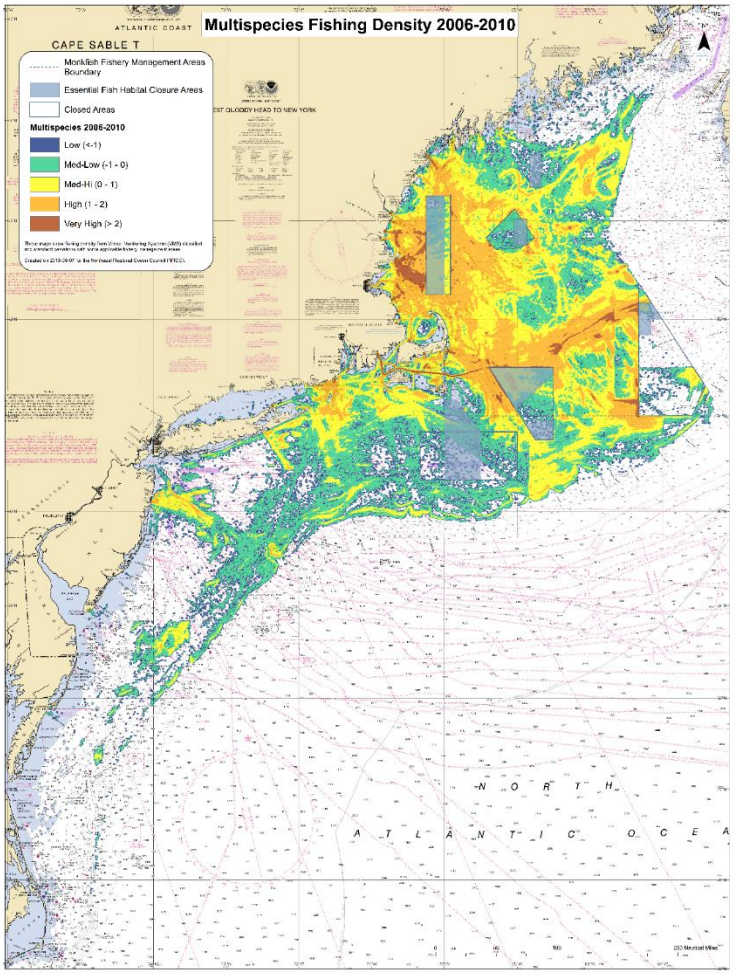
Final Report
Commercial Fisheries Spatial Characterization
Phase II



Prepared for the
Northeast Regional Planning Body

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EXECUTIVE SUMMARY

This project focused on four topics of commercial fisheries spatial characterization for consideration by the Northeast Regional Planning Body as it develops a regional ocean plan for New England as required by Presidential Executive Order 13547. The four topic areas were (1) producing maps of commercial fishing activity using vessel monitoring system (VMS) data for fisheries that use this technology, (2) comparing maps based on vessel monitoring system data with maps based on vessel trip report (VTR) data, (3) determining the most appropriate regional spatial characterization for the American lobster fishery, and (4) conducting a pilot project to test electronic location tracking and catch reporting for the party / charter sector.

Maps based on VMS data were produced for the groundfish, monkfish, herring, scallop and surf clam / ocean quahog fisheries for 2006-2010 and 2011-2014. Maps were also produced for the squid and mackerel fisheries for 2014, the only year VMS data were available for these fisheries. Maps for all fisheries using VMS separating fishing activity and transit activity were produced for 2011-2014 (2014 for squid and mackerel fisheries). The influence of concentration of VMS signals in port locations was examined and determined not to be skewing map results in offshore fishing areas.

Maps produced using VMS data were compared to maps of the same fisheries using VTR data, and both showed similar spatial patterns. Both techniques produce maps that are valuable for ocean planning interests. The choice of mapping technique can be made based on available data and resources, and the objective of a particular ocean planning process.

It is important to note that no single available data source accurately captures all necessary information on the myriad commercial fisheries important in New England. Data for ocean planning must rely on multiple data sources, all of which come with some inherent limitations.

Various maps of lobster fishery spatial patterns were examined to determine which mapping effort produced the best map product for ocean planning interests. Most maps of lobster fishing spatial patterns were not conducted regionally and therefore do not allow a region wide portrayal of the fishery. Other maps covered the entire New England region but were based on incomplete reporting of the fishery. For ocean planning purposes, the map of trap and pot endlines compiled for the National Marine Fisheries Service is recommended as the best current portrayal of the spatial characterization of the lobster fishery.

The pilot test of an electronic reporting and location tracking system on party / charter vessels was conducted on 14 vessels in Rhode Island, Connecticut, New York, and New Jersey. The pilot project showed that the technology provided catch and location

information that the participating captains could use in the future. It also provided location tracking that could help fill an existing data gap to help inform ocean planning efforts.

1. PROJECT OVERVIEW

The ocean is a vital part of the economy, culture, and history of New England. People in New England greatly value their ocean heritage and are seeking ocean-dependent jobs, food, energy, and recreation in new and complex ways. Ocean planning is one way to meet the challenge of balancing varied ocean uses. Government agencies and stakeholders working together can anticipate needs, set priorities, and make decisions from a regional perspective. The Northeast Regional Planning Body was established in New England in 2005 to develop an ocean management plan for New England.

As part of the Northeast Ocean Planning process, project teams engaged various ocean users through a suite of public participation activities. The goal of this outreach was to ensure that the final plan reflect the knowledge, perspectives, and needs of ocean stakeholders – fishermen, scientists, boaters, environmental groups, leaders in the shipping, ports, and energy industries, and all New Englanders whose lives are touched by the ocean.

Commercial fishing holds a special place in this regional fabric and planning process. Understanding how commercial fishing occurs in New England waters is critical to planning current and future uses of the ocean. Mapping ocean use patterns of commercial fishing is a foundational step for those conducting the ocean planning effort in New England Phase I of the Fishery Characterization Project[1] examined how various map or spatial characterization data could be used to describe how commercial fisheries use New England's ocean waters as part of the RPB's ocean planning process. Phase I[2] used existing VMS[3] and VTR[4] data to map the spatial footprint of fishing over the entire northeast region. Objectives of that project were: (1) to consider the use of products derived from VMS and VTR data to develop a series of maps that characterized New England's commercial fishing patterns, including party / charter boats, for ocean planning purposes; (2) to meet with fishermen and others to modify the maps based on their feedback, to best reflect historic and current fishing patterns in New England; and (3) to make recommendations for future work to improve mapping efforts of commercial fishing activity in New England. The Phase I report is available at www.northeastoceancouncil.org and Phase I map products are available on the Northeast Ocean Data Portal[5].

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[1] Battista N., A. Cygler, G. Lapointe and C. Cleaver. 2103. Final Report to the Northeast Regional Ocean Council: Commercial Fisheries Spatial Characterization. http://neoceanplanning.org/wp-content/uploads/2013/12/Commercial-Fisheries-Spatial-Characterization-Report.pdf (Site access 9/18/2015)

[2] http://northeastoceancouncil.org/wp-content/uploads/2013/09/Commercial-Fisheries-Spatial-Characterization-Report.pdf (Site access 9/18/2015)

[3] Vessel Monitoring Systems (VMS) is a satellite surveillance system primarily used to monitor the location and movement of commercial fishing vessels.

[4] Vessel Trip Reports (VTR) are reports required of fishing vessels for each fishing trip taken, including location information.

[5] http://www.northeastoceandata.org/data-explorer/?commercial-fishing (Site access 12/15/2015)

Phase II of the commercial mapping project began in 2014, further mapping commercial fishing activity and exploring methods for mapping lobster fishing and party / charter fishing, recognizing the information gaps associated with these two fisheries. This work was conducted by George Lapointe, in close coordination with many fishing industry representatives, fishery managers, and ocean researchers. The primary geographic scope of the project was the ocean waters of New England. The Mid-Atlantic region was added for VMS mapping and for the comparison of VMS and VTR mapping of commercial fishing activity.

Phase II of the project concentrated on four areas:

1. Characterization of fishing activity using VMS data updated to cover 2011-2014, and to separate fishing and vessel transit activity

   Fishery mapping using VMS data was updated to add the 2011-2014 period to the original time period of 2006-2010, to separate fishing from vessel transit activity, and to explore mapping questions raised during stakeholder and RPB meetings, e.g. whether port VMS signals skew fishery spatial use patterns and how various vessel speed breaks between fishing and transit impact fishery spatial use patterns.

2. Comparison of fishery mapping methods and products from VMS and VTR data

   The Project compared mapping of commercial fisheries using VMS and VTR data which were the primary mapping methods used in the New England and Mid-Atlantic regions, respectively.

3. Lobster fishery mapping

   Lobstering is one of the most commercially valuable, ubiquitous, and culturally important fisheries in New England but mapping the fishery is difficult because of a lack of consistent reporting requirements and a variety of sub-regional mapping efforts conducted in different ways. The Project explored means of characterizing this fishery spatially across the entire region.

4. Party / charter boat[6] electronic reporting pilot project support

   Mapping the charter fishery for ocean planning is difficult because of varied reporting requirements and inconsistent location reporting on VTRs. The Project included a cooperative pilot project to test an electronic catch and location reporting system for the charter fishery.

Project results, as described in this report, are intended to inform those developing the Northeast Regional Ocean Plan being prepared pursuant to the National Ocean Policy.[7]

2. KEY PROJECT ENGAGEMENT AND OUTREACH

A critical component of this effort to characterize the commercial fisheries in the northeast was talking with many different groups and individuals representing fishermen, fishery managers, fisheries scientists, and other stakeholders. Stakeholders provided project staff with information and advice on:

- The accuracy of project map products in characterizing various fisheries (based on the experience of representatives of the commercial and for-hire fisheries, state fishery management professionals, the Northeast Regional Planning Body, and members of the public).
- How to best portray project maps and best provide appropriate context for public understanding and future use, e.g. using NOAA charts as a background and including management areas important to the fisheries with VMS data
- Potential uses for NROC map products and stakeholder concerns about how maps could be used in the future.

Stakeholder meetings were conducted throughout coastal New England and at meetings of regional fishery management organizations from September 2014 to November 2015. Project staff met with the following groups:

- Atlantic Coastal Cooperative Statistics Program (ACCSP)
- Atlantic States Marine Fisheries Commission (ASMFC)
- Cape Cod Commercial Fisheries Association
- Connecticut Department of Energy and Environmental Protection, Marine Fisheries Section
- Connecticut Party and Charter Boat Association
- Maine Coastal Community Sector
- Maine Department of Marine Resources

[6] The party / charter fishery consists of fishermen who take recreational anglers fishing for a fee, and are limited, by regulation, to six passengers.

[7] https://www.whitehouse.gov/administration/eop/oceans/implementationplan (Site access 9/18/2015)

- Maine Fishermen's Forum
- Massachusetts Division of Marine Fisheries
- Massachusetts Lobsterman's Association
- Mid-Atlantic Fishery Management Council
- New England Fishery Management Council
- New Hampshire Department of Fish and Game, Marine Fisheries Division
- New Hampshire Marine Fisheries Advisory Committee
- NOAA Fisheries Office of Law Enforcement
- Rhode Island Coastal Resources Management Council
- Rhode Island Division of Fish and Wildlife, Marine Fisheries Section
- Rhode Island Charter Boat Captains Association
- UMass Dartmouth School of Marine Science and Technology
- Island Institute

Input on map products was also gained through one-on-one meetings with fishing industry members and ocean stakeholders. These meetings provided the chance to have in-depth discussions about draft maps or other ocean planning concerns in settings not constrained by group dynamics where some might dominate the conversation.

Project staff were often unsuccessful scheduling meetings to discuss VMS maps with some groups or members of the industry. There are a number of potential reasons why this occurred. Many fishing industry representatives feel beset by government institutions, so they could be disinclined to disclose information to institutions that they believe are impacting their livelihoods and ways of life. Second, fishing industry representatives feel that they must focus their attention on those fisheries management issues that are most important to them, and they don't consider regional ocean planning a high priority. Third, there is a persistent concern that ocean planning is either an indirect way of eliminating commercial fishing or is a way for oil and gas interests to "get their foot in the door" in New England through funding ocean planning activities. Lastly, many had already seen NROC map products, so there may not have been a strong interest in contributing to what they perceive as minor changes to these maps.

