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A comprehensive assessment of baseline recreational fishing effort for highly migratory species in southern New England and the associated Wind Energy Area

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Abbreviations:
BOEM: Bureau of Ocean Energy Management
CTD: conventional tagging data
LPS: Large Pelagics (Intercept) Survey
HMS: highly migratory species
MADMF: Massachusetts Division of Marine Fisheries
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
OCS: outer continental shelf
SAFE: Stock Assessment and Fishery Evaluation
SNE: southern New England
WEA: Wind Energy Area

Disclaimer

The conclusions presented in this report are to be considered those of the authors and do not necessarily reflect the opinions or perspectives of the data providers. All groups that provided tag data were provided a description of how their data would be used at the inception of the study and were updated on the extent to which their data contributed to the analyses and conclusions presented herein. Large Pelagics Intercept Survey data analyzed herein were publicly-available, but NOAA Fisheries does not endorse or assume responsibility for the manner in which they were used in this study.

Citation

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Executive summary

The offshore waters of southern New England (SNE) serve as feeding grounds, migratory corridors, and essential fish habitat for numerous highly migratory species (HMS), such as tunas, billfish, mahi mahi, and sharks. Hundreds of recreational fishing vessels also target HMS at popular SNE fishing areas, including those that occur within and around the federally-designated Rhode Island/Massachusetts and Massachusetts Wind Energy Areas, which are collectively referred to as the "WEA" in this report. To improve our understanding of how recreational fishing activities for HMS may be impacted by offshore wind development, this study collected baseline data on the timing, nature, and extent of recreational fishing effort in SNE by: (1) surveying recreational fishermen from the private and charter/headboat sectors to characterize their fishing effort for HMS in SNE over the past five years, and (2) mining and analyzing both direct and indirect data on recreational fishing effort for HMS in SNE over recent decades.

For (1), a four-question online survey was created and hosted on Survey Monkey from August 23, 2019 to March 15, 2020 (205 days). A total of 171 respondents (136 private anglers, 34 charter/headboat captains, 1 unknown category) reported using mobile fishing tactics (e.g., trolling, drifting) to target several HMS, particularly bluefin tuna and mahi mahi, in SNE on an average of 37 – 65 days per year (range: 1 – 190 days per year). Respondents exerted effort throughout SNE with the highest amount occurring at fishing areas locally known as Coxes Ledge, The Dump, The Lanes, The Fingers, and The Claw. Within the WEA, the highest amount of effort was exerted at Coxes Ledge, The Fingers, and The Claw. For (2), fisheries-dependent data in the form of responses to the National Marine Fisheries Service Large Pelagics Intercept Survey (LPS) and conventional tagging data (CTD) provided by four sources were compiled and analyzed over a 36 (W) by 28 (H) cell grid (referred to as the "SNE grid") to directly and indirectly characterize recreational fishing effort for HMS in SNE. LPS data from 2002 – 2018 documented 2,393 directed recreational trips and 16,760 catch records for 22 HMS in the SNE grid; 290 trips and 2,281 catch records for 13 HMS occurred within the WEA. 'Sharks' and 'tunas' were the primary species complexes targeted; shortfin mako and bluefin tuna were the most commonly-targeted HMS. Data from 53,991 conventional tagging events within the SNE grid were compiled from 1954 – 2019, 10,548 of which occurred within the WEA. A total of 12,537 and 2,313 tagging events occurred from 2002 – 2018 in the SNE grid and WEA, respectively. The majority of tagging events were of blue sharks (~70%) and bluefin tuna (~20%).

Together, fisheries-dependent data indicated that recreational effort for HMS is widespread in SNE from June to October (peaking June to September) and is primarily focused to the west of the WEA in the waters south and east of Montauk Point and Block Island. Within Vineyard Wind lease areas (OCS-A 0501 and OCS-A 0522), the available data indicated that recreational fishermen primarily target bluefin tuna, shortfin mako, and 'any tuna species', with trips originating primarily from Massachusetts and Rhode Island. Lease area OCS-A 0501 experienced 0.75 – 5.13% of total effort

in the SNE grid and 6.21 – 27.80% of total effort within the WEA, while comparatively less effort was exerted in OCS-A 0522 (0.08 – 0.36% of all effort in the SNE grid and 0.69 – 2.63% of all effort within the WEA). Combined effort in the two leases represented 0.84 – 5.20% of all effort in the SNE grid and 6.90 – 28.19% of all effort within the WEA. Effort in OCS-A 0501 is concentrated near the 31 Fathom Hole and Gordon's Gully; effort in OCS-A 0522 is sporadic. Additional work is required to assess potential impacts from offshore wind energy development on recreational fishing for HMS; this report is not intended to imply that such development will preclude future recreational fishing activity in the SNE WEA.

Background and justification

The offshore waters of southern New England (SNE) have long supported populations of highly migratory fish species (HMS; e.g., tunas, billfish, mahi mahi, sharks) and many fisheries that target them. In addition to serving as a migratory corridor for numerous HMS (Galuardi and Lutcavage, 2012; Vaudo et al., 2016; Kohler and Turner, 2019), SNE is ecologically-important and contains Essential Fish Habitat (i.e., the waters and substrate necessary for spawning, feeding, and growth to maturity) for at least 13 HMS including albacore (*Thunnus alalunga*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), common thresher shark (*Alopias vulpinus*), porbeagle (*Lamna nasus*), white shark (*Carcharodon carcharias*), dusky shark (*Carcharhinus obscurus*), sandbar shark (*Carcharhinus plumbeus*), tiger shark (*Galeocerdo cuvier*), and sand tiger (*Carcharias taurus*) (NMFS, 2015). SNE also contains historical fishing grounds for iconic species such as swordfish (*Xiphias gladius*), bluefin tuna, white marlin (*Kajikia albida*), and shortfin mako, and supports an extensive contemporary recreational fishery for HMS in which hundreds of vessels participate each year. Of interest, a proportion of this recreational fishing effort for HMS occurs within popular fishing areas that have been leased for offshore wind development.

With the recent prospect of wind energy development in SNE, considerable effort has been directed at collecting baseline (i.e., pre-construction) data to assess the potential impact of wind infrastructure development on common fish species (e.g., Atlantic cod, *Gadus morhua*) and the local fisheries that target them. However, to date little attention has been paid to the potential impacts on HMS and the recreational fishery they support within the Rhode Island/Massachusetts and Massachusetts Wind Energy Areas (Figure 1), which are collectively referred to as the "WEA" in this report. For example, scientists and fishery managers do not know whether turbine presence will affect the residency or movements of HMS in the WEA, whether HMS foraging success will be impacted, or if HMS will be completely displaced from the WEA due to pre-construction surveying, turbine construction, turbine operation, or electromagnetic fields generated during operation (MADMF Research Priorities White Paper, November 2018). There is also an incomplete understanding of how offshore wind development will impact recreational fishing activities (i.e., fishing methods), including the extent to which fishing effort may be disrupted due to the displacement of target species or fishing vessels from popular areas that fall within the WEA (MADMF Research Priorities White Paper, November 2018). To complicate matters, many recreational fishermen do not seem to be aware of how wind energy development will affect the HMS fishery due to a poor understanding of the extent of planned development (e.g., the number of turbines and grid spacing), and an uncertainty over how that development will affect HMS distribution/availability and their ability to fish (J. Kneebone, personal observation). In light of these knowledge gaps and uncertainties, it is apparent that increased research efforts are needed to better understand HMS and recreational fisheries for HMS in SNE and to collect baseline data that will serve as the foundation for monitoring the incidental impacts of wind energy development.

