use it and should give the largest ships ample room to navigate, under VTC one-way traffic control.

Potential limitations to the comparability of our yaw analysis from different parts of the channel and arising from the scarcity of data for ships transiting at compliant speed, indicate the need for the USACE to conduct a well-designed simulation study of the problem, with 10-knot speed runs simulated under varying conditions. The number of runs should be large enough to produce meaningful yaw analysis over a range of navigational conditions, from benign to adverse (Gray et al., 2002).

Vessel Size

All vessels, irrespective of size, were piloted through the entrance channel at speeds intended to be reserved for worst case scenarios. The steady rise in the percentage of larger ships calling at the port may conflict with USACE and NMFS' assurances that channel improvements to accommodate them pose no potential adverse effect on right whales. There are no published reports on Post Panamax ships similar to *Vessel Collisions with Whales: The Probability of Lethal Injury Based on Vessel Speed*, Vanderlaan, et al., 2006. Probability determinations based on Post Panamax ships averaging and exceeding 15 knots, would be useful. It is a logical inference that larger ships do in fact pose a higher risk of serious injury and mortality from collisions to right whales. Probability determinations might also take into account the particular vulnerability of mother-calf pairs.

Wind Speed Data

To compare actual pilotage to the simulated runs, we matched wind speed time-stamps from NOAA's National Data Buoy Center (NDBC) to VPR time-stamps for February 2019 (Lang et al., 2020), available on the Maritime Whale website; our most detailed transit speed to wind speed comparisons are based on that month (figure 8). We expected to see some correlation between vessel speed and wind speed in the data, specifically that ships would have to carry more speed when wind speed was higher, to prevent "crabbing." But our analysis indicates a very weak correlation between the two. A scatter plot (figure 9) depicts vessel speed and wind speed, showing that a correlation between wind speed and vessel speed is extremely low, with a value of -0.000236 telling us that one does not depend on the other; therefore we did not match wind speed time-stamps to transit sheets for other months. Instead, we characterized wind speed for other months in our analysis using National Buoy Data Center historical data from observations at NOAA's Station 41004 buoy, 41 nautical miles southeast of Charleston (figure 10). Wind speed less than or equal to 20 mph was typical, observed 63% of the time during the period of analysis. Average wind speed was 16 mph.

Savannah Sample Analysis

We made a brief analysis of Savannah, to ascertain whether it too exhibits poor regulatory compliance with the speed restrictions, and to confirm that the whales encounter not one but two dangerous port areas in the southern section of the MAUS SMA. We filtered 8,800 VPRs, to yield 750 unique transits (figure 20) Lang, J. (2020). [Vessel Movements Report], available on the Maritime Whale website. Of those VPRs, the average transit speed in the SEC for the period February 1 to March 31, 2019 was 14.5 knots (figure 21). Four ships were in compliance, yielding a compliance rate of approximately 0.5%. It would be interesting to see if this pattern is maintained with a larger sample. Recommendations pertaining to Charleston may apply to Savannah as well, to include a USACE ship simulation report to establish compliance standards, thresholds for navigational safety exceptions, and the development of methodologies for vessel traffic control and pilotage.

Discussion

The level of expertise required to bring ships into harbor puts the pilots in a position of trust, with near unassailable authority with respect to navigation through the entrance channels. Nevertheless, an objective analysis of pilotage reveals areas in which they appear to be using their position of authority to take liberties with regulations governing their speed through the SMA, putting endangered right whales at risk of ship strikes.

Monitoring

The availability of unbiased, comprehensive AIS data allows efficient, accurate monitoring of ship speed across North Atlantic right whales' migration to wintering/calving grounds. Routine monitoring and the certainty of detection may be critical to effective protection under the existing regulation. Near-real time data is available for analysis, which can reliably identify patterns of non-compliance, and can be summarized for regulators and law enforcement in a timely manner. In this context, third-party monitoring can report compliance rates to regulators as soon as monitoring cycles are completed. Because data collection and methods are verifiable, compliance in high risk areas can be efficiently targeted for ongoing active monitoring in the future. The certainty of detection, backed up by enforcement, can focus stakeholders' attention on compliance with the regulation in order to avoid sanctions, penalties, and negative publicity (Organization for Economic Cooperation and Development, 2000). Maritime Whale, which we administer, is monitoring Charleston and Savannah and publishing daily shipping summaries, at www.maritimewhale.com.

Enforcement

The United States Coast Guard (USCG) partners with NOAA's Office of Law Enforcement (OLE) to monitor and enforce the ship strike rule *(North Atlantic Right Whale Ship Strike Reduction Rule Enforcement Guidance,* United States Coast Guard, 2008; *Activities Report to the Atlantic Large Whale Take Reduction Team,* United States Coast Guard, 2018). As the federal government's primary at-sea enforcement agency, USCG actions include detecting vessels in violation, hailing them, and informing them of the ship strike rule and speed requirements. USCG then provides written notification to NOAA OLE for further engagement, as necessary. Field units work with NOAA OLE on a case by case basis regarding egregious violations, and primary enforcement is conducted shoreside by NOAA OLE. In practice, for the ports of Charleston and Savannah, those enforcement actions are practically non-existent, as seen from a figure provided in the *USCG Activities Report* [Op Cit.] (figure 24). Note the single instance of enforcement action relative to the Southeast (D7: SC-FL), in the ten-year time frame.

To the extent that enforcement is appropriate, the Endangered Species Act [Prohibited Acts, Section 9] Penalty Schedule is applicable. The range in penalties for a violation of the speed regulation is $2,500-$5,500 for the first violation; $5,000-$8,000 for the second violation; $7,500 to $52,596 for a third and subsequent violations for incidents involving prohibited acts under Section 1538 of the ESA. NOAA and the USCG are deflecting their duties by not recognizing these violations.