3. FISHERY MAPPING USING VMS DATA

The VMS portion of the project was conducted by George Lapointe of George Lapointe Consulting, working with a team of NROC staff and Northeast Ocean Data Portal (Data Portal) staff. Data Portal staff produced maps from VMS raw data on vessel location by date (2006-2010) or date/time (2011-2014). Project staff signed non-disclosure agreements with NOAA Office of Law Enforcement to protect the confidentiality of VMS data as required by federal law.

Decisions about what to capture and display on maps were made iteratively through discussions among NROC staff, Data Portal staff, and George Lapointe. These decisions included the steps needed to produce draft map products, how to best share these products

with fishing industry members, stakeholders and RPB members, then how to review and revise the maps to be finalized.

Phase II built directly on the Phase I final report, which recommended further efforts be undertaken to (a) conduct further work on VMS and VTR data to (b) address misleading ("false") VMS signals, i.e. where vessels are declaring into a particular fishery as required by management measures but may be targeting other species (an example is a vessel with herring VMS fishing for squid, (c) delineate transit time from fishing activity, (d) define the value of continuing to work with VTR data, (e) include additional, non-catch, fisheries-related data sets, (f) address shifts in the ecosystem, (g) determine the role and value of working waterfront infrastructure, and to create new data sets to better map lobster, tuna, charter boat, and community fishing areas. For Phase II, the team had access to VMS data from 2006-2014 through the NMFS Office of Law Enforcement. Data for 2006-2010 did not have the time information needed to separate fishing and transit activity. Data for 2011-2014 had time/ date information and could, therefore, be used to look at the fishing and transit activity in the VMS fisheries by approximating vessel speed as described below. On September 1, 2014, a new regulation required that all fishing vessels in the squid, mackerel, and butterfish fisheries use VMS on their vessels. This allowed project staff to look at spatial use patterns in these fisheries for the last four months of 2014. Until this change, VMS-derived maps representing "herring" had also included squid and mackerel boats, as those same boats had herring permits and thus were required to use a VMS unit even when fishing for the other species.

a. Methods and display

VMS data were mapped into fishery-specific products based on declaration codes which designate VMS records into various fishery plans. These fisheries are outlined below along with their associated fishery plan and/or program information. Table 2 also contains the time periods used to map each fishery.

The VMS records were initially mapped into point locations in order to generate the density grids for each fishery product. These points were then plotted onto a 100 meter (m) raster grid, which accounted for the distribution and number of points across the study area. Values were generated for each 100m cell based on a search radius of 1,000m, such that a grid cell within 1,000m of a VMS point would be assigned a density value. Grid cells within 1,000m of multiple VMS points would be assigned higher density values. Grid cells that did not lie within the search distance of VMS points were assigned zero values. This process was performed using the ArcGIS Spatial Analyst Point Density tool[8].

Prior to running the density gridding process, a preliminary screening analysis was performed to eliminate VMS records that did not preserve data confidentiality based on application of the "Rule of Three" required by NMFS OLE. The Rule of Three required the removal of VMS points where fewer than three records were represented in any given location. Therefore, a screening

[8] http://desktop.arcgis.com/en/desktop/latest/tools/spatial-analyst-toolbox/point-density.htm (Site access 12/28/2105)

grid with a 1,400m resolution was used to remove VMS points if fewer than three points occurred within a screening grid cell. This resolution was chosen because a 1,400m square is the largest square that fits entirely within a 1,000m radius circle, which was the search distance used to generate the density products. Therefore, the resulting density maps show locations of VMS data that adhered to the Rule of Three, i.e. keeping data confidential if the data come from fewer than three individual people, vessels, or businesses.

Once the screening and density analyses were run for each fishery product, the output density grids were log transformed and standardized to identify patterns of distribution inherent to each product.

The maps of fishing spatial activity for the fisheries with VMS information were developed for the New England and Mid-Atlantic ocean regions depending on the geographic scope of a given fishery, i.e. New England through the Mid-Atlantic for the herring fishery and New England to the Mid-Atlantic for the scallop fishery. Fishery activity was portrayed in categories based on standard deviations. Figure 1 shows the breakdown of fishing vessel activity levels in graphic format. The lowest density values appear as dark blue, while medium density values are green and yellow. Together the medium classes include all values within one standard deviation of the average, and they are broken out into two classes to better identify fishing patterns. The high values are orange and red and represent the most heavily fished or transited areas within the product. While these represent classifications of the data based on statistically calculated values, it is best to interpret the maps qualitatively on a scale from low (blue) to high (red).

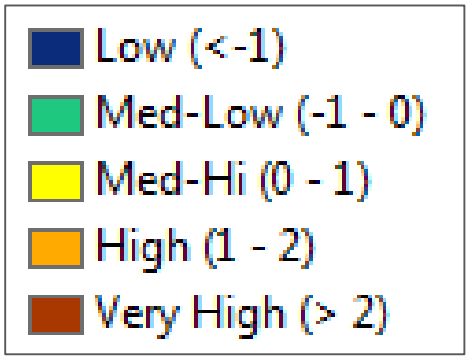


Figure 1: Fishing vessel activity categories and colors used to depict activity on VMS maps

The VMS maps developed in this project are for multiple years, i.e. 2006-2010 or 2011-2014, in order to show multi-year patterns, which is more useful for ocean planning. Shorter time periods had more data excluded because of application of the Rule of Three. The 2006-2010 and 2011-2014 maps were produced using the same methods, which means that fishing spatial pattern maps for the two time periods are comparable.

b. VMS speed for fishing and transit

In addition to the methods described for the overall VMS work, to examine separation of fishing from vessel transit the project team used two methods to examine spatial use patterns to differentiate fishing and transit. First, they discussed with fishing industry members and managers what vessel speeds should be used as a cutoff for fishing (lower speeds) and transit (higher speeds) for vessels in particular fisheries. Second, they used a variety of speed cutoffs in the Northeast Multispecies fishery to see how sensitive the final maps were to different speeds being used in mapping fishing and transit activity (i.e., for this purpose, would it matter if speeds of 3.5, 4, or 4.5, etc. knots were used as a threshold). The speed cutoffs used in the various fisheries with VMS are shown in the table below.

Fishery	Speed Cutoff Used in Maps
Multispecies (Groundfish)[9]	4 knots
Monkfish	4 knots
Sea Scallop	5 knots
Surfclam / Ocean Quahog	4 knots
Atlantic Herring	4 knots
Atlantic Mackerel	4 knots
Squid	4 knots

Table 1: Vessel speeds used to delineate fishing activity from transit activity.

Maps showing the fishing and spatial patterns for the various fisheries can be found in Appendices 1 to 19. Note that patterns shown on the maps are approximations for separating fishing and transit activity, because the speeds at which various vessels fish or travel can vary by vessel size, by design, or by the captain's practices.

Project staff held meetings with fishing industry members, managers (e.g. New England Fishery Management Council representatives), state marine fisheries agency staff, and also attended other meetings where fishermen gathered such as the Maine Fishermen's Forum (Appendix X) from October 2014 to June 2015. During these discussions, they asked participants how the patterns of fishing would change when different fishing/transit cutoff speeds were used. Some people interviewed thought that it was important to look at spatial use patterns below 1 knot regionally because they believed it was important to look for areas that might be commonly used for sorting catch or being stationary (laying to). If project staff identified areas where vessels were staying almost stationary, this would comprise important information for ocean planning. The multispecies fishery was used for this analysis, mapping at speeds less than 1 knot, 3 knots, 3.5 knots, 4 knots, 4.5 knots, 5 knots, 5.5 knots and 6 knots. Examination of the maps shows minor differences between maps of close speed cutoffs, e.g. 3.5, 4, or 4.5 knots, and larger differences between more widely separated speeds, e.g. 3 and 6 knots. As shown in

[9] The multispecies or groundfish Fishery Management Plan includes the following species: cod, haddock, yellowtail flounder, pollock, plaice, witch flounder, white hake, windowpane flounder, Atlantic halibut, winter flounder, redfish, Atlantic wolffish, and ocean pout

Appendix 2, this analysis demonstrates that fishing patterns as indicated on VMS-derived maps are not sensitive to minor changes in the cutoff speed being used. Therefore, when various industry members argued for using 4 knots as compared with 3.5 knots or 4.5 knots, the fishing patterns were similar across the geography and timeframe (annual) that was being considered.

c. Pre / post catch share display for groundfish

A number of people interviewed in Phase I and II of the project said that it was important to examine spatial use patterns in the groundfish fishery before and after the imposition of catch shares in May 2010[10]. Figure 2 shows groundfish spatial patterns from 2006-2010 and from 2011-2014, which allows a preliminary comparison of spatial use patterns in this fishery before and after this change.

[10] http://archive.nefmc.org/nemulti/planamen/Amend%2016/final%20amendment%2016/091016_Final_Amendment_16.pdf (Site access 10/4/2014)

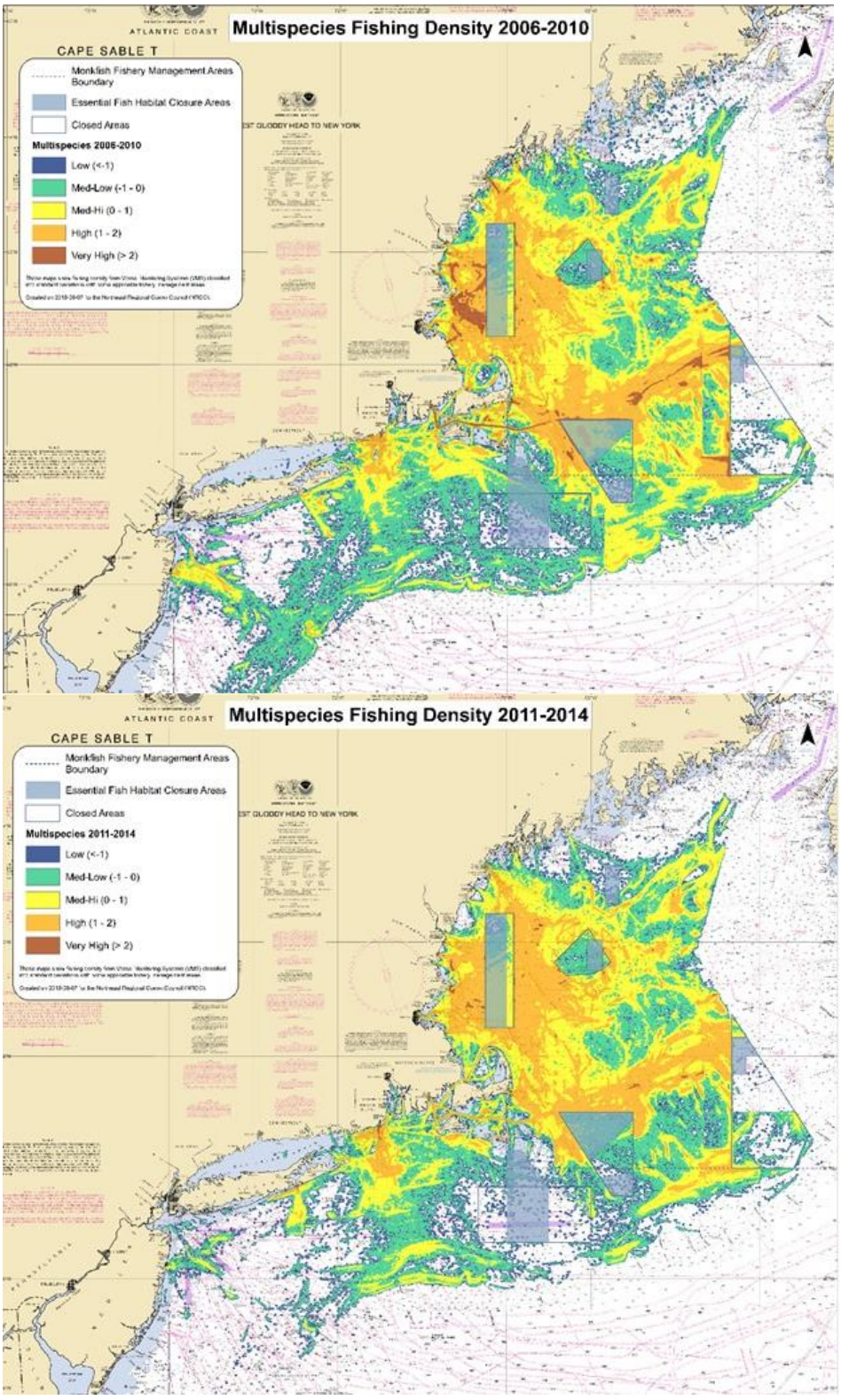


Figure 2: Multispecies (Groundfish) Fishing Density for 2006-2010 (top map) and 2011-2014 (bottom map)

The time separation between the early and later time periods on the maps does not match exactly with the imposition of catch shares, which began on 1 May 2010 while the 2006-2010 map on the left is for the full calendar year. Nonetheless, the two maps show similar spatial use in the groundfish fishery between the two time periods. There are differences in fishing activity density, which could be accounted for by decreased annual catch limits in the latter time period or by decreased participation in the fishery.

d. Impact of VMS signals in port on fishing pattern densities at sea

Discussions about the VMS maps raised the question about whether the high density of VMS-signals in ports such as New Bedford led to a skewed portrayal of at-sea activity levels. For example, would the removal of near-port VMS signals result in portraying at-sea patterns with a more pronounced breakdown of areas of mean to high standard deviations above mean activity levels (yellow, orange, or red areas on the maps)?