Objectives

To begin to fill the aforementioned data gaps, the objectives of this project were to compile existing fisheries-dependent data and to engage with members of the recreational HMS fishing community to document the nature, extent, and magnitude of the recreational fishery for HMS in and around the SNE WEA in both space and time. To accomplish this, we followed a two-pronged approach that included: (1) surveying members of the recreational HMS fishing community representing the private and charter/headboat sectors to characterize their fishing effort in SNE over the past five years; and (2) mining and analyzing direct and indirect data on recreational fishing effort for HMS in SNE over recent decades.

Methods

Online survey

Survey design

To better understand the nature and extent of recreational fishing for HMS in and around the SNE WEA over the past five years, an online survey was developed and hosted live on Survey Monkey from August 23, 2019 to March 15, 2020 (205 days). Hyperlinks to the survey were disseminated via several mechanisms including a webpage on the Vineyard Wind website, direct email communications, posts on online fishing discussion boards/forums, social media posts, blogs on the New England Aquarium Anderson Cabot Center for Ocean Life website, and an advertisement on the *On the Water Magazine* website (www.onthewater.com). For the purposes of this survey, HMS included several popular and commonly-caught pelagic species including: bluefin tuna, yellowfin tuna, albacore, mahi mahi (*Coryphaena hippurus*), white marlin, wahoo (*Acanthocybium solandri*), and 'sharks', which included shortfin mako, blue shark, common thresher shark, porbeagle, tiger shark, and smooth hammerhead (*Sphyrna zygaena*). The survey consisted of four questions (Table 1) aimed at (Q1) quantifying the amount of annual effort exerted by recreational fishermen when targeting HMS at specific fishing areas in SNE (Figure 1), (Q2) documenting the HMS most commonly targeted by the recreational fleet, (Q3) documenting the fishing methods used to target HMS, and (Q4) establishing differences in effort between the private (i.e., recreational anglers holding a federal HMS angling category permit) and charter/headboat (i.e., federal HMS charter/headboat permit holders) sectors. Note that in Q3, 'casting/run and gun' refers to the tactic/method during which fishermen actively travel over large expanses of ocean while looking for signs of schools of fish feeding on the surface to which baits/lures are casted.

Analysis

At the close of the survey, individual responses were downloaded and the IP address of each respondent was reviewed to identify duplicate records (from a single IP address). Multiple responses were obtained from three IP addresses, including two IP addresses that responded twice, and one IP address that responded three times. However, none of the responses were duplicative; each response provided different answers to each of the four questions. Duplicative responses also appeared to be honest and did not appear to be attempts to artificially increase the apparent effort (e.g., the selection of the maximum amount of effort at each fishing area named in Q1; see below). Given this, all records were assumed to be independent and were retained for analysis.

All individual responses were then pooled and tabulated to quantify fishing effort by location/fishing area (Q1) and to characterize the nature of the fishery. In Q1, respondents were provided the option to select a category of effort (Table 1) for several popular recreational fishing areas both within and outside the WEA. Thus, to conservatively estimate the total number of days fished in each area in a typical year, the minimum number of days in each selected category (i.e., 1 – 2 = 1 day, 3 – 4 days = 3 days, 5 – 6 days = 5 days, 7 – 10 = 7 days, >10 days = 10 days) were summed for each fishing area and for each respondent. Although '0 days' was provided as an option to signify 'no effort', many respondents did not select any effort category for multiple fishing areas. Thus, in any instance wherein no category was selected, it was assumed to also be an indicator of no effort (i.e., a '0 days' response). Bubble frequency and histogram plots were constructed to illustrate relative effort between the fishing areas listed in Q1/Figure 1 by sector. Responses to Q2, Q3, and Q4 were tabulated and plotted to identify trends in target species, fishing method, and permit category/fishery sector.

To roughly estimate the extent to which our online survey reached the recreational HMS fishing community in SNE, the percentage of HMS permit holders in the region who responded to the survey was estimated using data on 2018 permit sales provided in the 2018 NOAA Fisheries HMS Stock Assessment and Fishery Evaluation (SAFE) report (NMFS, 2019). First, the total number of permits sold in 2018 was estimated for each category/sector (angling and charter/headboat) by summing the total permit sales (by state of origin) in Massachusetts, Rhode Island, Connecticut, and New York. These four states represent the points of origin for the majority of trips monitored in SNE by the National Marine Fisheries Service (NMFS) Large Pelagics Intercept Survey (herein defined as LPS; see Results) and, therefore, best approximates the potential pool of respondents. The number of survey respondents was then divided by the total number of federal HMS permit holders from these states to estimate the percentage of permit holders, in each sector/category and over both sectors/categories, that took the survey.

<u>Fisheries-dependent data compilation and analysis</u>

To generate a comprehensive assessment of the historical and contemporary recreational fishing effort for HMS in and around the SNE WEA, fisheries-dependent data that represent both direct and indirect indicators of recreational fishing effort were obtained from multiple sources. Data were obtained from both public (e.g., NOAA) and private sources, and permission to use the available data in the manner described herein was requested and granted from the provider.

NMFS/QuanTech Large Pelagics Intercept Survey (LPS)

Direct data on recreational fishing effort for HMS in SNE was obtained by downloading publicly-available records generated by the LPS. The LPS was established in 1992 by the NMFS and is a seasonal (June through October) dockside survey of fishing access sites designed to collect monthly information about catch data from private and charterboat captains who participate in the recreational fishery directed at large pelagic species (tunas, billfishes, swordfish, sharks, wahoo, and dolphinfish; i.e., HMS) in the offshore waters from Maine through Virginia. The LPS is managed and executed by the Fisheries Research Group of QuanTech Inc. (Rockville, MD), and collects detailed information on recreational effort and catch for the estimation of total recreational catch by species. For this analysis, data from the LPS were used to investigate the number of recreational trips and total recreational catch in SNE, including within the WEA, from 2002 – 2018; data are only publicly-available during this time period. Data sourced from the LPS included trip level information on: the date (month and year) of the trip, the state and county where the intercept survey occurred (i.e., the port of origin for the trip), the reported fishing location (latitude-longitude coordinates), the target species, and the reported catch by species.

Conventional tagging data (CTD)

To supplement the effort data obtained from the LPS, historical records representing conventional tagging events of HMS occurring solely aboard recreational vessels using rod and reel were compiled from several groups/entities that maintain active volunteer tagging programs in the U.S. Atlantic. Those groups included the NMFS Cooperative Shark Tagging Program (Apex Predators Program), NMFS Southeast Fisheries Science Center Cooperative Tagging Center, The Billfish Foundation, and the American Littoral Society. Although conventional tagging data cannot be used as a direct measure of fishing effort, for this analysis it was assumed that a tagging event was an indirect indicator of effort since the tagged fish had to have been caught, tagged, and released by a recreational (rod and reel) angler during a fishing trip. Following this logic, the compilation of CTD (originating from the recreational sector) serves as a reasonable indirect proxy for fishing effort (i.e., the location of effort and catch) in both space and time; CTD records were not used to estimate the number of trips occurring in SNE in space and time. Information requested from CTD suppliers included metadata for each tagging event: the date of tagging, the species tagged, and the location of tagging (latitude longitude).

Analysis

All fisheries-dependent data available from the LPS and CTD sources, although assumed to have already been examined for quality control by their provider, were filtered for inaccuracies or duplicate records. For instance, provided locations from records that intersected with inland portions of U.S. Atlantic states were removed. Entries among CTD sources were also filtered for duplicate records according to species, year and month of capture, and location (latitude-longitude coordinates), to prevent artificially increasing sample size and indirect proxies of fishing effort.