Regulatory Exceptions

Regulatory effectiveness in Charleston and Savannah depend on the pilot's ability to comply with ship speed restrictions. Their capacity to comply under ordinary conditions must be distinguished from unusual conditions that would prevent compliance. Specific regulatory exceptions must be established for those adverse conditions pertaining to navigational safety. Understanding the regulated entities' ability to comply, through consultation and analysis, should help address navigational safety concerns, eliminate obstacles to compliance, and motivate regulated individuals and organizations to comply. A well-designed USACE ERDC/CHL simulation may help distinguish between legitimate navigation problems and resistance to compliance arising from institutional, economic and cultural incentives. Performance standards that promote protective policy goals, and that are practical from a navigational safety perspective, can be developed by USACE, with input from pilots and other stakeholders (Wiley et al., 2013).

Conclusion

Evidence of habitual non-compliance with the speed rule, coupled with perspective from the bridge of simulated ships, should lead to better guidance pertaining to the navigational safety exception provision of the ship speed rule. NOAA should take action to extend the success at other Mid-Atlantic SMAs to the SMAs at Charleston and Savannah. As it stands, the speed rule imparts a veneer of effectiveness, a false promise of protection, and results in the reality of no protection at Charleston and Savannah at all.

Figures

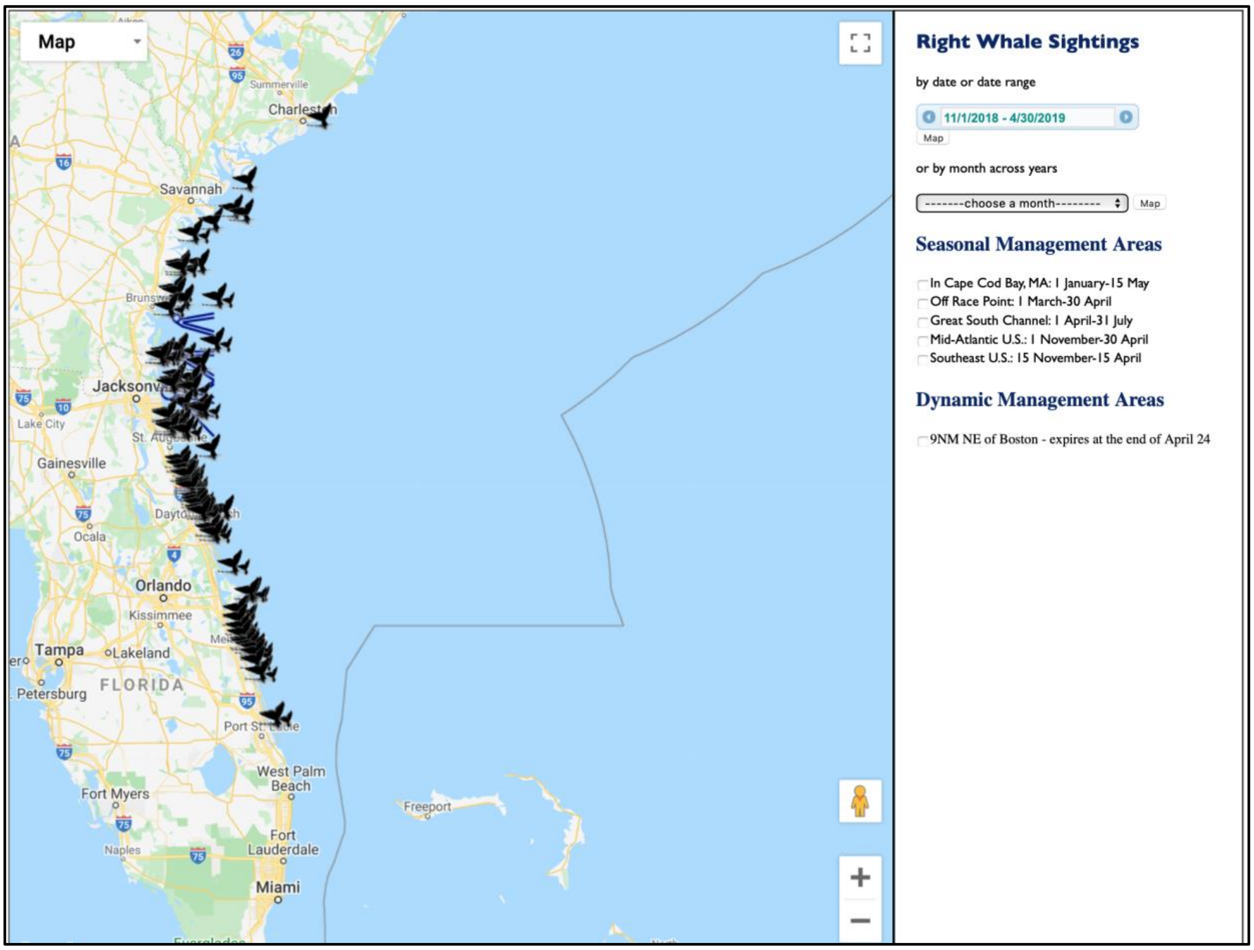


Figure 1. Right whale sightings SMA 2018-2019. Note: North Atlantic right whales sighted in SEUS have migrated past the Charleston and Savannah entrance channels and will migrate through them a second time with calves on the migration north. Source: NOAA Right Whale Sighting Advisory System