The potential for this bias was examined by manually eliminating VMS points in ports in the multispecies (Figure 3) and scallop (Figure 4) fisheries at different mapping scales. Looking at the fisheries at different scales, at 4 maps[11] for groundfish and 3 maps[12] for scallop, shows very little change in the fishery when port VMS signals were removed or retained. Project staff concluded that port and near-port VMS signals have very little impact on at-sea fishing density patterns.

[11] Upper left – New England region, Upper right – Southern New England from eastern Long Island to Nantucket, Lower left – Southern Georges Bank east of Groundfish Closed Area II, Lower right – Gulf of Maine around Western Gulf of Maine Closed Area

[12] Upper left – New England region, Upper right – Southern New England from eastern Long Island to Nantucket, lower left – Northern New Jersey to mid-Long Island

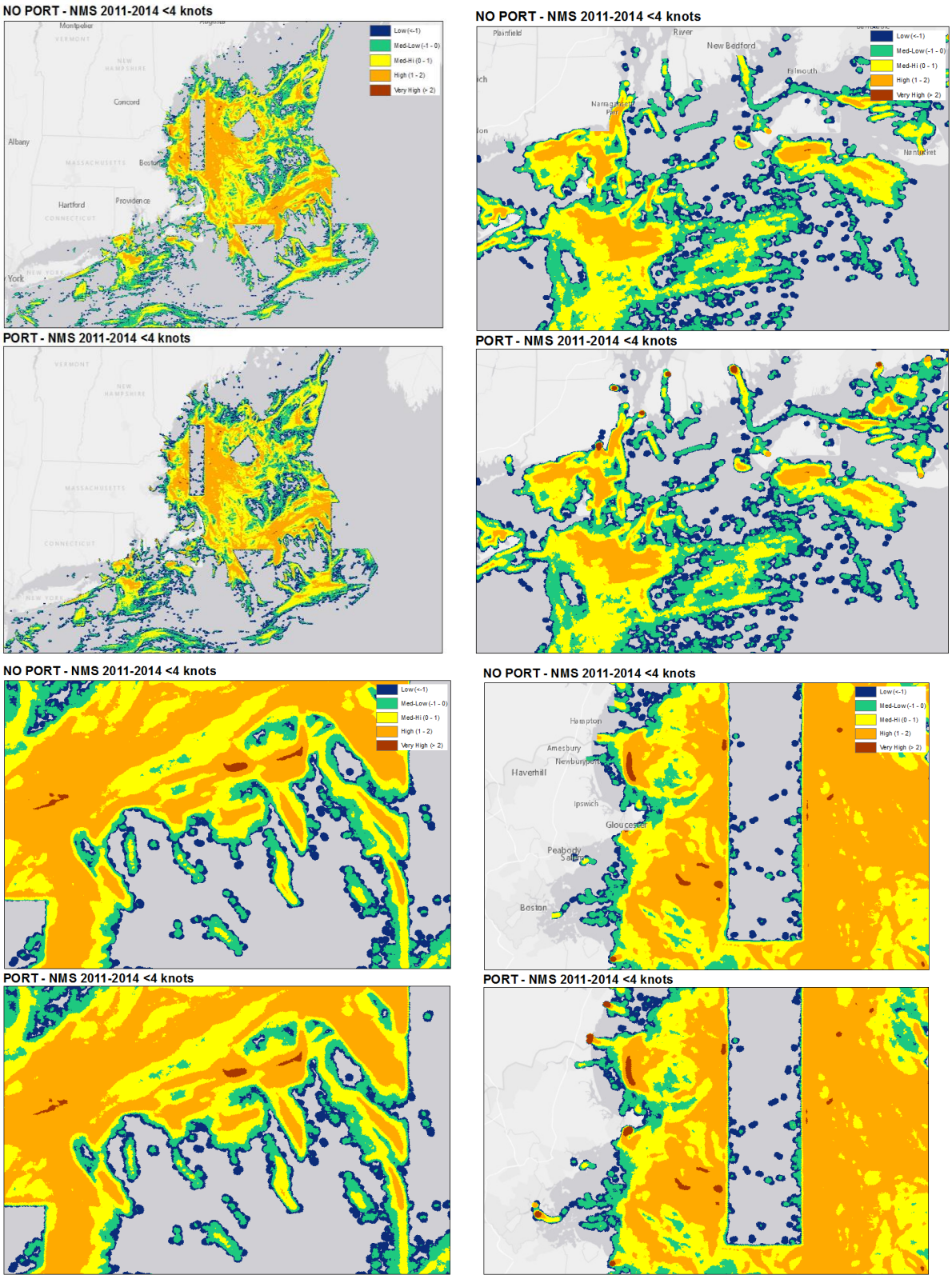
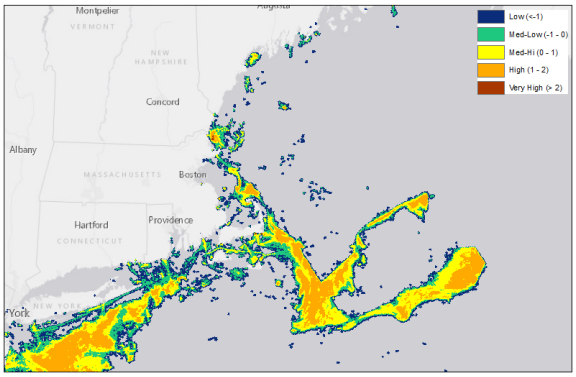
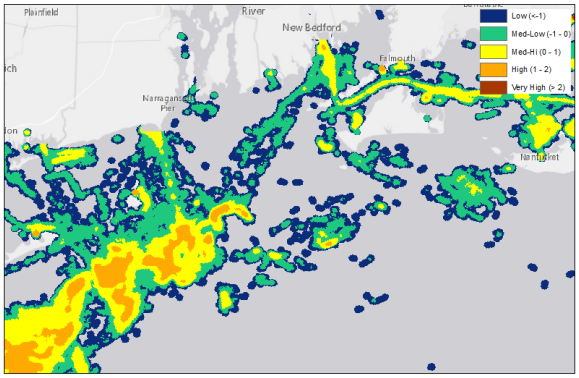


Figure 3: Various aspects of regional spatial patterns in the groundfish fishery with VMS signals from near ports removed (upper maps) and retained (lower maps)

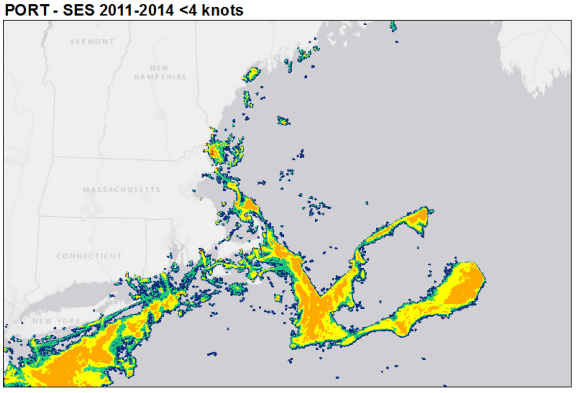
NO PORT - SES 2011-2014 <4 knots



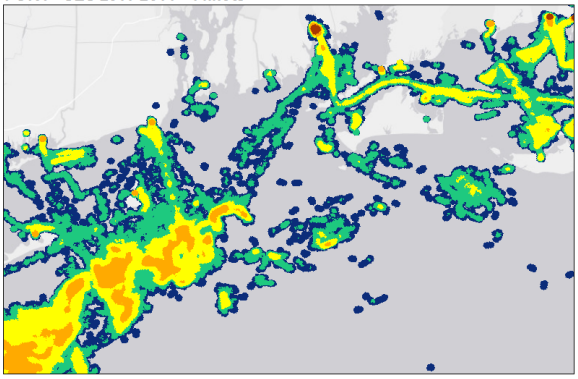
NO PORT - SES 2011-2014 <4 knots



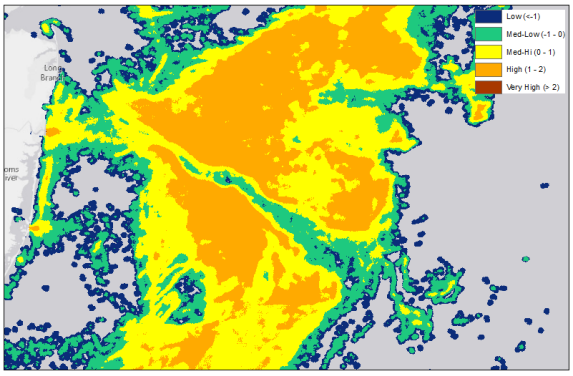
PORT - SES 2011-2014 <4 knots



PORT - SES 2011-2014 <4 knots



NO PORT - SES 2011-2014 <4 knots



PORT - SES 2011-2014 <4 knots

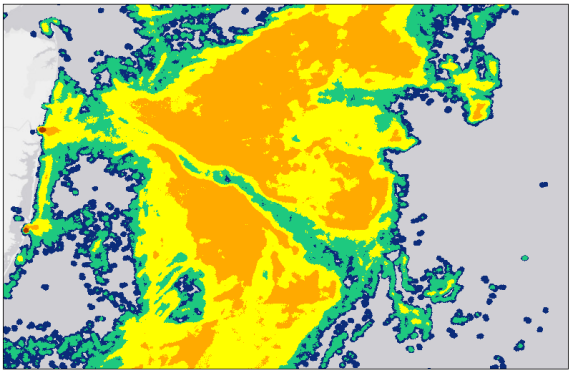


Figure 4: Various aspects of regional spatial patterns in the scallop fishery with VMS signals from near ports removed (upper maps) and retained (lower maps)

e. Maps produced

Table 2 lists the maps produced for individual fisheries, time periods, and vessel speed combinations. These maps are included in Appendices 1 to 19, and are available electronically on the Northeast Ocean Data Portal[13].

Fishery	Appendix Number	VMS Code	Map years / vessel speed
Multispecies (groundfish)	1	NMS	2006-2010
Multispecies (groundfish)	2	NMS	2011-2014
Multispecies (groundfish)	3	NMS	2011-2014 less than 4 knots
Monkfish	4	MNK	2006-2010
Monkfish	5	MNK	2011-2014
Monkfish	6	MNK	2011-2014 less than 4 knots
Scallop	7	SES	2006-2010
Scallop	8	SES	2011-2014
Scallop	9	SES	2011-2014 less than 5 knots
Surfclam / Ocean Quahog	10	SCO	2006-2010
Surfclam / Ocean Quahog	11	SCO	2011-2014
Surfclam / Ocean Quahog	12	SCO	2011-2014 less than 4 knots
Herring	13	HER	2006-2010
Herring	14	HER	2011-2014
Herring	15	HER	2011-2014 less than 4 knots
Mackerel	16	SMB/MAC, MAS, MAH, MHS	2014
Mackerel	17	SMB/MAC, MAS, MAH, MHS	2014 less than 4 knots
Squid	18	SMB/SQL, SQM,SCH, SHM	2014
Squid	19	SMB/SQL, SQM,SCH, SHM	2014 less than 4 knots

Table 2: Maps produced using VMS data for selected fisheries in Northeast

Additionally, it is important for those involved in ocean planning to recognize that many fisheries do not use VMS as part of their management program (for example American lobster, summer flounder, scup and black sea bass, tuna, and hagfish). For these fisheries, other

[13] http://www.northeastoceandata.org/data-explorer/?commercial-fishing (Site access 12/15/2015)

techniques will be needed to understand the spatial use of these fisheries as part of ocean planning or project consideration.