Given the project's objectives and geographic area of interest, fisheries-dependent data were aggregated over a 36 (W) by 28 (H) cell grid (cell dimension: 4.8 km width, 4.8 km height; total cells = 1,008) spanning Montauk, New York to Nantucket, Massachusetts, that is henceforth referred to as the "SNE grid" (Figure 2). The cells in the grid exactly match the Bureau of Ocean Energy Management (BOEM) Outer Continental Shelf (OCS) lease blocks established in the SNE region. LPS trip level data and CTD records were subsequently analyzed over this grid to characterize effort and catch data over all cells and those cells within the WEA.

To cohesively analyze large amounts of complex data from two sources, LPS and CTD records were subsetted into spatial (i.e., within the SNE grid and within the WEA) and temporal (i.e., entire time series of each data source vs. overlapping years from 2002 – 2018) groups. Further divisions were established to investigate recreational activity for specific groups of HMS, including all categories of bluefin tuna (e.g., school bluefin, large/medium bluefin, giant bluefin), all sharks, and all tropical pelagics (Table 2), as well as the combination of these groups (i.e., 'all HMS'). Species groupings were created based in part on preliminary information gathered on target species by the online survey and similarities in fishing methods used to capture groups of HMS. For example, recreational fishermen typically target all sharks by drift fishing and tropical pelagics by trolling. Thus, grouping the species in this manner allows for both an assessment of spatial trends in locations where species are targeted/caught and the fishing method used to capture them.

Upon subsetting, data were tabulated and summary statistics were calculated to better describe the nature of the fishery. To document the HMS targeted by recreational fishermen in the SNE grid and WEA, the number of trips targeting each species and species groups was calculated from LPS trip level data. The port (state) of origin for all trips that occurred both within the SNE grid and WEA was also summarized. The number of observations of each species and species group recorded by the LPS (catch) and CTD (tagging events) was also summarized both within the SNE grid and the WEA. To examine the location of HMS fishing effort on a finer scale, the location (latitude-longitude coordinates) of each LPS trip and CTD record was interpolated onto the aforementioned SNE grid to examine total effort (LPS: number of trips and total catch; CTD: number of tagging events) by grid cell. Interpolation (rather than plotting raw locations) was necessary due to data confidentiality requirements of some of the data providers. Interpolations

were completed for the aforementioned spatial, temporal, and species-specific groupings and were plotted to compare the relative amount of recreational fishing effort for HMS throughout the SNE grid and WEA. Because the number of interpolated records in each cell differed greatly over space and time and by species, natural jenks (or jenks natural breaks) were used to establish a four-level ordinal scale for interpreting relative levels of fishing effort. All analyses were performed in the R Statistical Environment (version 3.6.2; R Core Team, 2019). Plots were generated using R and QGIS (version 3.8).

Results

Online survey

Respondents

A total of 171 respondents took the online survey, 170 (99.4%) of which answered all four questions. One respondent only answered Q2 and Q3, testifying to targeting bluefin tuna by trolling. Data from this respondent were therefore tabulated only to assess target species (Q2) and fishing method (Q3) but were excluded from consideration in effort calculations by sector (e.g., Q1 and Q4). The survey took roughly 2 minutes and 15 seconds to complete and 100% of the respondents who opened the survey link completed the survey (i.e., answered at least two questions and submitted their response).

Effort

Respondents included 136 angling category permit holders, 34 charter/headboat permit holders, and one respondent who did not indicate which permit they held (Table 3). Over the past five years, respondents testified to actively fishing for HMS in SNE from 1 to 190 days per year with a total of 7,185 days of effort (solely from respondents) occurring in the region on a typical annual basis. On average, respondents holding a charter/headboat permit testified to exerting ~1.75X more effort than private recreational anglers holding angling category permits. Respondents testified to targeting several HMS in SNE, with bluefin tuna and mahi mahi being the primary and secondary target species, respectively, for both permit categories/sectors (Figure 3). Respondents also reported using mobile (e.g., trolling, drifting, casting) and stationary (e.g., anchoring) tactics to target HMS; all respondents used at least one mobile method to target HMS in SNE (Figure 4).

Survey respondents testified to fishing within all of the named areas listed in Figure 1, as well as in non-named areas both inside and outside of the WEA (Figures 5 – 9). In the broader SNE region, the highest amount of effort was reported to occur at Coxes Ledge, The Dump, The Lanes, The Fingers, and The Claw. Within the WEA, the highest amount of effort was exerted at Coxes Ledge,

The Fingers, and The Claw. A large amount of effort was also reported in non-named areas both within and outside the WEA. In general, the areas experiencing the highest amount of effort were similar for fishermen holding angling category and charter/headboat category permits.

Survey coverage

According to the 2018 NMFS HMS SAFE report, there were 6,423 HMS permit holders (5,276 angling category and 1,147 charter/headboat category) from Massachusetts, Rhode Island, Connecticut, and New York in 2018 (Table 4). Thus, the respondents of this survey (n = 171) represent 2.65% of all federal HMS permit holders in the SNE region. Similar coverage was calculated for both the private (angling category; 2.58%) and charter/headboat (2.96%) sectors. It is important to note, however, that these percentages do not consider the number of HMS permit holders who are active participants in the SNE recreational fishery for HMS. In other words, just because a vessel held a federal HMS permit in a New England state does not mean that they normally participate in the recreational fishery for HMS in SNE. The percentages estimated herein should therefore be interpreted as minimum survey coverage rates.

Fisheries-dependent data

LPS

Between 2002 and 2018, 2,393 directed recreational trips for HMS were documented within the SNE grid area, 290 (12%) of which occurred within the WEA (Table 5). Effort occurred from June to October, with a peak in July and August (Figure 10). Trips with fishing effort occurring in the SNE grid originated from seven states, with the greatest amount of effort exerted by fishermen from New York, Rhode Island, Massachusetts, and Connecticut. Trips with effort occurring in the WEA originated from five states; >99% of the total effort originated from Connecticut, New York, Rhode Island, and Massachusetts. By state, Rhode Island, New York, and Massachusetts logged the largest percentage of trips in the WEA.

Fishermen responding to the LPS testified to targeting numerous HMS and HMS complexes/groups in the SNE grid and WEA (Table 6). Sharks and tunas were the primary species complexes targeted, and shortfin mako and bluefin tuna were the two most commonly targeted species in both the SNE grid and WEA. Catch data originating from the 2,393 LPS-documented trips occurring in the SNE grid included 16,760 records for 22 HMS (Table 7). Within the WEA, 2,281 catch records from 13 HMS were available (Table 7). In order, blue shark, bluefin tuna, mahi mahi, and shortfin mako were the four most commonly captured HMS in both the SNE grid and WEA. Yearly trends in LPS trip and catch counts within the SNE grid and WEA by species groups are presented in Figures 11 & 12.

Interpolation of LPS effort data (i.e., number of trips and total catch) onto the SNE grid revealed areas of high recreational fishing effort for HMS throughout the region over the period of 2002 – 2018 (Figures 13 – 16). In general, the greatest amount of recreational fishing effort for HMS occurred to the west of the WEA in the waters south and east of Montauk Point (NY) and Block Island (RI). A large amount of fishing effort for all HMS also occurred in The Dump. Within the WEA, effort for all HMS was greatest at Coxes Ledge, The Fingers, and The Claw.

CTD

Data from 53,991 conventional tagging events of 18 HMS were compiled within the SNE grid over the period of 1954 – 2019, including 10,548 tagging events of 14 HMS that occurred within the WEA (Table 7). During the period that LPS data were also available (2002 – 2018), a total of 12,537 and 2,313 tagging events for 16 and 7 HMS occurred in the SNE grid and WEA, respectively. From 2002 – 2018, tagging effort occurred from March to November, with markedly higher effort from June to October and a peak from June to August (Figure 10). Only nine tagging events occurred during the months of March (n = 2), April (n = 4), May (n = 2), and November (n = 1). The vast majority of tagging events in the SNE grid and WEA over both the full and truncated time periods were of blue sharks, which represented ~70% of all tagging events. Bluefin tuna were the second most commonly tagged species in the SNE grid and WEA, representing 16.5 – 22.4% of all tagging events. Yearly trends in CTD tagging events within the SNE grid and WEA by species groups are presented in Figures 17 & 18.