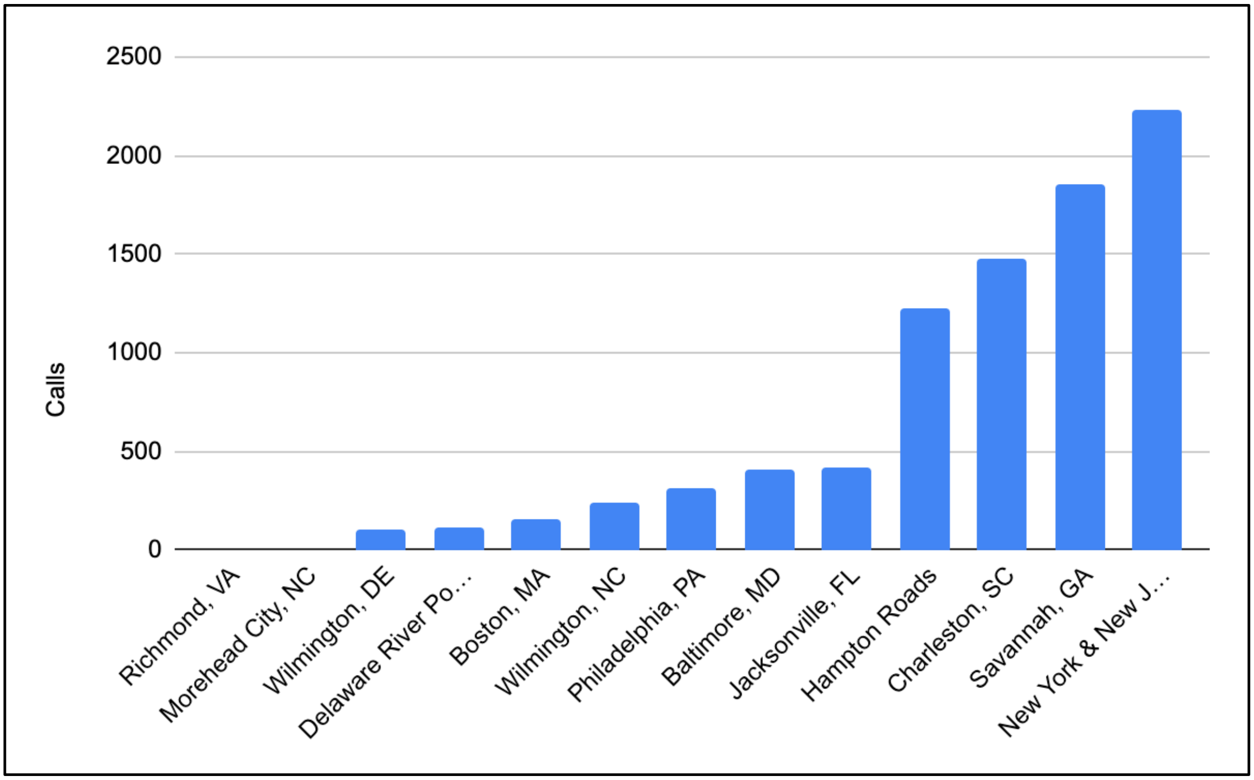


Figure 2: Containership vessel calls in selected U.S. ports, 2015; source U.S. Department of Transportation

Figure 3: Transit speed plot for March-April 2017-2018 shows even distribution of high transit speed along length of Charleston entrance channel

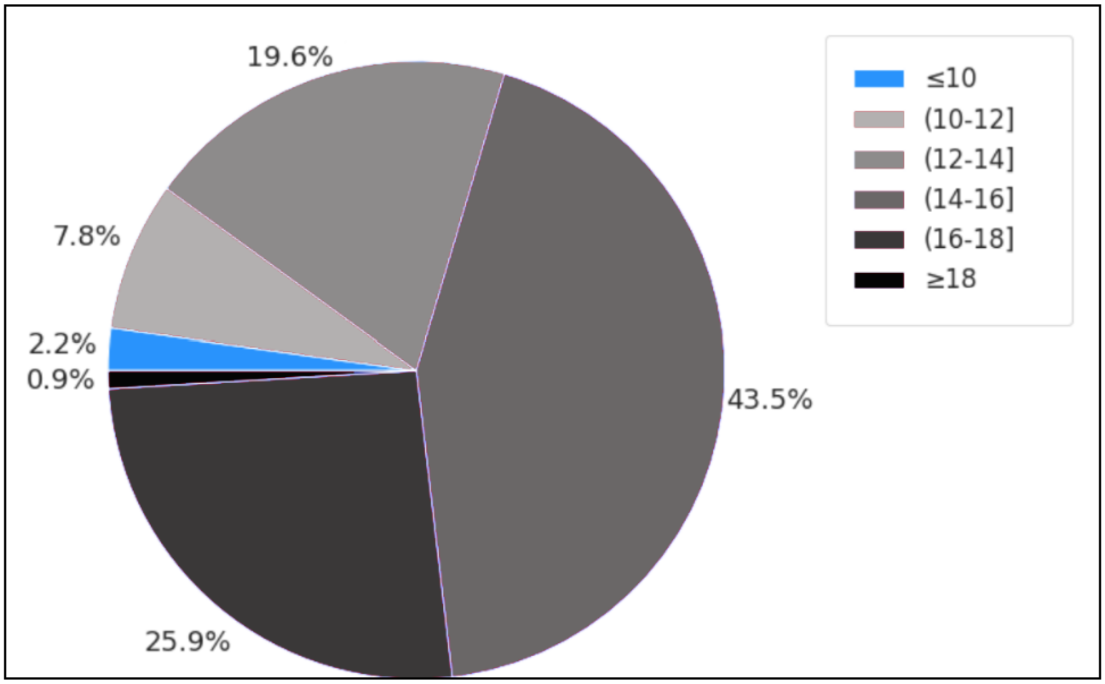


Figure 4. Transit speed, Charleston entrance channel. Source: VesselFinder.