4. COMPARISON OF VMS AND VTR MAPPING TECHNIQUES

Most of the ocean planning work related to commercial fishing has taken a regional or sub-regional perspective, looking at fishery activity at a broad geographic scale using the VMS mapping process discussed above. The need to understand commercial fishing activity at a more local or community level has been recognized by a number of stakeholders in northeast regional ocean planning. The local or community focus is particularly important when considering planning on individual projects or cumulative impacts of multiple projects.

Another method of mapping commercial fishing activity is community resource area (CRA) mapping conducted in the New England and Mid-Atlantic regions. Those mapping use vessel trip reports (VTRs) as their original data source. These community resource area mapping researchers argue that most efforts at GIS-based mapping of resources and resource uses does not adequately capture the human dimensions (and, specifically, which local areas are important to communities or groups of fishermen[14]). The researchers used federal VTR-derived maps as the starting point to interview fishermen from various New England ports to see what fishing areas were important to fishermen from these communities. The researchers then mapped commercial fishing activity by utilizing CRAs and areas of ocean important to fishermen that hail from particular ports or communities. The CRA mapping process was also used in the Mid-Atlantic region[15] as part of the Mid-Atlantic Regional Council on the Ocean (MARCO) work to characterize commercial fishing activity in that region.

Those engaged in regional ocean planning efforts need to consider the appropriate scale for mapping ocean activities, including commercial fishing, to understand how proposed activities or projects will impact groups of users, communities, and the entire New England region. Planning activities should not rely on one method or data source when considering proposed new ocean development. NROC's VMS maps show broad geographic areas and regional relative use intensity for the fisheries which have VMS requirements. These maps (for example, Figure 5) can inform sub-regional or regional planning about patterns of fishing and transit areas. As noted in the Phase I report however, these VMS maps do not highlight areas that are important locally but might appear on region-wide VMS maps as low use (blue or green). There is a risk that ocean planners or project proponents will use VMS maps as their only source of information, which could cause them to easily overlook locally important fishing areas.

[14] St. Martin, K. and M. Hall-Arber. 2008. Commercial Fisheries Spatial Characterization. Marine Policy 32 (2008) 779– 786.

[15] McKay, L. 2014. Developing data for ocean planning. Mid-Atlantic Regional Council on the Ocean. Powerpoint presentation. 32pp.

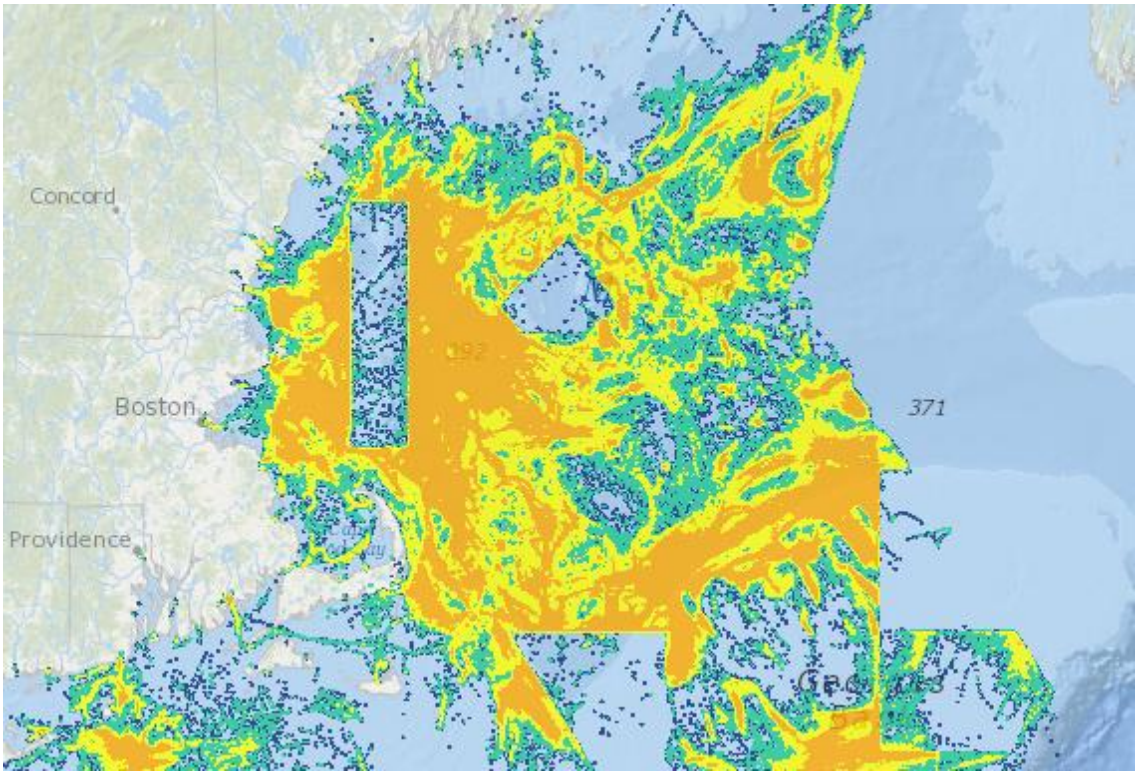


Figure 5: Groundfish VMS, 2011-2013

Mapping community resource areas shows commercial fishing activity emphasizing the port affiliation of vessels fishing in specific areas, in addition to showing regional spatial use by commercial fishermen (Figure 6). This is one example of a way to show local areas that are important to local fishermen or communities, information that people should consider when during further ocean planning or specific ocean use projects.

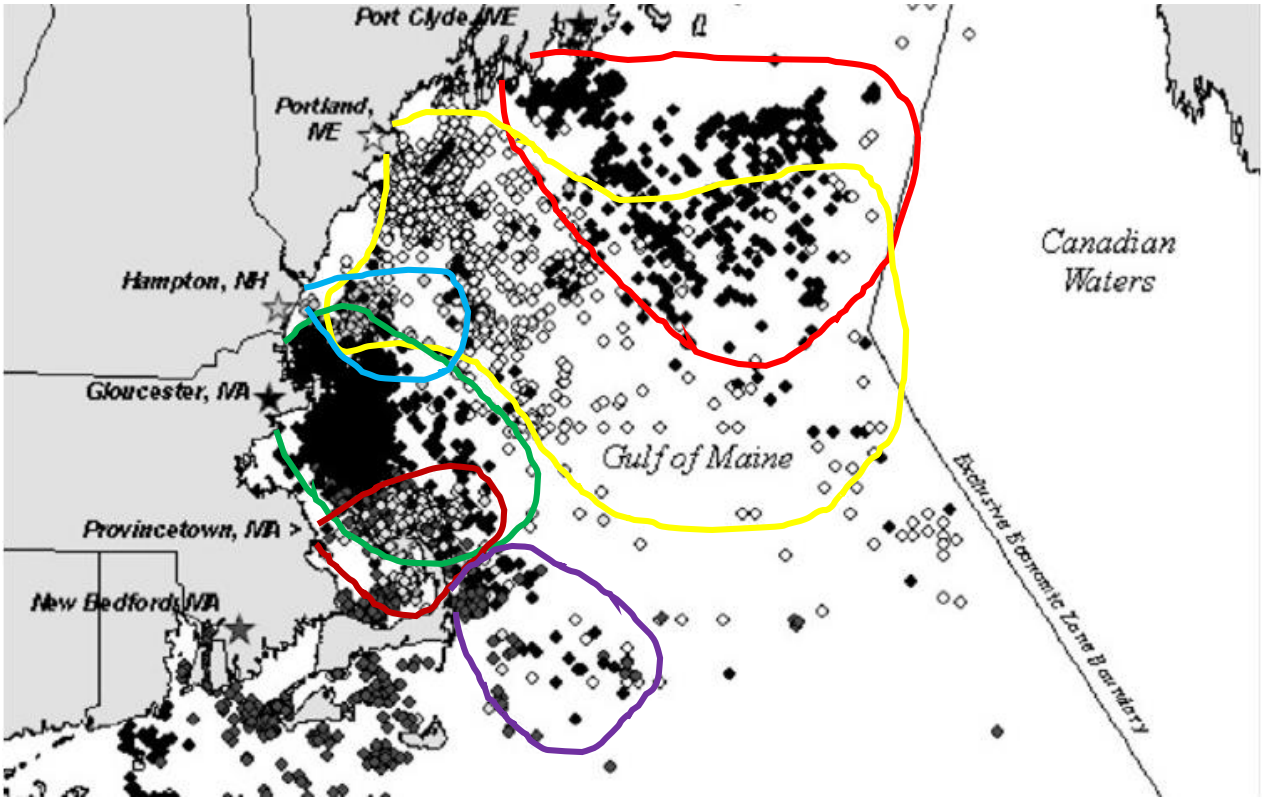


Figure 6: Community resource area mapping example (from St. Martin and Hall-Arber 2008[16]). Trip locations for vessels deploying trawl gear 2002–2004 from six representative ports in the GOM. Trip location color shades correspond to port symbol colors. The rough lines around community resource use areas were drawn by G. Lapointe to highlight primary fishing areas used by fishermen from various ports.

The two mapping approaches, relying on separate data sources and methods, offer two contrasting, valid ways of characterizing commercial fishing activity. The VMS maps show broad geographic use of an area, in addition to showing intensity of use on a low to high scale, using VMS location signals from all permitted groundfish vessels from 2006 to 2014. The community resource area maps show spatial use focused on individual communities or ports based on vessel trip report data from 1996 and subsequent interviews of fishermen in various ports. These community resource area maps are likely also influenced by the number and perspectives of people interviewed.

Comparing ocean characterization using the two methods in selected areas illustrates some of the differences between VMS and CRA mapping. The first example (Figure 7) shows the area from Portsmouth, New Hampshire to Martha's Vineyard (southern extent of Massachusetts)

[16] St. Martin, K. and M. Hall-Arber. 2008. Commercial Fisheries Spatial Characterization, Marine Policy 32 (2008) 779– 786.

and seaward to the east side of the Western Gulf of Maine Closed Area. The community resource use map of this area contains the areas used by fishermen of selected ports, showing the importance of multiple, discrete areas to local fishermen and fishing communities. It clearly shows a more site-specific use pattern than the VMS maps. Relying solely on the community resource use map could lead ocean planners to overlook other areas, in this case those of value to the groundfish fishery. The areas indicated as being use by fishermen are similar between the two maps. The VMS map shows more extensive overall use of the geographic area. This may be due to higher sample sizes including vessels, vessel types, and communities that were not included in the community resource use maps. Additionally, the community resource use maps do not appear to include transit or more lightly used areas.

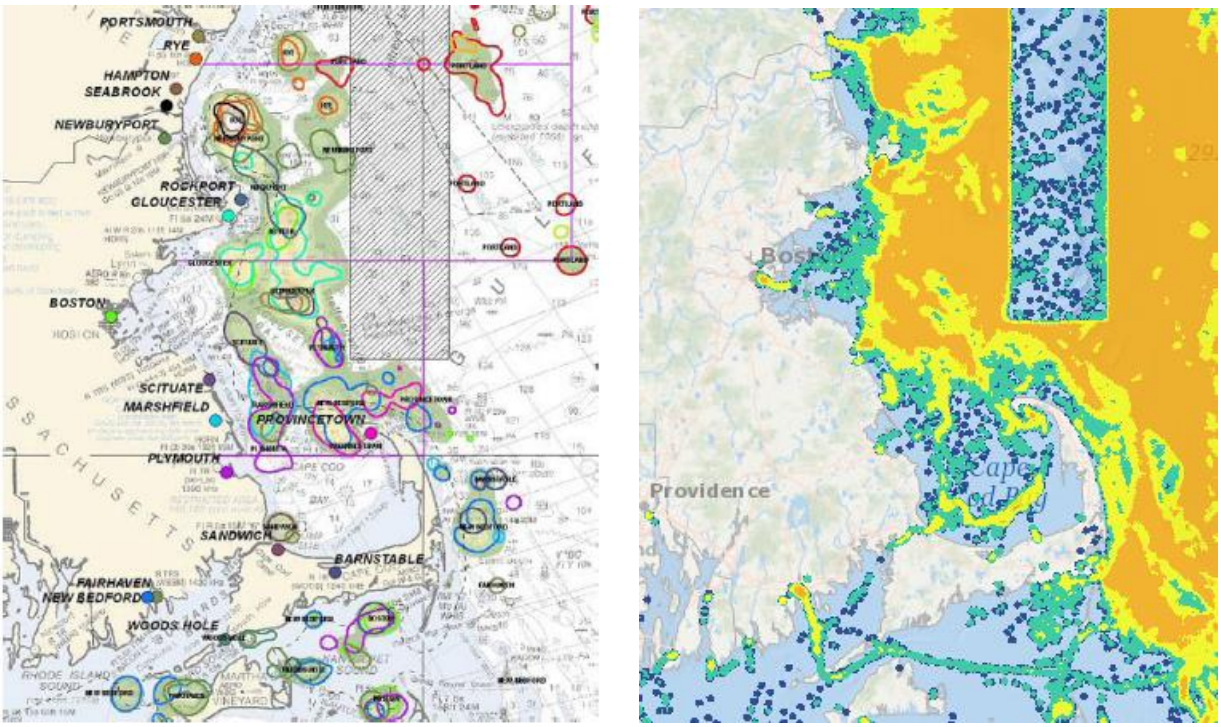


Figure 7: Community resource use map (left) and groundfish VMS map (right) of Portsmouth, NH to Martha's Vineyard area.