Interpolation of CTD rod and reel tagging events onto the SNE grid revealed widespread recreational effort for HMS with several areas of concentrated effort emerging over the periods of 1954 – 2019 and 2002 – 2018 (Figures 19 – 22). In general, the greatest amount of recreational effort for HMS occurred to the west of the WEA in the waters south and east of Montauk Point (NY) and Block Island (RI). A large amount of tagging effort for all HMS also occurred in The Dump. Within the WEA, effort was greatest at Coxes Ledge, The Fingers, and The Claw. The geographic extent of tagging effort, including areas of high activity, was also generally consistent between historical (i.e., full time series) and more recent (i.e., 2002 – 2018) periods, with the exception of the tropical pelagics group which experienced no tagging effort in the WEA in recent years (Figure 21).

Vineyard Wind lease areas (OCS-A 0501 & OCS-A 0522)

To better illustrate the nature, extent, location, and magnitude of recreational fishing effort in the Vineyard Wind lease areas (OCS-A 0501, OCS-A 0522), LPS and CTD records were summarized for each lease (Table 8). Recreational fishermen responding to the LPS testified to targeting bluefin tuna, shortfin mako, and ‘any tuna species’ in the two lease areas, with trips originating from Massachusetts and Rhode Island. LPS catch and CTD records indicated that 12 species of HMS

were captured in the two lease areas, with bluefin tuna and blue shark being the most commonly captured species. Lease area OCS-A 0501 experienced higher effort than OCS-A 0522 over all metrics/categories. Based on the LPS and CTD, lease area OCS-A 0501 experienced 0.75 – 5.13% of all effort in the SNE grid and 6.21 – 27.80% of all effort within the WEA, while comparatively less effort was exerted in OCS-A 0522 (0.08 – 0.36% of all effort in the SNE grid and 0.69 – 2.63% of all effort within the WEA) (Table 9). Combined effort in the two leases represented 0.84 – 5.20% of all effort in the SNE grid and 6.90 – 28.19% of all effort within the WEA.

Interpolation of the location of LPS and CTD records indicated that recreational fishing effort for HMS occurs throughout all of lease area OCS-A 0501 and in a portion of lease area OCS-A 0522 (Figures 23 – 26). Within OCS-A 0501, effort appears to be concentrated in two areas, near the 31 Fathom Hole (and northeast corner of The Dump) in the southwest extent of the lease, and near Gordon's Gully in the northeast extent of the lease. This general trend was evident with respect to effort for bluefin tuna and all sharks, with little to no effort for tropical pelagics occurring in this region from 2002 – 2018 (Figure 25). Of note, considerable historical fishing effort for tropical pelagics, primarily white marlin, occurred northeast of lease OCS-A 0501, but this effort has curtailed recently potentially as a result of the demise of local billfish tournaments operating out of Martha's Vineyard and Nantucket (Skomal and Chisholm, 2011; Greg Skomal, Massachusetts Division of Marine Fisheries, personal communication). Limited and sporadic recreational effort for HMS appears to occur in lease OCS-A 0522.

Synthesis and conclusions

By combining the human dimension and complimentary fisheries-dependent data from two sources, this report provides a comprehensive, baseline assessment of the timing, nature, and extent of recreational fishing effort for HMS in SNE and the associated WEA over recent decades. In particular, we tabulate the relative amount of recreational effort exerted in these areas in both space and time, document the HMS and groups of HMS that are commonly targeted by the recreational fishery, and identify 'hotspots' that support high levels of historical and contemporary fishing activity. Collectively, these data should be useful for monitoring the impacts of wind energy development on HMS and recreational fisheries targeting HMS during survey, construction, and operation phases of wind energy projects in SNE.

Recreational fishing effort for HMS occurs seasonally (June to October) in the Vineyard Wind lease areas, particularly lease OCS-A 0501, as evidenced by their support of hundreds of cumulative days of recreational effort in a typical year. However, data from all three sources (e.g., online survey, LPS, CTD) collectively indicated that these areas support lower amounts of effort than other, more popular areas in the SNE region. The relative amount of effort exerted in the Vineyard Wind lease areas also differed depending on the data type, thereby demonstrating the

importance of using several data sources to obtain a comprehensive assessment of recreational fishing effort in the SNE region. For example, according to the LPS data, total recreational HMS fishing effort in lease areas OCS-A 0501 and OCS-A 0522 represented 0.75% and 0.08% (of total trips) and 1.21% and 0.36% (of total catch) of all fishing effort in the SNE grid and 6.21% and 0.69% (of total trips) and 8.86% and 2.63% (of total catch) of all effort in the WEA from 2002 – 2018, respectively. In contrast, the CTD indicated that tagging effort in leases OCS-A 0501 and OCS-A 0522 represented 5.13% and 0.07% of all tagging effort in the SNE grid and 27.80% and 0.39% of all tagging effort in the WEA, respectively, during this same time period. Interestingly, the CTD also indicated that tagging effort was higher in the Vineyard Wind lease areas in more recent years, however, the factors influencing this trend were not investigated further. Additional work is required to assess potential impacts from offshore wind energy development on recreational fishing for HMS; this report is not intended to imply that such development will preclude future recreational fishing activity in the SNE WEA.

Despite the diversity of data and data sources analyzed by this project, a great deal of consistency was evident with respect to several key findings. Of particular importance and interest was the universal identification of widespread recreational effort for HMS throughout the SNE region and the (relatively) higher amounts of effort in several well-known fishing areas in SNE. For example, Coxes Ledge, The Fingers, and The Claw (Figure 1) were identified as the three areas in the WEA that support the highest level of recreational fishing for HMS in all three data sources (i.e., online survey, LPS data, CTD; Figure 7 & 26). This high degree of consistency is a strong testament to the importance of these areas to the recreational fishing industry. Outside the WEA, online survey and fisheries-dependent data also uniformly indicated that large amounts of recreational effort for HMS occurs in other areas such as The Dump, Tuna Ridge, The Horns, and The Lanes (Figures 7 – 9). Although these areas fall outside the WEA, it is important to note that fishermen will oftentimes have to travel through at least some portion of the WEA to reach The Dump or The Lanes, depending upon their port of origin. Transit through the WEA will also be necessary to fish in some of the SNE canyons, which are popular areas to target tropical pelagics. Furthermore, given the close proximity of popular areas such as The Dump, Tuna Ridge, and The Mudhole to the WEA, a considerable amount of effort likely occurs on the periphery of the existing leases.

Data collected by this project also consistently indicated that bluefin tuna, mahi mahi, and sharks, particularly blue shark and shortfin mako, are the most commonly targeted and captured HMS in SNE and the WEA over the past decade. Interestingly, however, each data source indicated slight differences in the relative importance and/or amount of effort directed at each target species. For example, online survey respondents testified that bluefin tuna was the most commonly targeted HMS in SNE over the past 5 years, while LPS respondents reported most commonly targeting shortfin mako during trips in SNE from 2002 – 2018. Mahi mahi was also the second most commonly targeted HMS in SNE over the past 5 years according to online survey respondents but was only targeted by 1.13% of LPS trips in SNE from 2002 – 2018. Interestingly, mahi mahi were

not historically captured in more inshore fishing areas of SNE (e.g., The Claw, The Fingers, Coxes Ledge) prior to the last decade (Greg Skomal, Massachusetts Division of Marine Fisheries, personal communication), but were the fourth most commonly caught species on LPS trips from 2002 – 2018. Mahi mahi are also typically retained by recreational fishermen which likely influenced the absence of CTD for the species. LPS catch and CTD records indicated that blue shark, bluefin tuna, and shortfin mako were the three most commonly caught species in SNE from 2002 – 2018. However, it is important to note that retention of blue sharks by recreational anglers is relatively rare, which creates more tagging opportunities for this species since blue sharks are the most abundant species in the region and the vast majority of animals are released (e.g., Kohler and Turner, 2019).