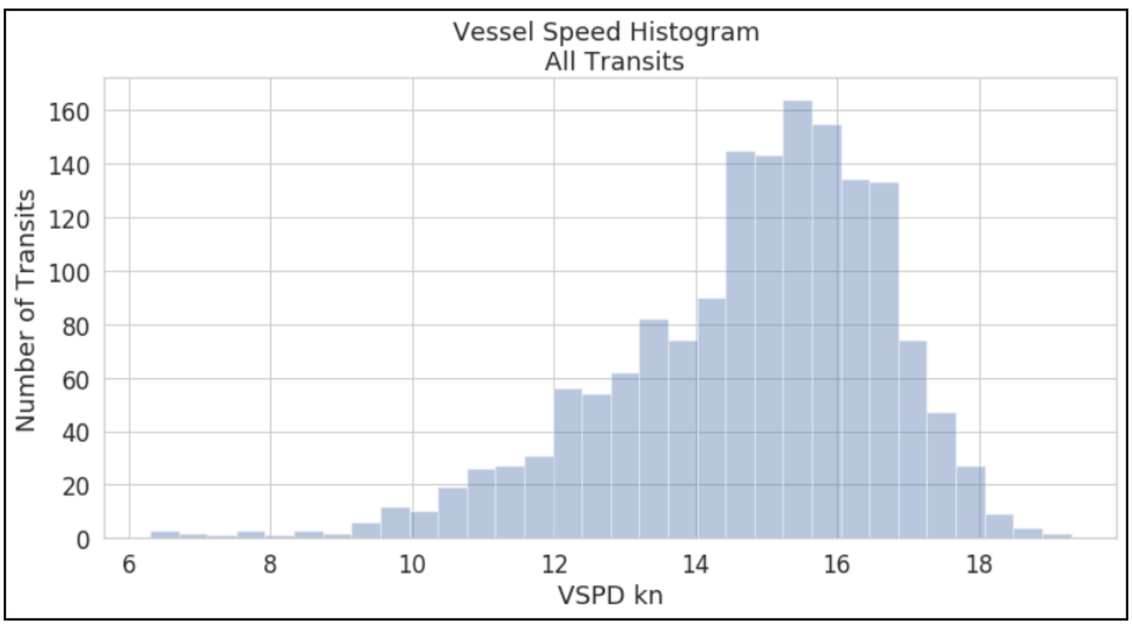


Figure 5. Transit speeds in the Charleston Entrance Channel. Source: VesselFinder.

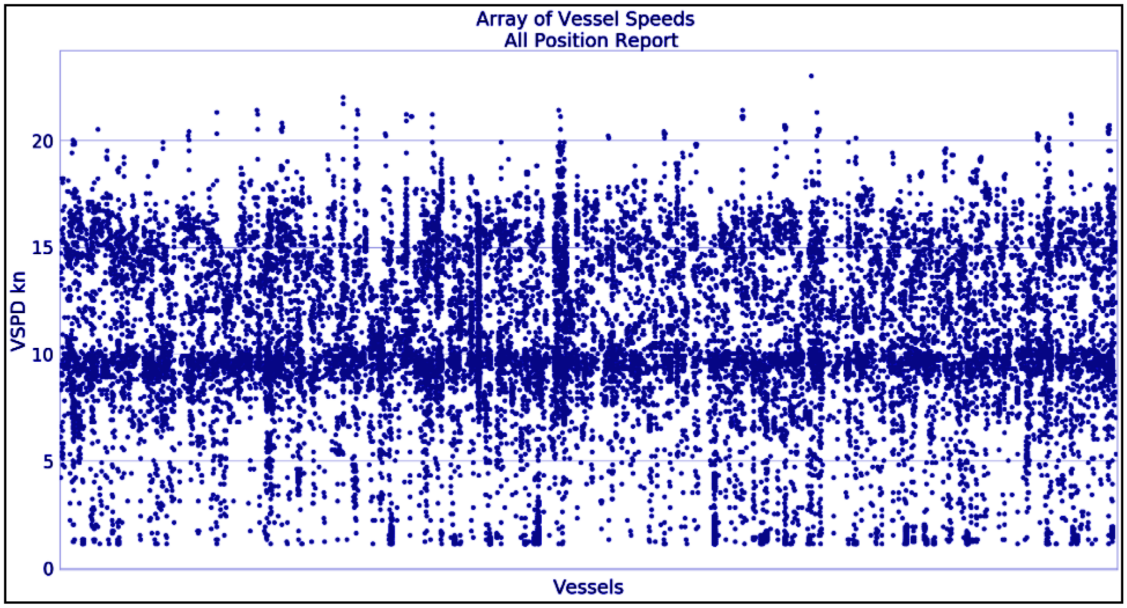


Figure 6. Vessel Speed, February 2019, Charleston SMA.

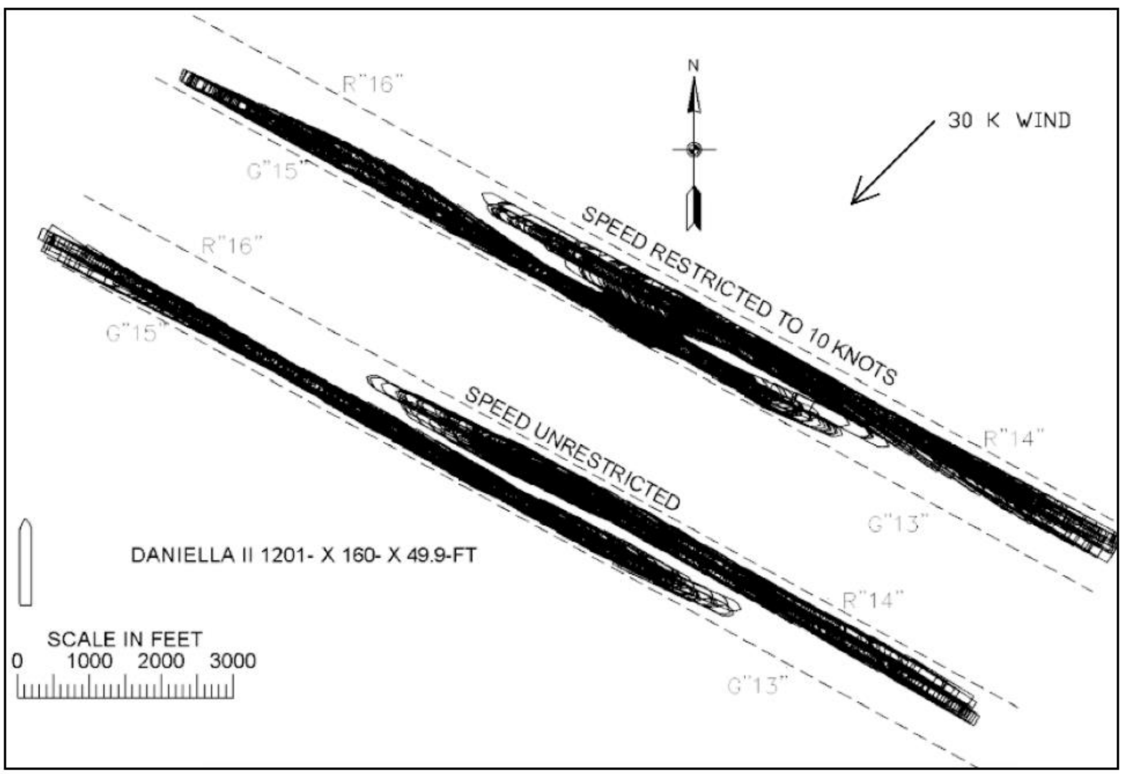


Figure 7. Plot of simulated runs from Charleston Harbor Deepening and Widening Study.