Comparison of the two methods in New England and the Mid-Atlantic (Figure 8) shows many similar use patterns, more in Southern New England and New England than in the Mid-Atlantic. The disparity in the Mid-Atlantic is likely because of community resource area mapping picking up fisheries not covered by VMS, most particularly the Mid-Atlantic mixed trawl fleet fishing in the summer flounder, scup, and black sea bass fisheries. Therefore, these maps cover a wider range of fisheries than the VMS maps.

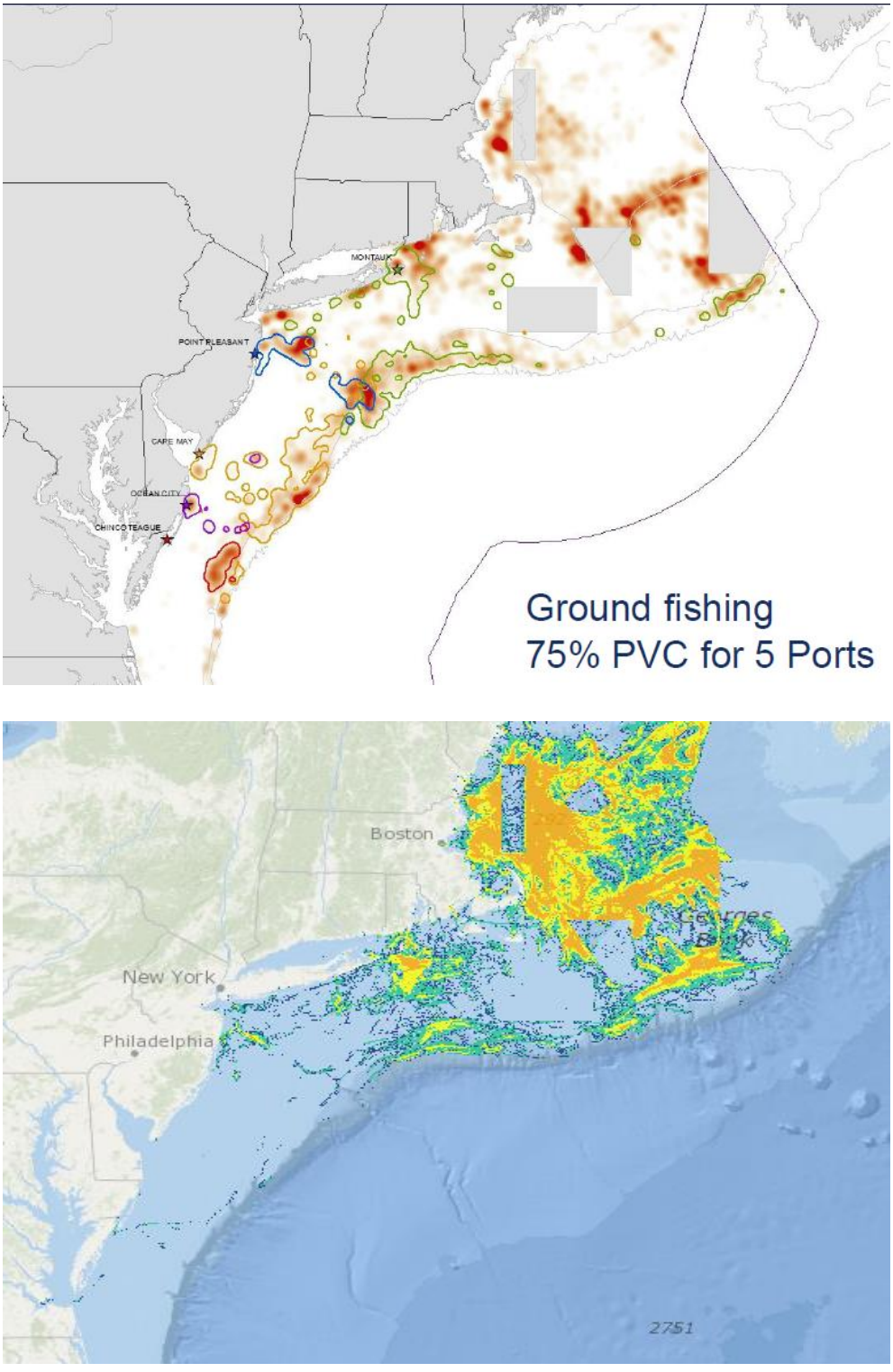


Figure 8: CRA map (above) and groundfish VMS map (below) for New England and Mid-Atlantic. For the CRA, PVC is the percent volume contour. In this case 75% PVC is the contour within which 75% of fishing activity is reported by a group of individuals from a particular community or port.

Visual comparison of VMS maps developed for northeast regional ocean planning and VTR-derived maps of similar fisheries shows much overlap. For groundfish (Figure 9), the VMS map is compared with VTR maps for groundfish vessels less than 65 feet, groundfish vessels over 65 feet and gill net vessels because vessels in these three categories are almost certain to have VMS as well.

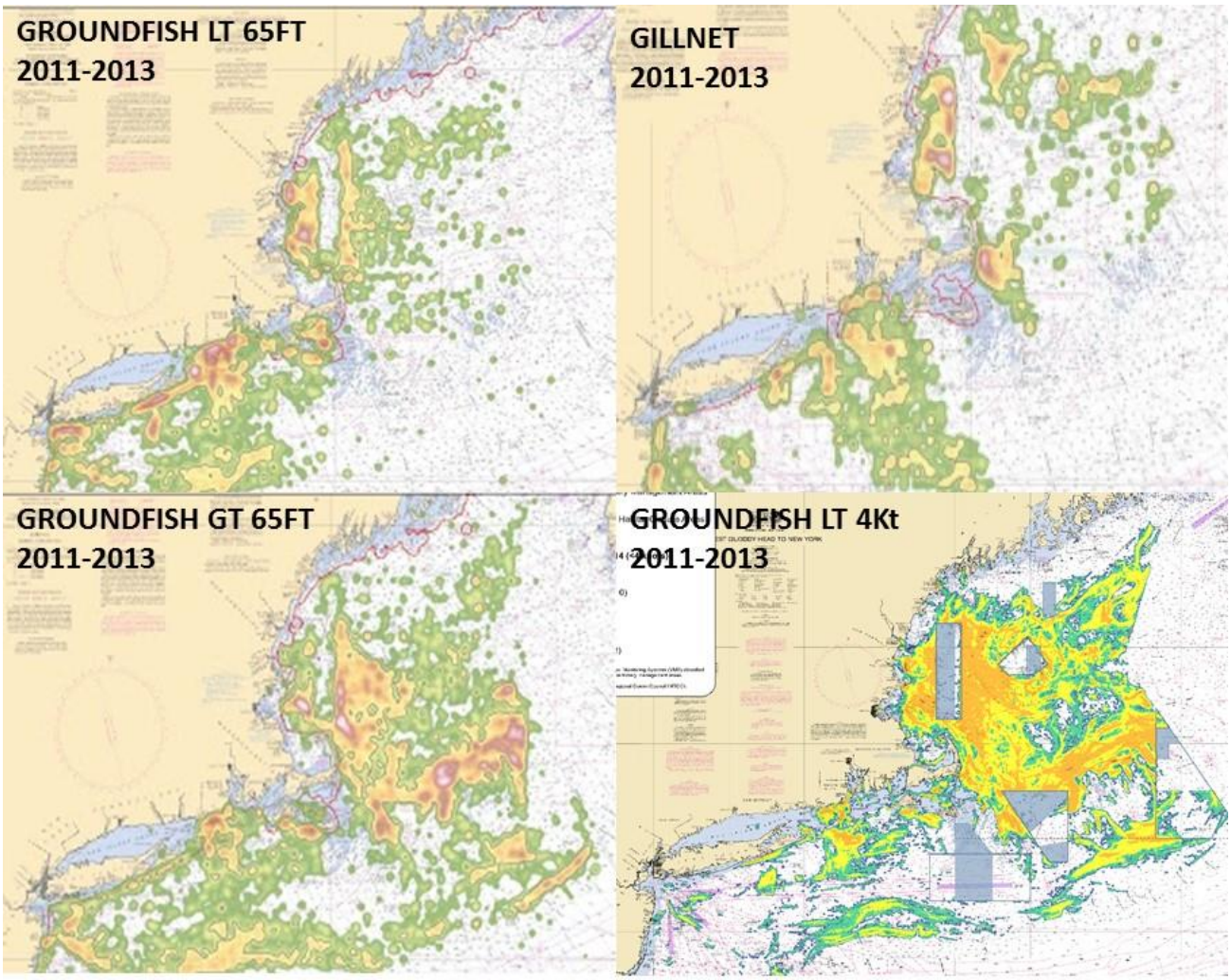


Figure 9: VTR based maps for groundfish less than 65 feet, groundfish over 65 feet, and gillnets with the VMS based map for groundfish. All maps are from 2011-2013.

Differences exist among the various characterizations, but the overall patterns are similar, suggesting that the two techniques could be considered complementary based on the management or ocean planning questions being addressed.

A visual comparison of VMS maps for surfclam/ocean quahog and scallop with the VTR map for dredge activity below also shows similar spatial use patterns (Figure 10). In this case, the VMS

maps show differences in spatial use between the surfclam / ocean quahog and scallop fisheries that are not discernable on the VTR dredge map because both fisheries are combined on the VTR based map.

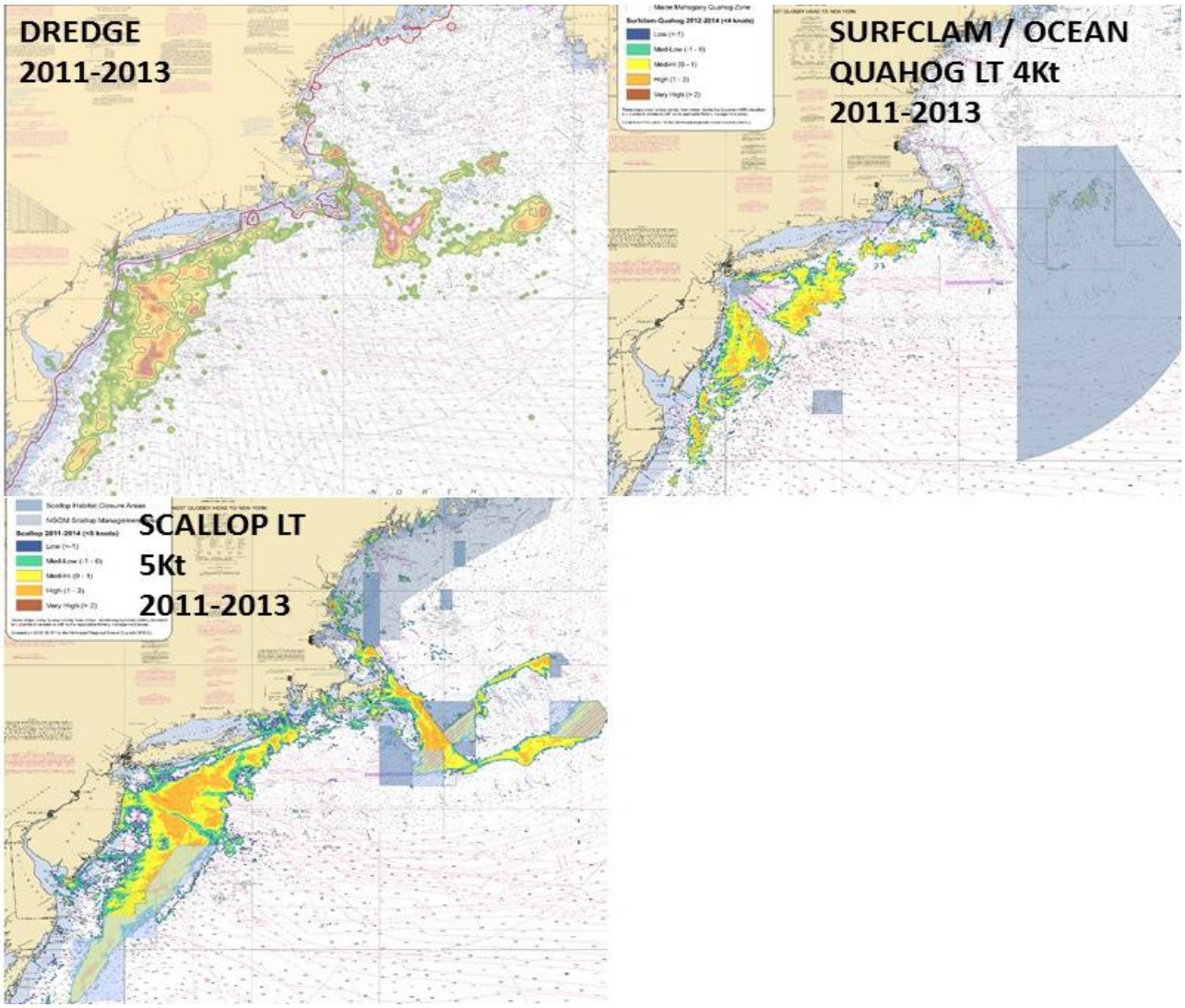


Figure 10: VTR based maps for dredge vessels and VMS based maps for surfclam / ocean quahog and scallops fisheries. All maps are from 2011-2013.