The analysis of online survey responses and fisheries-dependent data also indicated that recreational fishermen use a wide range of fishing methods to target HMS in SNE, but that mobile fishing methods predominate. Of the online survey respondents, 100% testified to using a mobile fishing method (e.g., drifting, trolling, casting/run and gun) to target HMS in SNE, which given the concentration of effort in popular locations within the WEA (e.g., Coxes Ledge, The Fingers), sets up a situation wherein numerous vessels may be operating in close proximity within a turbine array. Indeed, large fleets of 50 to 100 recreational vessels sometimes congregate in small geographic areas when targeting popular HMS such as bluefin and yellowfin tuna (J Kneebone, personal observation; Greg Skomal, Massachusetts Division of Marine Fisheries, personal communication).

Technical considerations

Due to the multiple sources from which fisheries-dependent data were collected in this study and the long time periods that the data represent, it is important to disclose some of the nuances associated with the analyses and figures presented or reported herein. With respect to the locations of fishing effort reported in the LPS and for CTD records, it should be understood that the latitude-longitude coordinates available in the data may not accurately reflect the exact location in which fishing effort occurred. For example, numerous CTD and LPS records had coordinates that occurred on coastal towns/cities/ports, which likely resulted from survey respondents or taggers reporting general locations such as ‘Nantucket’, ‘Block Island’, or ‘Montauk’ as the fishing/capture location associated with a given record. Similarly, LPS and CTD data auditors likely frequently interpolated coordinates from survey responses or tagging records that indicated approximate fishing/capture locations such as ‘20 miles south of Martha’s Vineyard’. In addition, review of LPS and CTD revealed that numerous records from different dates/times all had the same coordinates associated with them and occurred in the vicinity of popular, named fishing areas (e.g., Coxes Ledge, The Dump, etc). Reviewing this trend, it became apparent that each fisheries-dependent data provider used a fixed set of coordinates whenever a trip or tagging event was identified as having occurred in a named area. Indeed, the LPS has an established, default list of

coordinates for numerous named fishing areas along the U.S. east coast that are used whenever a respondent testifies to fishing in a general location (e.g., Coxes Ledge, The Fingers, The Dump, etc.). Although this convention limits the amount of highly accurate information on the location of recreational fishing effort for HMS in SNE, the widespread popularity of named fishing areas (e.g., Figure 1) still allows for a general review and comparison of the location of fishing effort in the SNE region and associated WEA. In addition, some popular fishing areas such as Coxes Ledge, The Fingers, The Claw, Inside Fingers, and Gordon's Gully occur entirely (or almost entirely) within the WEA, thereby reducing the impact of the limited location accuracy on the review of total recreational fishing effort within the WEA and its individual leases.

The restriction of LPS sampling effort to the months of June through October (NMFS, 2012) precluded the assessment of direct recreational fishing effort for HMS in SNE over all months of the year. Based on the available CTD, there was evidence that a small amount of effort occurred in the months of March, April, May, and November. However, the relative paucity of records during these months indicates that recreational effort for HMS is limited outside of the June to October time period (i.e., when the LPS is active).

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Table 1 – List of questions and potential responses included in the online survey designed to characterize the nature and extent of recreational fishing effort for highly migratory species (HMS) in southern New England (SNE) in a typical year. Please reference Figure 1 for a list of the fishing spots referenced in question 1.

Question	**Potential responses**
1. Of the fishing spots present in the above map (Figure 1), how many days do you fish for HMS in each spot during a typical season/year?	1. 0 days, 1 - 2 days, 3 - 4 days, 5 - 6 days, 7 - 10 days, >10 days; one response per location identified in Figure 1
2. What highly migratory species (HMS) do you target when fishing in these offshore areas? Please check all that apply.	2. Bluefin tuna, yellowfin tuna, albacore tuna, white marlin, mahi mahi, wahoo, sharks (mako, thresher, blue, porbeagle, tiger, hammerhead)
3. What fishing methods do you typically employ when targeting HMS in these areas? Please check all that apply.	3. Trolling, drifting, anchoring, casting (run and gun)
4. What type of HMS permit do you hold?	4. Angling category, charter/headboat

Table 2 – List of highly migratory species (HMS) for which data were available from the Large Pelagics Intercept Survey (LPS; catch) and conventional tagging data (CTD; tagging events) within the southern New England (SNE) grid and Wind Energy Area (WEA) during defined time periods. Presence in a data subset is indicated by an 'X'.

Species group	Species	LPS 2002-2018 SNE grid	LPS 2002-2018 WEA	CTD 1954-2019 SNE grid	CTD 1954-2019 WEA	CTD 2002-2018 SNE grid	CTD 2002-2018 WEA
Bluefin tuna	Bluefin tuna (*Thunnus thynnus*)	X	X	X	X	X	X
Tropical pelagics	Albacore (*Thunnus alalunga*)	X	X	X	X	X	
	Bigeye tuna (*Thunnus obesus*)	X					
	Blue marlin (*Makaira nigricans*)	X		X	X	X	
	Little tunny (*Euthynnus alletteratus*)	X	X				
	Mahi mahi (*Coryphaena hippurus*)	X	X				
	Skipjack tuna (*Katsuwonus pelamis*)	X	X				
	Swordfish (*Xiphias gladius*)	X	X	X	X	X	
	Wahoo (*Acanthocybium solandri*)	X					
	White marlin (*Kajikia albida*)	X	X	X	X	X	
	Yellowfin tuna (*Thunnus albacares*)	X	X	X	X	X	
Sharks	Blue shark (*Prionace glauca*)	X	X	X	X	X	X
	Common thresher shark (*Alopias vulpinus*)	X	X	X	X	X	X
	Dusky shark (*Carcharhinus obscurus*)	X	X	X	X	X	X
	Great hammerhead (*Sphyrna mokarran*)	X		X	X	X	
	Porbeagle (*Lamna nasus*)	X		X		X	
	Sand tiger (*Carcharias taurus*)	X		X		X	
	Sandbar shark (*Carcharhinus plumbeus*)	X	X	X	X	X	X
	Scalloped hammerhead (*Sphyrna lewini*)			X		X	
	Shortfin mako (*Isurus oxyrinchus*)	X	X	X	X	X	X
	Smooth hammerhead (*Sphyrna zygaena*)	X		X	X		
	Tiger shark (*Galeocerdo cuvier*)	X		X	X	X	X
	White shark (*Carcharodon carcharias*)	X		X			

Table 3 – Summary of information collected from respondents to the online survey of recreational fishing effort for highly migratory species (HMS) in southern New England (SNE) and the Wind Energy Area (WEA). SD – standard deviation

Permit type	n	Days fished per year[B]		Target species		Fishing method		Preferred fishing location	
		Range (Mean ± SD)	Total	Primary	Secondary	Primary	Secondary	In SNE	In WEA
Angling (private)	136	1 - 190 (37 ± 36)	4971	Bluefin tuna	Mahi mahi	Trolling	Drifting	The Dump	Coxes Ledge
Charter/headboat	34	5 - 190 (65 ± 52)	2214	Bluefin tuna	Mahi mahi	Trolling	Drifting/Casting	The Lanes	Coxes Ledge
Overall	171[A]	1 - 190 (42 ± 42)	7185	Bluefin tuna	Mahi mahi	Trolling	Drifting	The Dump	Coxes Ledge

[A] includes one respondent that did not specify a permit type

[B] represents data from 170 respondents who provided information on fishing effort by area (survey Q1)

Table 4 – Rough approximation of the online survey coverage relative to 2018 federal highly migratory species (HMS) permit sales from the four states with the highest recreational fishing effort for HMS in southern New England (SNE) according to the National Marine Fisheries Service Large Pelagics Intercept Survey (LPS).