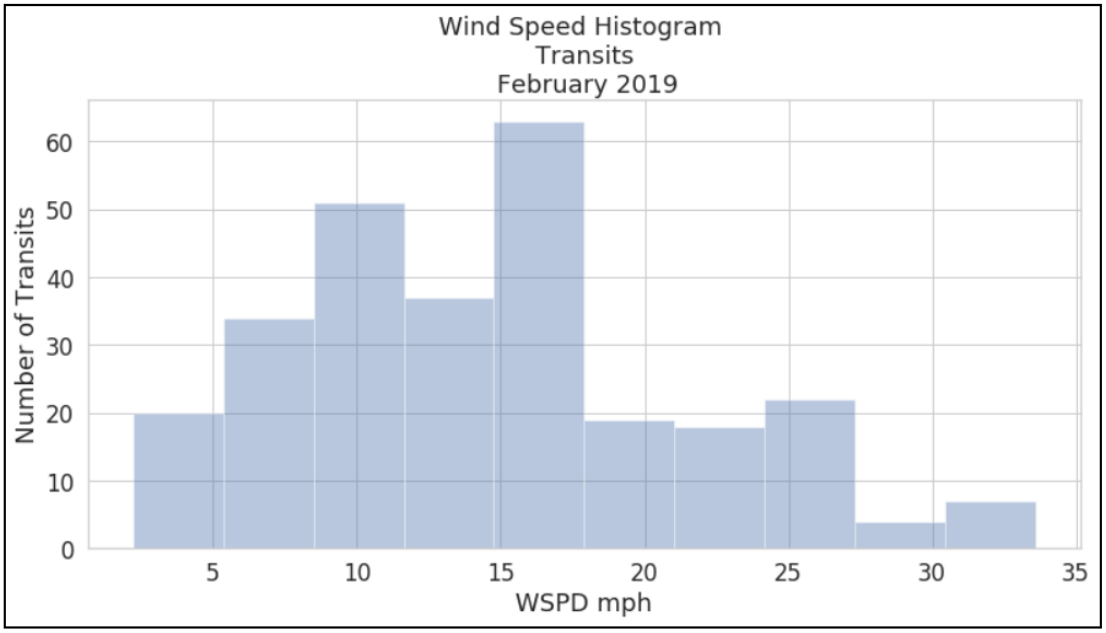


Figure 8. Wind speed, February 2019

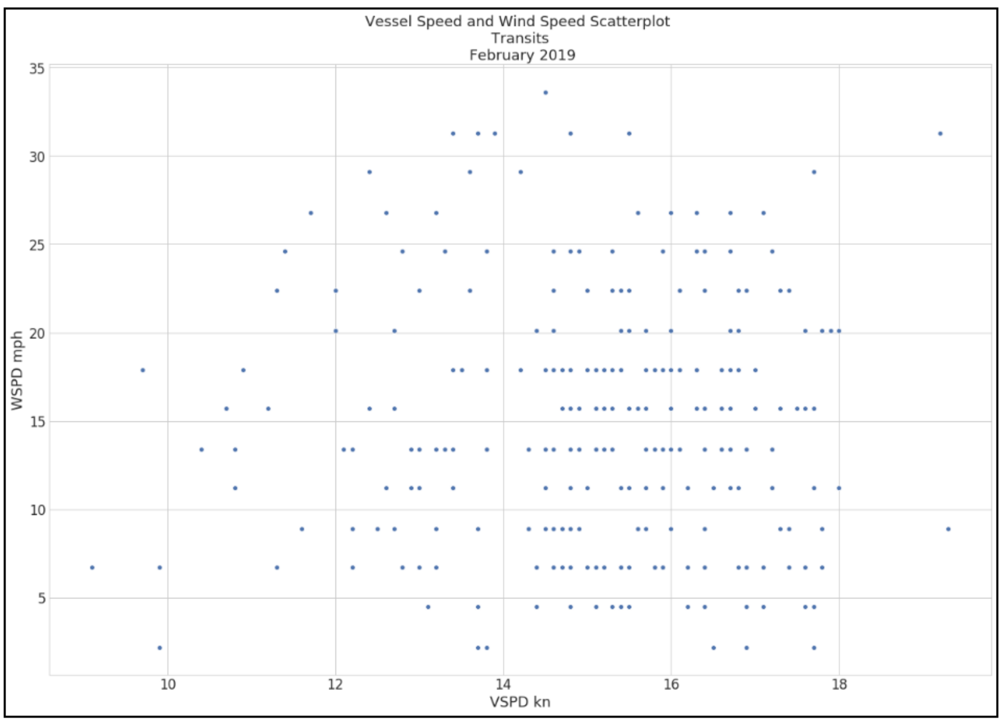


Figure 9. Vessel speed vs. wind speed, February 2019

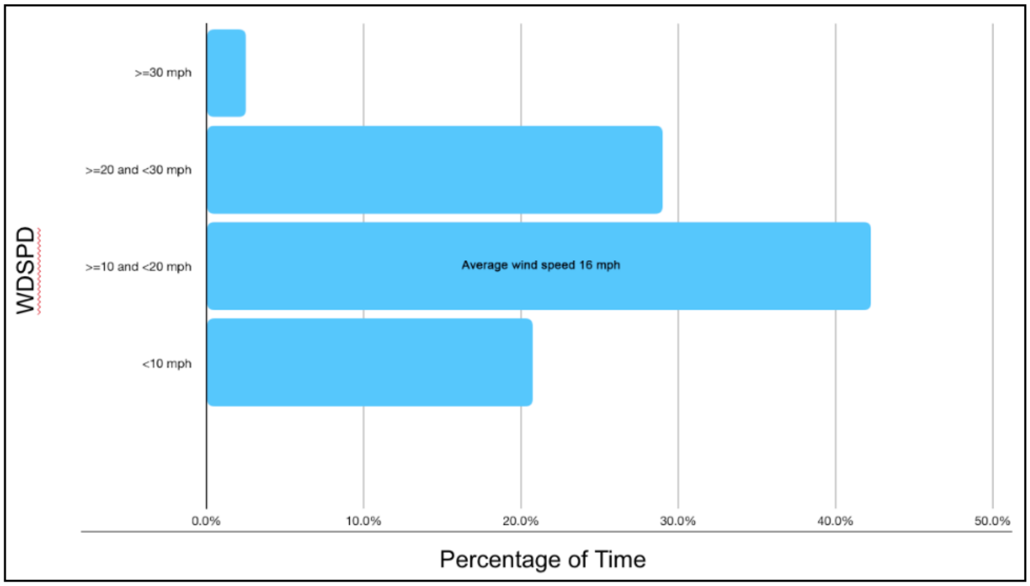