No single available data source accurately captures all necessary information on the myriad commercial fisheries important in New England. Data for ocean planning must rely on multiple data sources, all of which come with some inherent limitations.

Ocean planning should use as many data sources as are readily available to best understand past and current ocean uses when considering new or future uses of the ocean. Region-wide summary data such as this project's VMS maps now provide readily available data to help people better understand certain aspects of the commercial fishery in New England. The VMS

maps provide readily available, region-wide data on when and where specific types of commercial fishing have taken place. They show all vessels in fisheries with VMS requirements and, therefore, provide comprehensive data on a particular fishery. VMS data are separable by fishery, date and time, speed, and other factors[17]. All of these factors can provide useful information to ocean planners and others making use of the northeast regional ocean data portal. As noted previously, VMS maps are limited to certain fisheries and for relatively recent periods of time, from 2006 to the present (2014 for mackerel and squid fisheries).

The CRA mapping done by St. Martin and others, where available, provides a valuable, additional layer of information for ocean planners to better understand past and current ocean uses in a different way by connecting areas fished with home ports[18]. This data can inform project proponents and ocean planners about tradeoffs and impacts associated with new ocean uses. VTR data is available from 1996, giving the CRA maps an additional 10 years of data to use in mapping.

VMS and CRA maps are distinct but complementary because they show ocean areas used by fishermen at both a broad geographic area for VMS maps and at a community or port scale for CRA maps. Regionally, the maps differ based on fishery (VMS) or gear type (CRA). More locally, the CRA maps community or port associations useful to locally relevant projects. Which maps are used for ocean planning will likely depend on the time and resources available for mapping, data availability, and the needs of individual planning or permitting processes.

5. LOBSTER FISHERY MAPPING

Because of the economic and cultural importance of the lobster industry, those involved in coastal and ocean management in New England have been interested in characterizing regional lobster fishing activity in New England[19]. The lobster fishery in New England landed 148 million pounds with a value of $424 million in 2012[20], and is estimated to generate over $1 billion in economic activity annually. There have been several efforts to achieve this in the past (or that attempted to characterize lobster on a smaller scale), including Phase I of this project, which identified a list of sources of spatial information about the lobster industry:

[17] http://www.greateratlantic.fisheries.noaa.gov/vms/forms/vms_declaration_code_glossary.june.2015.pdf (Site access 12/21/2015)

[18] Port listed as home port on vessel permit on file with NMFS

[19] National Marine Fisheries Service. 2014. Fisheries Economics of the United States, 2012. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-137, 175p. Available at: https://www.st.nmfs.noaa.gov/st5/publication/index.html. (Site access 12/21/2015)

[20] National Marine Fisheries Service. 2014. Fisheries Economics of the United States, 2012. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-137, 175p. Available at: https://www.st.nmfs.noaa.gov/st5/publication/index.html. (Site access 12/21/2015)

a. National Marine Fisheries Service Vessel Trip Reports
b. National Marine Fisheries Service map of lobster catch based on Vessel Trip Reports;
c. Mid-Atlantic Regional Council on the Ocean (MARCO) map of lobster catch based on VTRs;
d. National Marine Fisheries Service Protected Species Division map of lobster trap endline[21] densities[22];
e. Keene State/Maine Lobsterman's Association 2012 data on lobster trap density by month;
f. Island Institute's Mapping Working Waters lobster pilot map;
g. New Hampshire lobster reporting data;
h. Massachusetts landings and sea sampling data;
i. Rhode Island landings reports and sea sampling data;
j. Connecticut landings reports and sea sampling data;
k. Fixed Gear Map from the Ocean Special Marine Management Plan process in Rhode Island; and
l. Massachusetts Division of Marine Fisheries data from the Massachusetts Ocean Management Plan.

These data sets cannot be used at a regional scale for regional ocean planning. Data sets (e) to (l) cover only a portion of the region and have varying data collection methods and time periods. These differing data collection and mapping techniques make it inappropriate to combine these data sets into a composite regional lobster fishing spatial characterization map. Data sets and maps (a) to (d) have consistent regional methodologies. Of these, (a) through (c) are based on VTR data. However, these data sources are incomplete; the vast majority of lobster fishermen do not report using vessel trip reports. Rather, they report through state landings reporting systems. Of the lobster fishermen who do report using VTRs, the most prevalent use is offshore which skews the landing patterns depicted in these maps offshore when the bulk of lobster landings are from the nearshore zone. Examples of maps of lobster fishing based on VTR can be found in Appendix D.

For ocean planning purposes, project staff recommend using the NMFS endline survey analysis conducted in 2010 and 2011 (Figure 11), or more current data if the endline survey is updated. The NMFS endline survey was done cooperatively with NMFS and state marine fisheries agencies. Those conducting the survey surveyed lobstermen about the location and number of endlines used in their lobster fishing operations. The endline map provides a surrogate for lobster fishing intensity because of a lack of other data sources. It is important to note that endline numbers do not suggest the same number of traps being fished nor the intensity of fishing or landings by area; there is variation in how gear is fished individually or sub-regionally. However, the strength of the region-wide survey outweighs the variation in endline, trap, and

[21] vertical lines from trap or trawl to buoy

[22] Industrial Economics Inc., Technical Documentation for the Vertical Line Model, March 2014 - NMFS Contract #EA133F-14-NC-0682.

fishery effort. The noted limitations of the endline map are similar to the limitations of all other mapping techniques and should be acknowledged when using any data source. The recommendation to use this map for regional ocean planning purposes was discussed with stakeholders during project outreach meetings and in presentations about the project. This included meetings with the Massachusetts Lobstermen's Association in January 2015, with numerous lobstermen at the 2015 Maine Fishermen's Forum, with state marine fisheries agencies throughout 2015, and with individual lobstermen over the course of the project. No opposition to using this map or suggestions about viable alternatives emerged from these discussions.

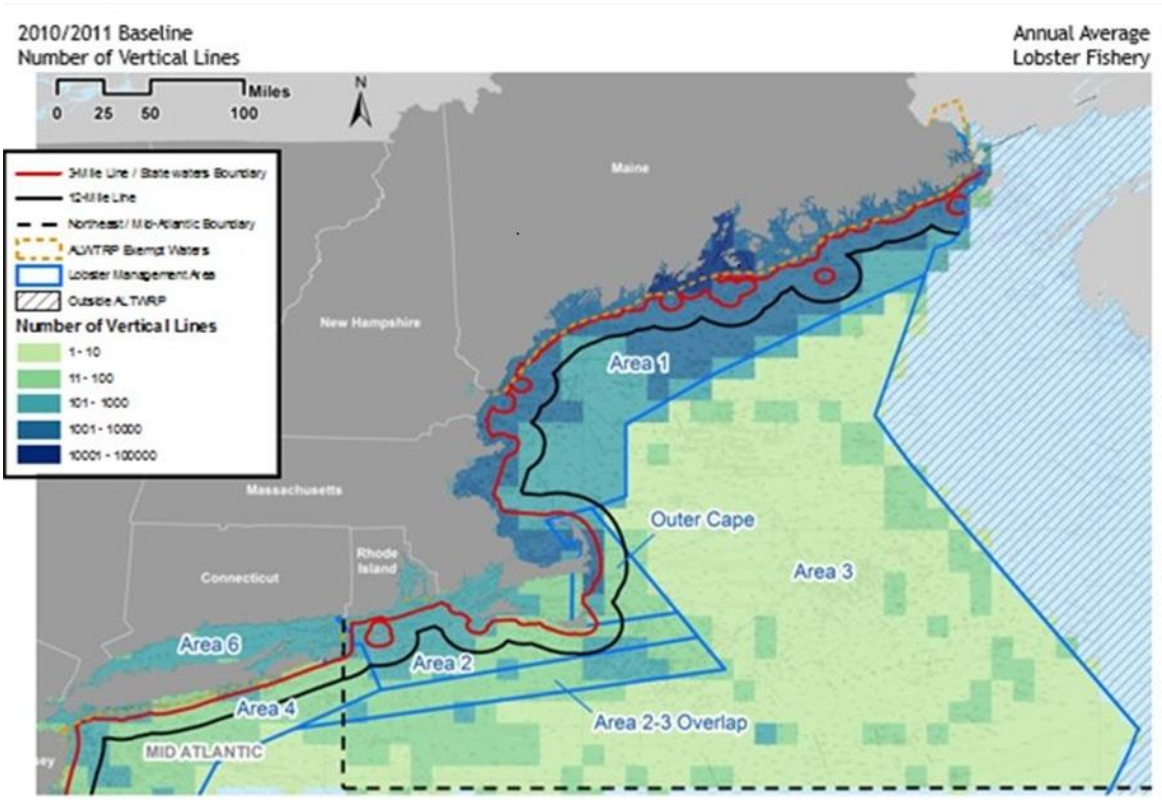


Figure 11: NMFS Endline Survey map. The Northeast / Mid-Atlantic boundary on the map separates year-round sinking ground line use (Northeast) from seasonal sinking ground line use (Mid-Atlantic).[23]

This project originally envisioned a pilot project to determine technologies and programs that might be used to better map lobster fishing activity. There are many location recording or tracking devices and programs that are commercially available that could be used in this or other fisheries. However, the issue for regional mapping of commercial fishing activity isn't one of technology. Rather, the critical issue for mapping is whether the activity is conducted

[23] Industrial Economics Inc., Technical Documentation for the Vertical Line Model, March 2014 - NMFS Contract #EA133F-14-NC-0682.

regionally in a consistent manner and whether enough fishermen throughout the region will use the technologies to accurately represent the fishery geographically. In New England, this would entail getting enough participation from the region's 7500[24] lobster license holders in a way that represented the entire coast and the variety of ways that fishermen pursue the fishery. The amount of work that would be required to conduct this type of mapping of the lobster fishery would be far in excess of what a pilot program could be expected to accomplish. One way to get location reporting would be to have a consistent location reporting requirement on all lobster licenses or permits issued regionally, but significant discussions would be needed to undertake an initiative at this level. Additionally, there would likely be resistance from the lobster industry to additional reporting requirements. However, the most useful maps produced by this project used data from mandatory data collection and/or data reporting systems, e.g. VMS or VTR, put in place as part of fishery management programs.

6. PILOT PROJECT FOR MAPPING SPATIAL USE OF PARTY / CHARTER VESSELS

The party / charter fishery, or for-hire fishery consists of fishermen who take recreational anglers fishing for a fee. The fishery generally consists of charter vessels that take up to six people (the passenger limit for US Coast Guard charter licenses) to fish, and party boats, which can take more passengers than charter vessels. Some boats, called head boats, take in excess of 100 anglers per trip. The New England for-hire sector generated over 1100 jobs and $214 million in sales and value added economic activity in 2012[25]. Even with this economic and recreational value to New England, information on where this fishing activity occurs is either poor or non-existent for a number of reasons. Reporting requirements vary by state and fishery, which means that some charter captains do not have to report fishing location as part of the fishery management process. For federally permitted for-hire vessels, vessel trip reports are a requirement in some fisheries, e.g. groundfish in New England and summer flounder, scup, and black sea bass in the Mid-Atlantic. There is concern that location data for party / charter operators may be filled out imprecisely. This imprecise location reporting was likely due either to captains not understanding the importance of reporting fishing location correctly or mis-reporting.