Permit type	Permits by state				Total permits	Survey respondents	% of total permits
	MA	RI	CT	NY			
Angling (private)	2244	532	623	1877	5276	136	2.58%
Charter/headboat	669	121	65	292	1147	34	2.96%
Overall	2913	653	688	2169	6423	170	2.65%

Table 5 – Summary of the number and percentage of total trips occurring within the southern New England (SNE) grid and the Wind Energy Area (WEA) by state of origin based on the Large Pelagics Intercept Survey (LPS).

State	Number of trips		Percent of trips	
	SNE grid	WEA	SNE grid	WEA
CT	153	13	6.39%	4.48%
MA	194	74	8.11%	25.52%
ME	1	0	0.04%	0.00%
NH	1	0	0.04%	0.00%
NJ	2	1	0.08%	0.34%
NY	1236	95	51.65%	32.76%
RI	806	107	33.68%	36.90%
NY/CT/RI/MA	2389	289	99.83%	99.66%
All states	2393	290	-	-

Table 6 – Summary of the number of trips targeting each target species/species group as reported by recreational fishermen interviewed by the Large Pelagics Intercept Survey (LPS) from 2002 – 2018. Data were available for 2,393 trips that occurred within the southern New England (SNE) grid and 290 trips in the Wind Energy Area (WEA). Due to the nature of the responses, all tunas were grouped together into a category; note that some of these species are included in different groupings in other components of the analysis.

Target species or species group	In SNE grid		In WEA	
	Number of trips	% of total trips	Number of trips	% of total trips in SNE grid
Tunas	653	27.29%	73	3.05%
Albacore[A]	3	0.13%		
Bigeye tuna[A]	3	0.13%		
Bluefin tuna[B]	413	17.26%	57	2.38%
Yellowfin tuna[A]	108	4.51%	11	0.46%
Little tunny[A]	8	0.33%		
Skipjack tuna[A]	6	0.25%		
Tuna (any)	112	4.68%	5	0.21%
Sharks	1664	69.54%	208	8.69%
Blue shark	69	2.88%	11	0.46%
Common thresher shark	95	3.97%	9	0.38%
Shortfin mako	1084	45.30%	140	5.85%
Mako shark (any)	4	0.17%	1	0.04%
Shark (any)	412	17.22%	47	1.96%
Tropical pelagics (non-tuna)	33	1.38%	4	0.17%
Mahi mahi	27	1.13%	4	0.17%
Wahoo	2	0.08%		
Blue marlin	1	0.04%		
White marlin	3	0.13%		
Any large pelagic species	10	0.42%		
No target species indicated	33	1.38%	5	0.21%

[A] Included in tropical pelagics group

[B] Included as its own species group

Table 7 – Summary of the number of observations of highly migratory species (HMS) available from the Large Pelagics Intercept Survey (LPS; catch) and conventional tagging data (CTD; tagging events) by species and species group and time period both within the southern New England (SNE) grid and the Wind Energy Area (WEA).

Group	Species	Number of observations					
		LPS 2002-2018 SNE grid	LPS 2002-2018 WEA	CTD 1954-2019 SNE grid	CTD 2002-2018 SNE grid	CTD 1954-2019 WEA	CTD 2002-2018 WEA
Bluefin tuna	Bluefin tuna	2244	250	8956	2396	2367	494
Tropical pelagics	Albacore	104	3	163	8	57	0
	Bigeye tuna	9	0	0	0	0	0
	Blue marlin	7	0	37	11	4	0
	Little tunny	907	25	0	0	0	0
	Mahi mahi	1350	243	0	0	0	0
	Skipjack tuna	624	124	0	0	0	0
	Swordfish	7	1	6	1	1	0
	Wahoo	12	0	0	0	0	0
	White marlin	19	1	890	19	124	0
	Yellowfin tuna	248	11	830	31	222	0
	Total	3287	408	1926	70	408	0
Sharks	Blue shark	9870	1439	39129	8857	7310	1650
	Common thresher shark	203	17	30	21	5	2
	Dusky shark	18	3	389	10	58	1
	Great hammerhead	16	0	7	5	2	0
	Porbeagle	2	0	7	5	0	0
	Sand tiger	1	0	3	3	0	0
	Sandbar shark	15	1	1836	243	144	7
	Scalloped hammerhead	0	0	5	3	0	0
	Shortfin mako	1093	163	1635	919	248	158
	Smooth hammerhead	1	0	7	0	1	0
	Tiger shark	9	0	59	5	5	1
	White shark	1	0	2	0	0	0
	Total	11229	1623	43109	10071	7773	1819
All HMS		16760	2281	53991	12537	10548	2313

Table 8 – Summary of recreational fishing effort data derived from the Large Pelagics Intercept Survey (LPS) and conventional tagging data (CTD) for highly migratory species (HMS) in the two Vineyard Wind lease areas. An 'X' denotes that that species/species group was targeted in that lease area. All other fields represent numerical counts of observations for that category.

Category	Lease area		
	501	522	501 & 522
LPS target species			
Bluefin tuna	X	X	X
Shortfin mako	X		X
Tuna (any)		X	X
LPS trip origin (# of trips)	18	2	20
Massachusetts	14	2	16
Rhode Island	4	0	4
LPS catch (# of fish)	202	60	262
Blue shark	51	0	51
Bluefin tuna	106	5	111
Common thresher shark	1	0	1
Mahi mahi	22	54	76
Shortfin mako	20	0	20
Skipjack tuna	2	0	2
Yellowfin tuna	0	1	1
CTD tagging events (1954 - 2019)	1651	59	1710
Blue marlin	1	1	2
Blue shark	1112	39	1151
Bluefin tuna	429	8	437
Dusky shark	3	0	3
Sandbar shark	11	2	13
Shortfin mako	48	2	50
Smooth hammerhead	1	0	1
White marlin	16	6	22
Yellowfin tuna	30	1	31
CTD tagging events (2002 - 2018)	643	9	652
Blue shark	327	6	333
Bluefin tuna	279	1	280
Sandbar shark	4	0	4
Shortfin mako	33	2	35

Table 9 – Summary of the percentage of total recreational fishing effort exerted towards highly migratory species (HMS) in the two Vineyard Wind lease areas based on the Large Pelagics Intercept Survey (LPS) and conventional tagging data (CTD). Percentages are reported with respect to total effort in the southern New England (SNE) grid and the Wind Energy Area (WEA).