Figure 10. Average Wind Speed, February and March, Edisto Buoy. Source: National Buoy Data Center

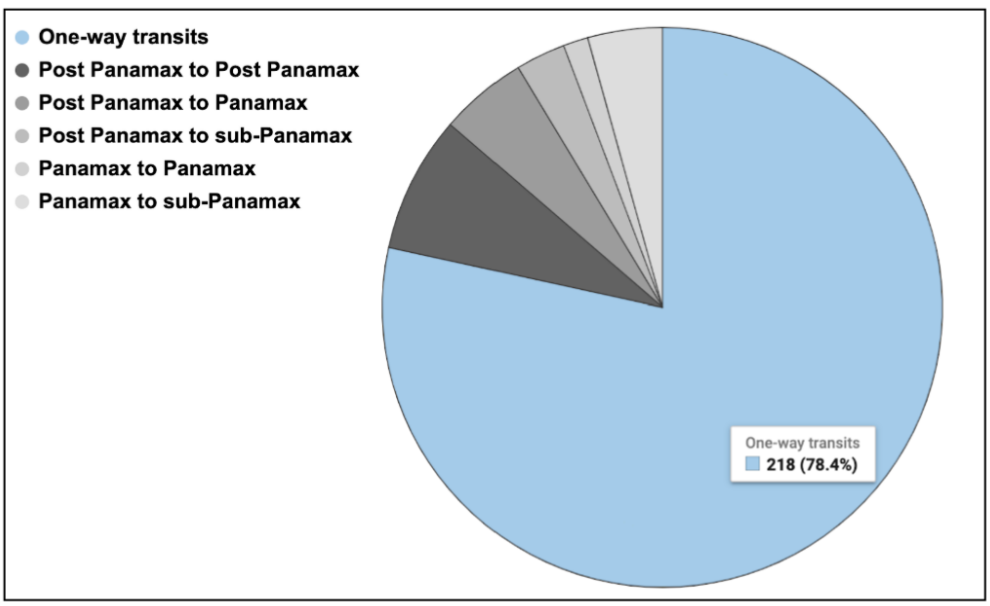


Figure 11. One-way and two-way traffic, Charleston entrance channel, February 2019