Because of the importance of this fishing industry and how the for-hire sector could be impacted by ocean planning efforts or specific ocean project proposals, those involved in northeast regional ocean planning have worked on a pilot project to conduct spatial characterization of the party / charter industry. Additionally, spatial use information by the for-hire fleet would be useful for fishery management. Phase I of this project mapped party / charter activity for vessels that were required to report with VTRs. However, as noted above, this information is incomplete and imprecise, and could give viewers an incorrect picture of where party / charter fishing occurs.

[24] License numbers obtained from New England state marine fisheries agencies

[25] http://www.st.nmfs.noaa.gov/Assets/economics/documents/feus/2012/FEUS2012.pdf (Site access 12/23/2015)

This initiative included a component to advance a pilot project begun in 2014 with members of the Rhode Island Party Charter Boat Association in which charter captains used a mobile device electronic landings system, eTrips Mobile, to record location and to allow electronic catch reporting.

In 2015, project staff collaborated with SeaPlan and the Atlantic Coastal Cooperative Statistics Program (ACCSP) to further develop and test a mobile device application that would allow catch and effort reporting and location tracking in the party / charter sector, and could be expanded to other states. The application, eTrips Mobile, was developed by Harborlight Software[26] for ACCSP to allow electronic catch and effort reporting and has been certified as an approved electronic reporting device by the Greater Atlantic Regional Office of the National Marine Fisheries Service.

Project staff sought volunteers to test the eTrips Mobile system in early 2015, and invited individual party / charter captains and party / charter boat associations from Maine to New York to participate. However, party / charter captains and associations in Maine, New Hampshire or Massachusetts were not interested in participating in the pilot project. Captains and managers in these states gave a number of reasons for their lack of interest, including:

- Concern that location information would be used against the captains and organizations in future fishery or ocean permitting, e.g. wind energy, management discussions
- Concern that specific location information would be made public, which could impact individual captains' or organizations' businesses by revealing exact locations of fishing activity
- Time needed to install and learn to use the device / program, and time requirements for ongoing use
- Concern about having another device onboard vessels

Volunteers were found in Southern New England (Figure 12) because of past work done with the Rhode Island Party and Charter Captain's Association and individual project contacts in Rhode Island, Connecticut, and New York. Project staff worked with captains to test the system by providing marinized (water and saltwater resistant) tablets to captains, and training participating captains to use the eTrips mobile system. Because of concerns about data confidentiality, captains were told that their information would not be used publicly without their permission, and that project staff would meet with captains at the end of 2015 to review their individual information and combined information for captains in their respective states. These meetings occurred in Connecticut and Rhode Island in December 2015.

[26] www.harborlightsoftware.com (Site access 12/15/2105)

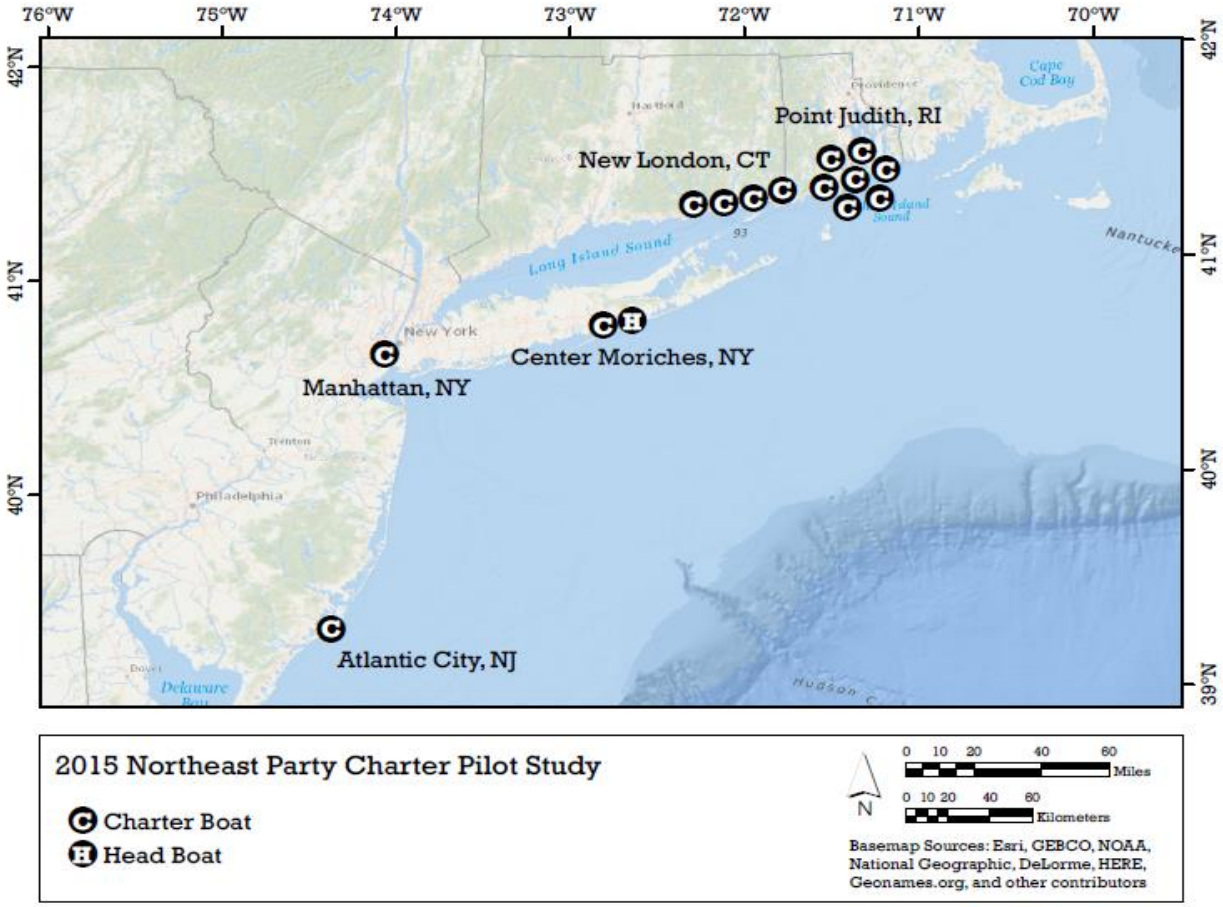


Figure 12: Location of cooperating party / charter and head boat vessels participating in pilot electronic reporting project

The meeting with Connecticut party / charter captains at the end of the season occurred on December 1, 2015 in New London, CT with four captains present. The meeting with Rhode Island party / charter captains occurred on December 10th with five of seven participating captains present. Project staff presented a report to the captains with various map products showing location of fishing activity (transit, trolling, and drift fishing) as well as the catch of various species with different disposition categories[27]. Overall, the captains liked using the system and were interested in using eTrips Mobile in the future. They were very interested in approval of the system by the NMFS Greater Atlantic Regional Office as an electronic reporting system (eVTR) because it would allow them to do their mandatory catch reports electronically[28]. Captains also saw the potential for their spatial use information in ocean planning or project efforts so they could accurately portray how they used the ocean for various types of fishing activity. They gave permission to use the pilot project maps to show

[27] Bait, food, no catch, released alive, too small, reason not specified

[28] eTrips Mobile was certified as an eVTR by the NMFS Greater Atlantic Regional Office in February 2016

how the eTrips mobile system portrayed party / charter fishing with one important exception being the map that showed areas of fishing with catch by species shown on specific locations.

The captains expressed concern that information linking area fished with species and amount caught might be used by others to learn of areas important to the business operations of Connecticut party / charter captains. The concern about this information was not that other party / charter captains would learn about areas but that others, particularly private recreational anglers, would use the information about good fishing locations in a way that could increase space competition at good fishing locations.

The captains at both meetings were comfortable with project staff showing the aggregate trip activity that was segregated by speed of activity (drifting, trolling, transit) for participating Connecticut (Figures 13) and Rhode Island (Figure 14) party / charter captains. These data are displayed in 1km^2 hexagons to generalize location data. For ocean planning and specific project consideration, this spatial use information shows enough detail to take party / charter use into account.

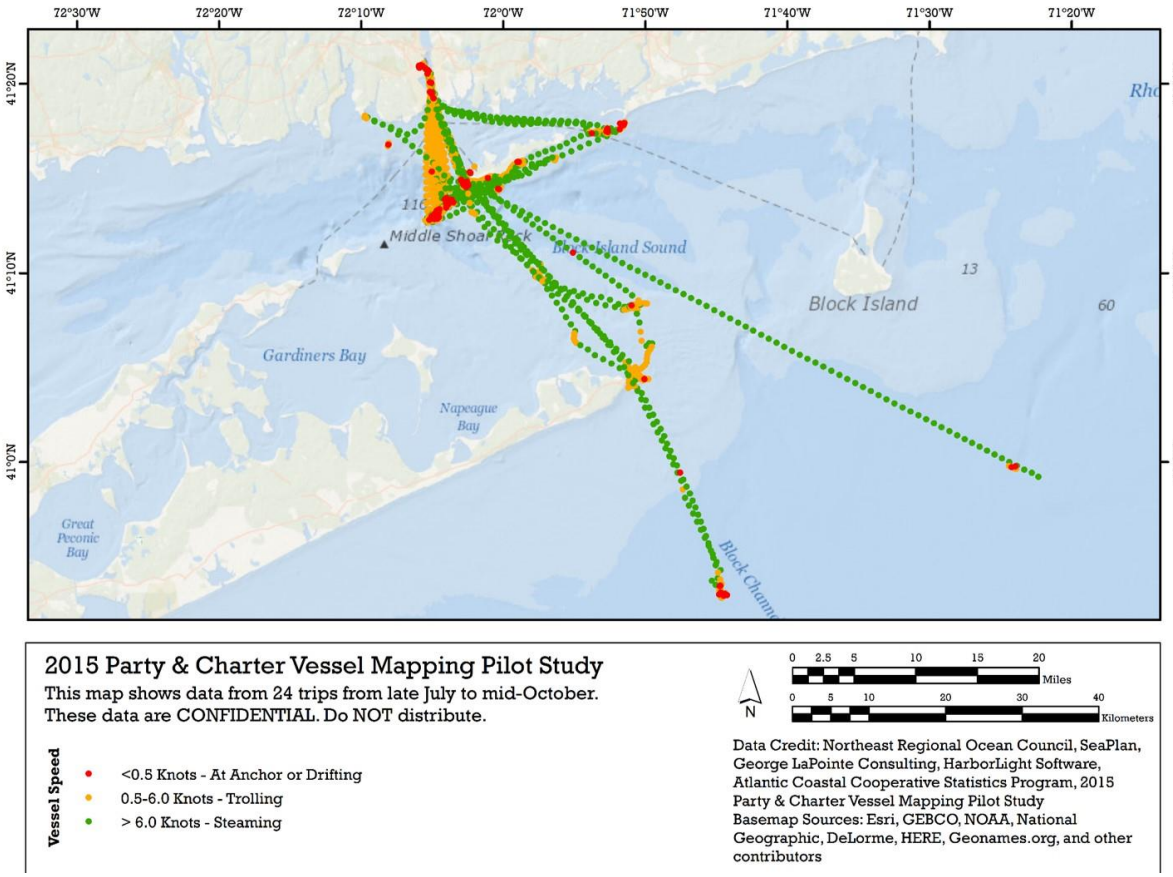


Figure 13: 2015 vessel activity tracks from 24 trips by participating Connecticut party / charter captains.
Map used with permission of participating charter captains.