Effort category	% of total effort in SNE grid			% of total effort in WEA		
	501	522	501 & 522	501	522	501 & 522
LPS trips (2002 - 2018)	0.75%	0.08%	0.84%	6.21%	0.69%	6.90%
LPS catch (2002 - 2018)	1.21%	0.36%	1.56%	8.86%	2.63%	11.49%
CTD events (1954 - 2019)	3.06%	0.11%	3.17%	15.65%	0.56%	16.21%
CTD events (2002 - 2018)	5.13%	0.07%	5.20%	27.80%	0.39%	28.19%

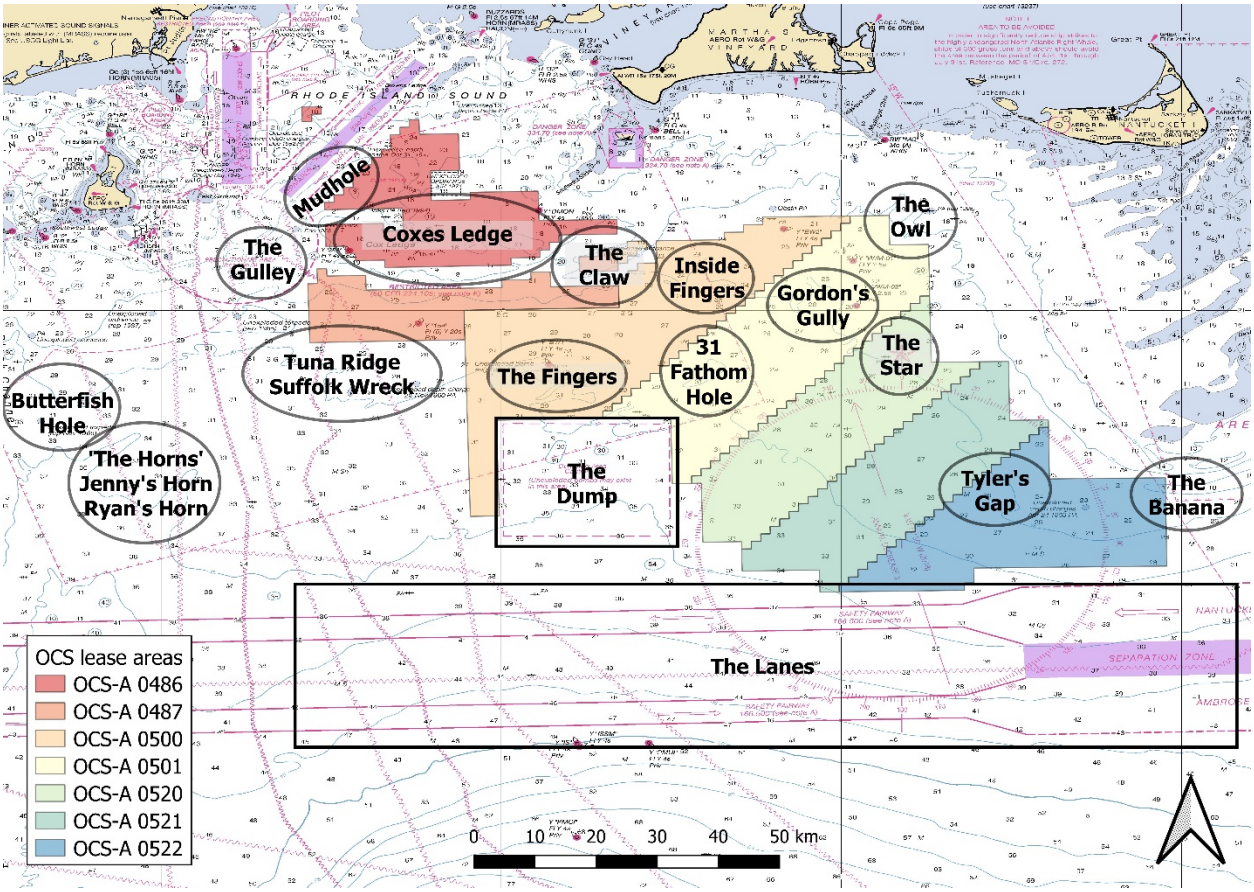

Figure 1 – Popular recreational fishing areas in southern New England (SNE) that were referenced in question 1 of the online survey and the seven individual outer continental shelf (OCS) lease areas that comprise the Wind Energy Area (WEA). Survey respondents were asked to indicate the amount of effort exerted in each named area in a typical year. Respondents were also asked to indicate their level of effort in other, non-named areas both inside and outside of the WEA.

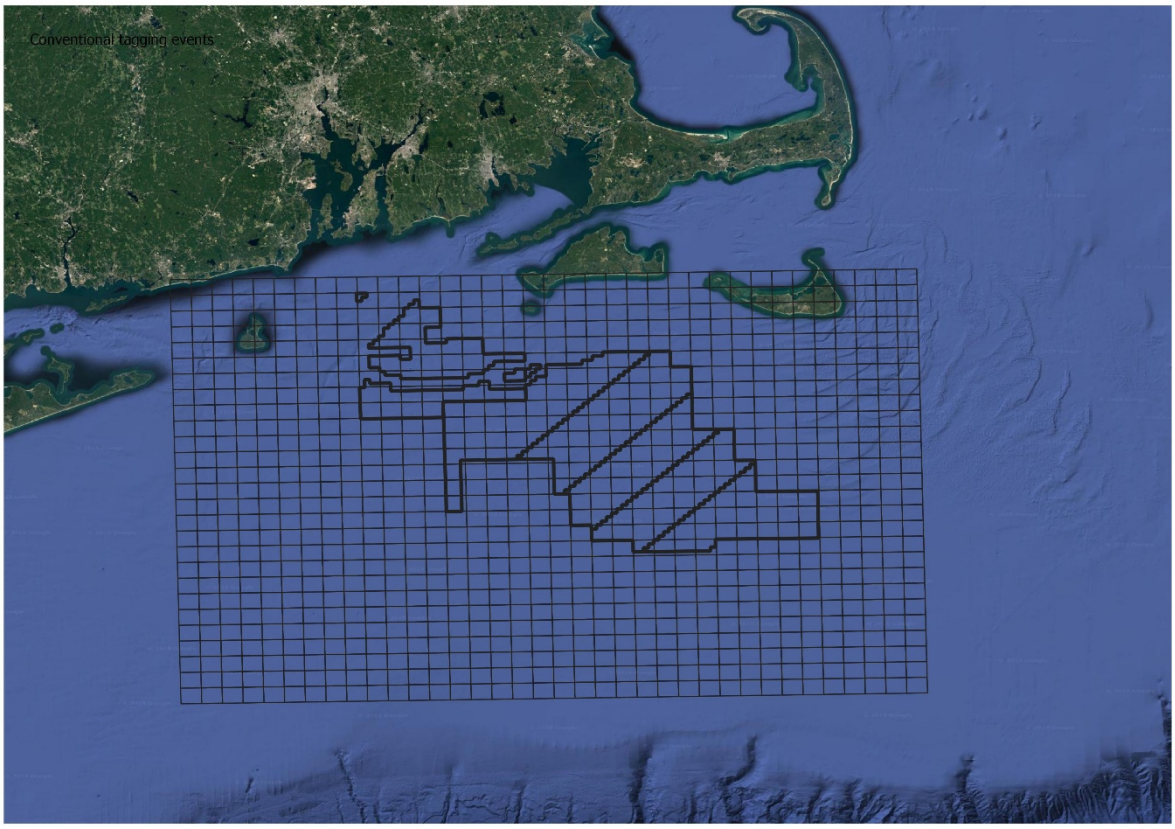

Figure 2 – The 1,008 cell “SNE grid” (Width: 36 cells; Height: 28 cells) onto which fisheries-dependent data were interpolated to examine recreational fishing effort for highly migratory species (HMS) throughout the southern New England (SNE) region, including within the Wind Energy Area (WEA). The grid was designed based on the Bureau of Ocean Energy Management Outer Continental Shelf lease blocks, which measure 4.8 km x 4.8 km. The WEA and the seven individual leases are outlined in black.