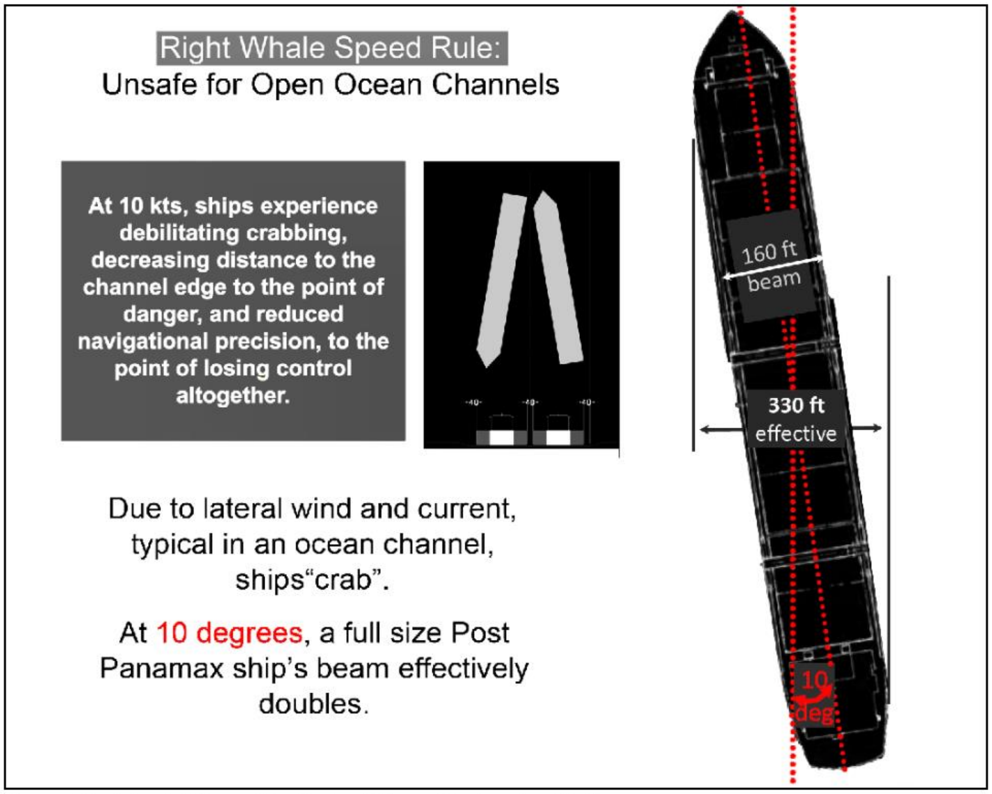


Figure 12. Adapted from Charleston Pilots: *Navigation Update*

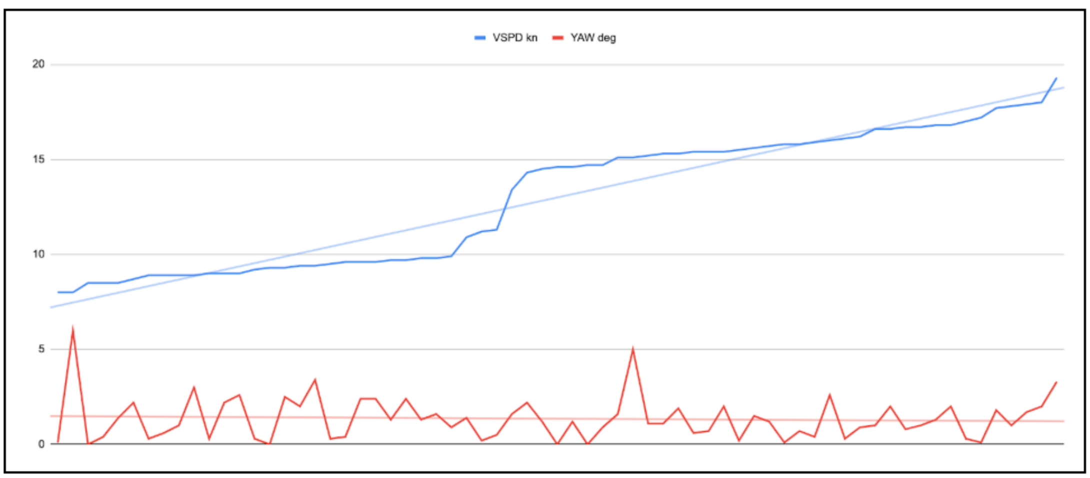


Figure 13. February 2019 vessel speed and yaw. Source VesselFinder.

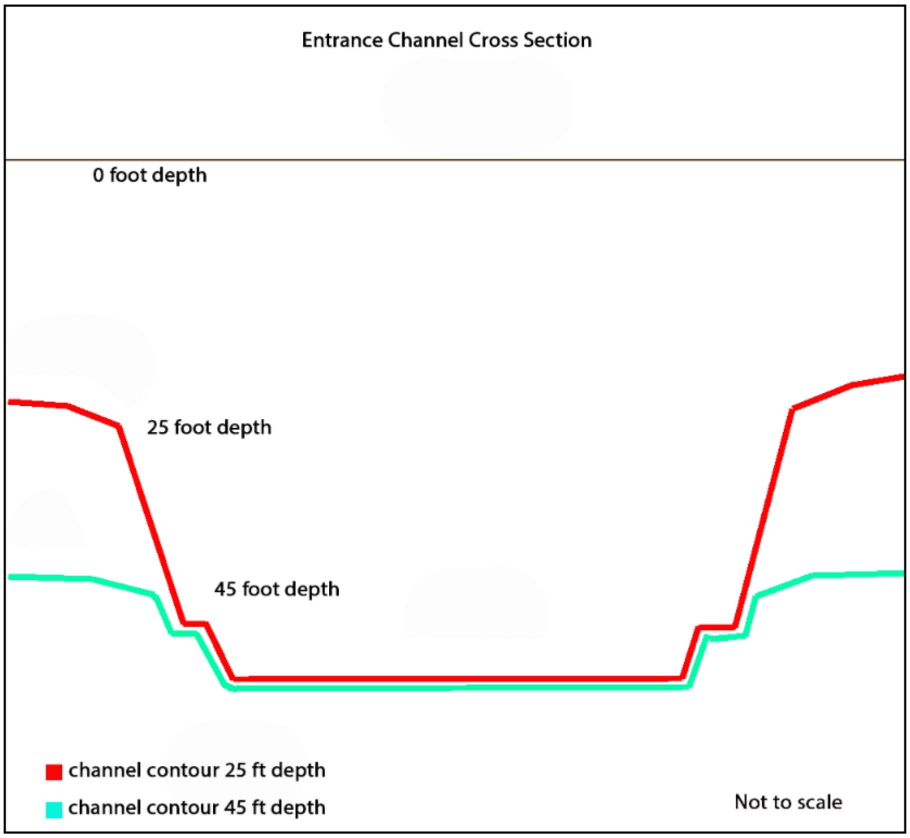


Figure 15. Charleston entrance channel cross section.

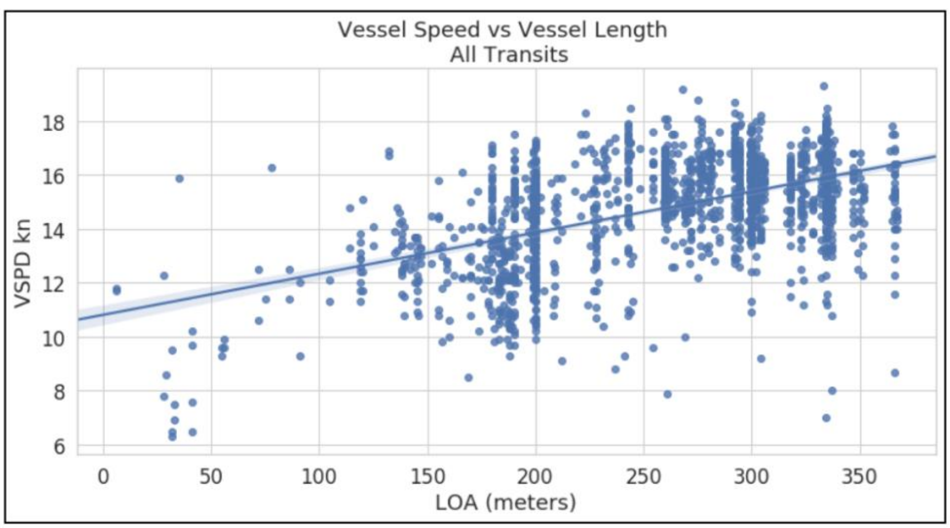


Figure 16. Vessel speed vs. vessel length.