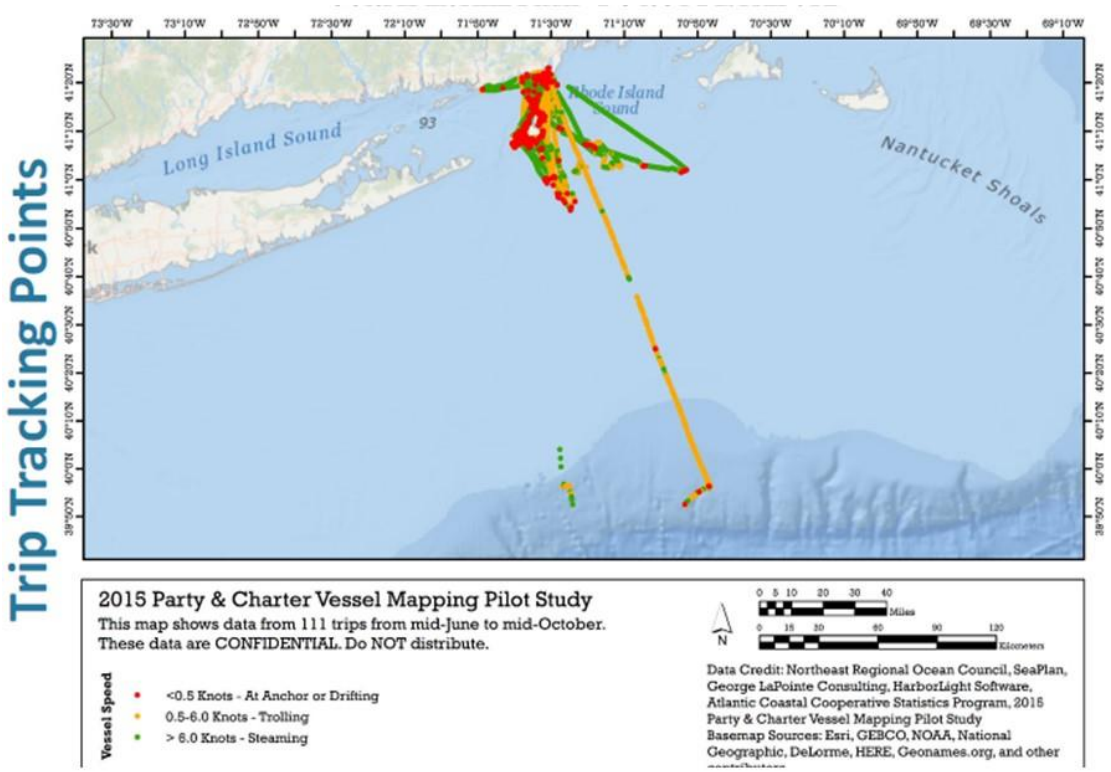


Figure 14: 2015 vessel activity tracks from 24 trips by participating Rhode Island party / charter captains.
Map used with permission of participating charter captains.

The party / charter eTrips Mobile pilot program provided valuable information on how to engage party / charter captains in using this technology, and the potential for using electronic reporting for fisheries management or ocean management discussions. Project staff had the following takeaways.

a. eTrips Mobile works to gather fisheries data

The eTrips Mobile system used in the pilot project was accepted by the participating captains as an effective electronic reporting tool that can provide accurate, timely information on fisheries catch and effort data, as well as tracking location of transit, trolling, and drifting fishing activity for ocean planning. eTrips Mobile is customizable for individual captains to allow favorite species or locations to be saved to make system use easier and more targeted for individual users.

As noted above, eTrips Mobile recorded vessel location accurately. This is important to the objective of being able to characterize spatial use of the ocean by party / charter vessels. This can include exact tracks or as generalized use patterns based on use in larger areas, e.g. 1 Km^2, to address concerns of individual captains about revealing the exact locations fished in their businesses (Figure 15). The location data generated also allows differentiation of party / charter vessels into transit, trolling, drift or anchored fishing based on vessel speed.

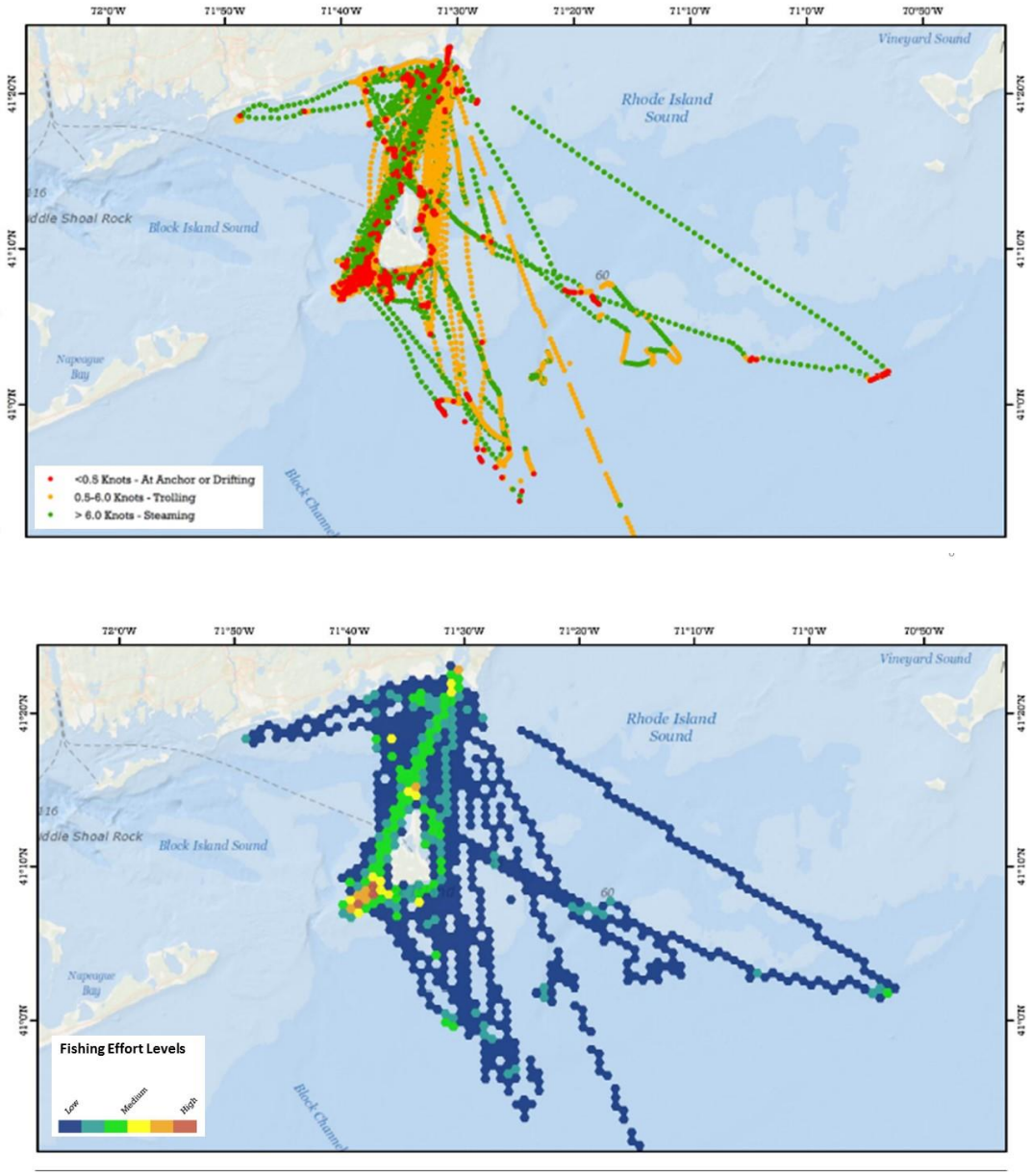


Figure 15: Spatial use patterns of 2015 pilot project participants from Rhode Island (specific data points on top, data points generalized to 1km^2 hexagons on bottom) aggregated data on left, data from one individual on right). Map images used with permission of participating captains.
Maps used with permission of participating charter captains.

The location tracking function of eTrips Mobile is an optional function on the downloadable version of the program, i.e. it can be turned on or off by the user. For the pilot project, the location function was programmed to remain on at all times. This was done with the

permission of project participants to ensure that location tracking data was obtained and to make the system easier for captains to use.

b. eTrips Mobile is scalable to meet project objectives

The eTrips Mobile system can be applied to any number of vessels based on project objectives. It could be used to get localized spatial use information associated with a specific ocean development project. It could also be used to collect fisheries catch and effort, or location data from all vessels in a state, region, or Council management region. Broad-scale use would require significant outreach with affected captains or regulatory changes to achieve enough participation to gather sub-regional or regional use patterns. Broad-scale use also has the potential for getting timely, accurate catch and location information efficiently.

c. The logistics of developing a workable, ongoing eTrips Mobile system are significant

An important lesson from the pilot project is that the amount of work to get the eTrips Mobile system installed and used correctly on individual vessels can be significant. This work includes:

i. Time needed for outreach to secure participants
ii. Installation and training
iii. Trouble shooting
iv. Data review for QA/QC related to individual operators

In the pilot project, project staff spent time with individual captains for training and troubleshooting as well as time with the project team (ACCSP, SeaPlan, Harborlight Software, NROC) to address individual issues that arose with data entry and quality control.

The staffing and time needed to implement an electronic reporting or location tracking system requires a significant investment. It is likely that the level of effort in terms of number of staff and time needed would decline over time as captains and data users became familiar with the system and how to use it.

An alternative to the workload and logistics associated with the eTrips Mobile application would be to use self-contained location tracking devices that gather location data only over some period of time and are subsequently retrieved for location data retrieval. This type of device involves less time in training and operation, which would be an advantage when working with many captains or vessels. There would also be significant logistical needs with this type of system in finding participants, getting units on vessels, ongoing maintenance, and unit retrieval for data downloading. Some disadvantages include monthly operational fees and using a device that is less useful to the party / charter captains because it does not allow them to also conduct their electronic catch reporting.

7. SUGGESTIONS FOR FUTURE WORK

a. Continued updating of VMS maps

As part of the Regional Ocean Plan, a process for ongoing updating of VMS maps could be included to keep the mapping information current and to provide a longer historical context for how spatial use in various fisheries has changed over time. If ongoing updating was done for the fisheries that have been mapped as part of this project, the workload associated with map updating would be minimized because the procedures and decisions already developed could be used to produce maps in an efficient way.

b. VMS maps with gear segregation

Producing maps by gear type could be done with the VMS mapping process developed as part of this mapping project. The NMFS Greater Atlantic Regional Office has information on gear type used as part of a fishing trip[29]. As an example, groundfish spatial patterns could be segregated for fixed vs. mobile gear.

c. Mapping of lobster fishing

The economic importance and broad spatial use of New England waters by the lobster fishery, combined with lack of precise spatial characterization of this fishery suggests that ongoing efforts should be made to better understand how this fishery uses New England waters. Ongoing ocean planning efforts will be hampered by lack of lobster spatial use information and the lobster fishery will likely be put in a defensive posture that would not be so critical if adequate spatial characterization maps were available.

A viable mapping option to map lobster fishing activity for discrete ocean use proposals would be for the project proponent to supply tracking devices to every lobstermen who fishes in the particular area. The tracking devices could be used for a full year, or fishing season, by many lobstermen in the area and would provide a valuable aggregate "footprint" of lobster fishing in the area. This may sound like a logistically challenging project but gathering information on how a particular area is used could provide objective, quantitative information for ocean project proponents and would allow lobstermen to show where local or sub-regional lobster fishing occurs so that this activity is not overlooked because of lack of quantitative information.

[29] http://www.greateratlantic.fisheries.noaa.gov/vms/forms/vms_declaration_code_glossary.june.2015.pdf (Site access 12/21/2015)

d. Party / charter vessel electronic reporting and location tracking

The party / charter electronic reporting and location tracking pilot project demonstrated the potential use of accurate spatial characterization for ocean planning and to protect the interests of party / charter fishermen. There is growing interest in region-wide use of electronic reporting of party / charter fishing activities in the Mid-Atlantic, South Atlantic, and Gulf of Mexico. As these programs expand, regional ocean planning interests should determine whether the location tracking functions of programs such as eTrips Mobile would provide spatial use data not previously available.

This work could be done using generalized location tracking to provide spatial use data for ocean planning but in a way that does not reveal specific location data important to the business operations of party / charter operations.

e. Ongoing coordination with other regional ocean planning efforts and mapping projects

Spatial characterization of commercial fishing activity should be coordinated with other regional planning efforts, mapping projects, and fisheries managers and stakeholders to share successful mapping techniques and coordinate among regional efforts to promote efficiencies of mapping efforts and to promote understanding and comparability among fisheries and regions. This is important because many fisheries are shared between regions such as New England and the Mid-Atlantic. It is confusing, and potentially redundant, to map differently among regions and fisheries without a strong reason for using different, and potentially incomparable, information.