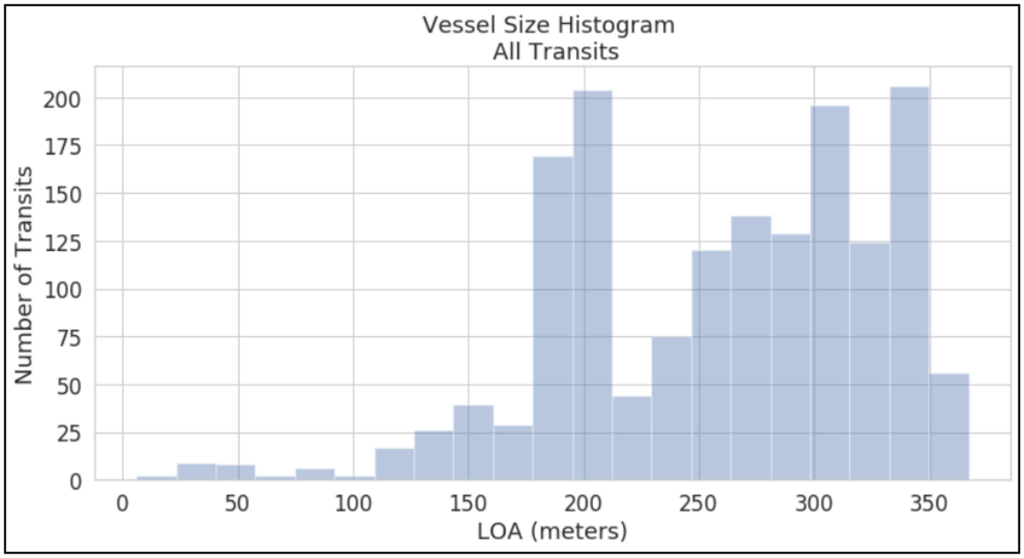


Figure 17. Size distribution of Post Panamax ships, Panamax and sub-Panamax vessels.

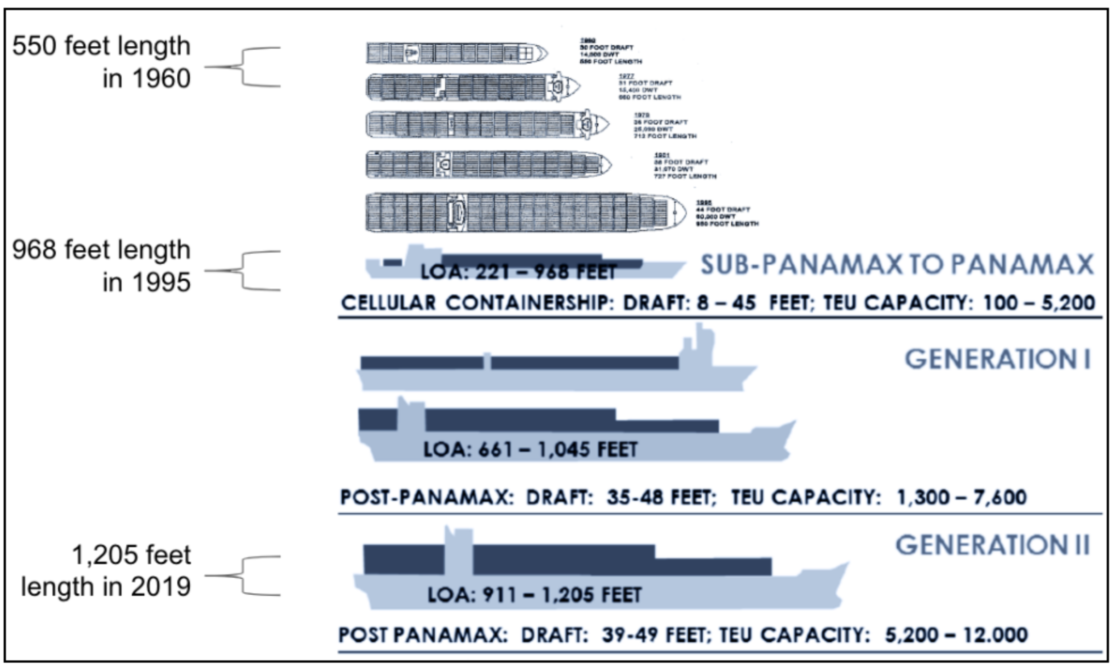
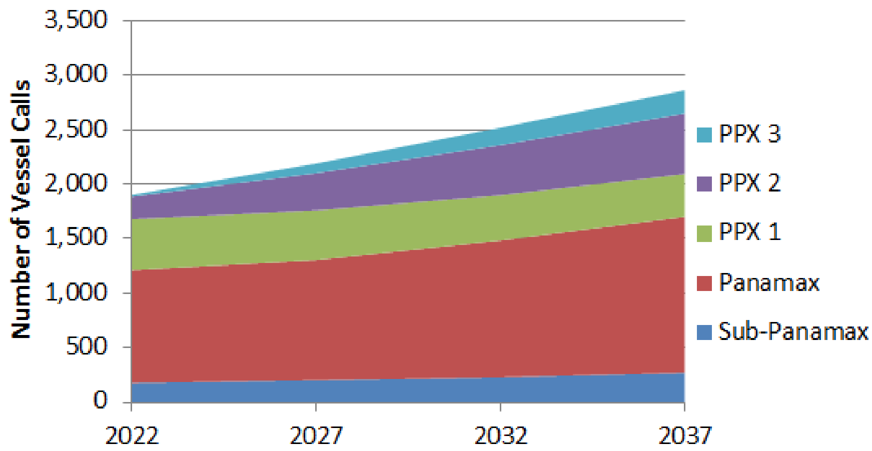


Figure 18. Container ships calling at Charleston 1960-2019. Source: USACE 1996, 2019



Vessel Class	2022	2027	2032	2037
Sub-Panamax	176	202	229	269
Panamax	1,035	1,103	1,255	1,434
PPX 1	470	456	416	392
PPX 2	206	342	460	555
PPX 3	16	89	161	214
Total	**1,903**	**2,192**	**2,520**	**2,863**

Figure 19. Projection of Vessel Calls at the Port of Charleston. Source: Charleston Harbor FIFR/EIS

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