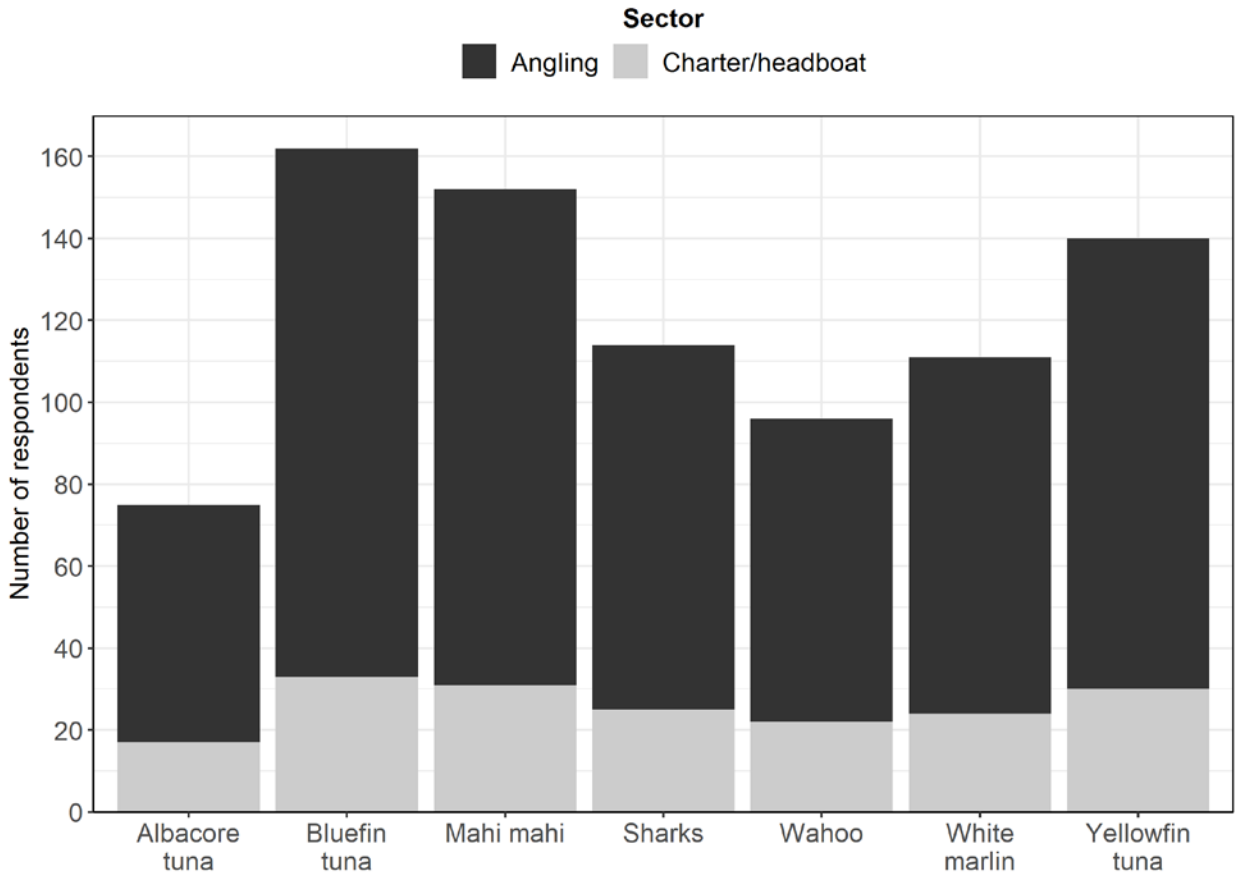

Figure 3 – The number of survey respondents (n = 171) holding federal angling and charter/headboat highly migratory species (HMS) permits who testified to targeting each listed HMS in southern New England (SNE). Note that sharks include shortfin mako, common thresher shark, blue shark, porbeagle, tiger shark, and smooth hammerhead.

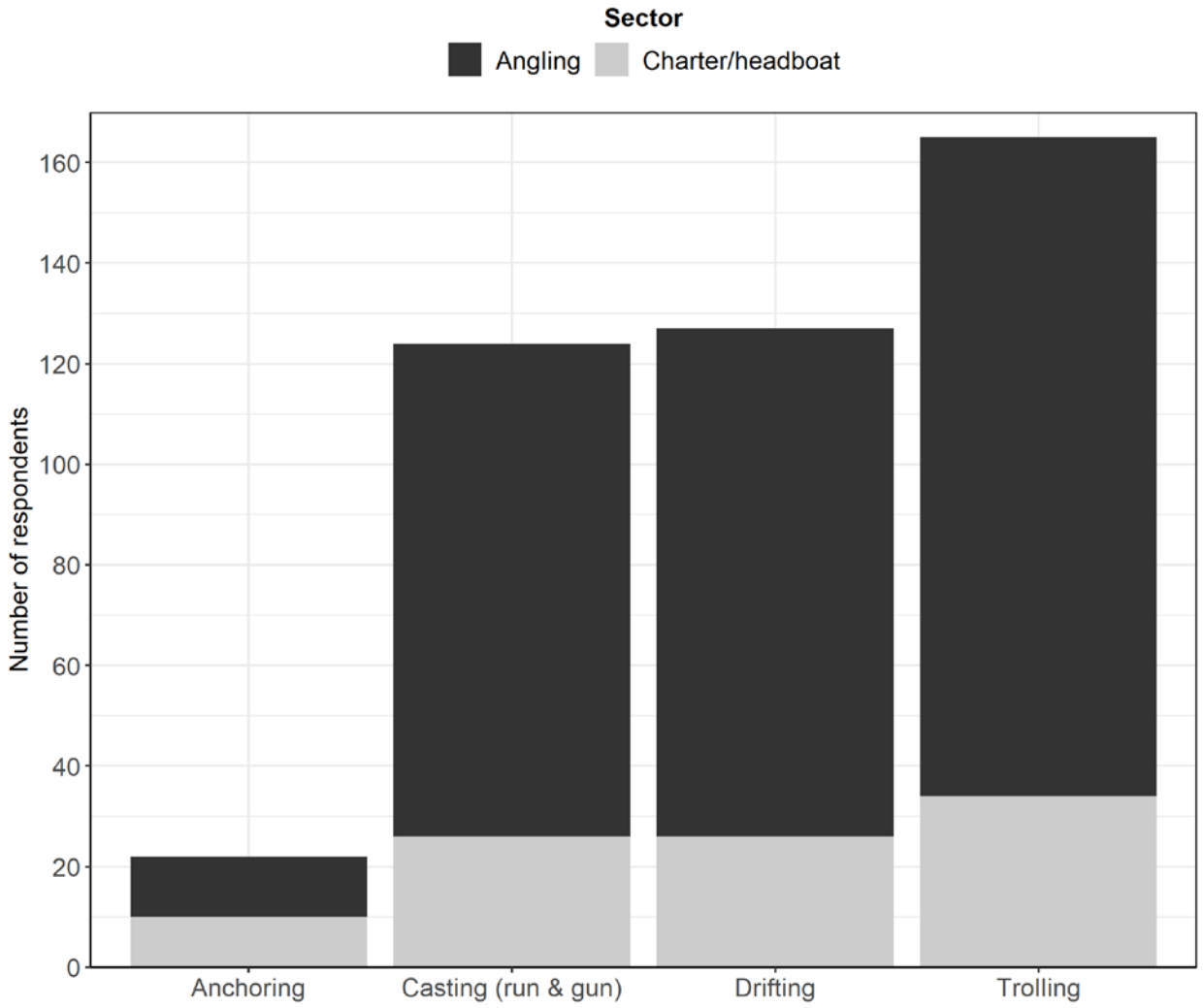

Figure 4 – The number of survey respondents (n = 171) holding federal angling and charter/headboat highly migratory species (HMS) permits who testified to using specific fishing methods to target HMS in southern New England (SNE).

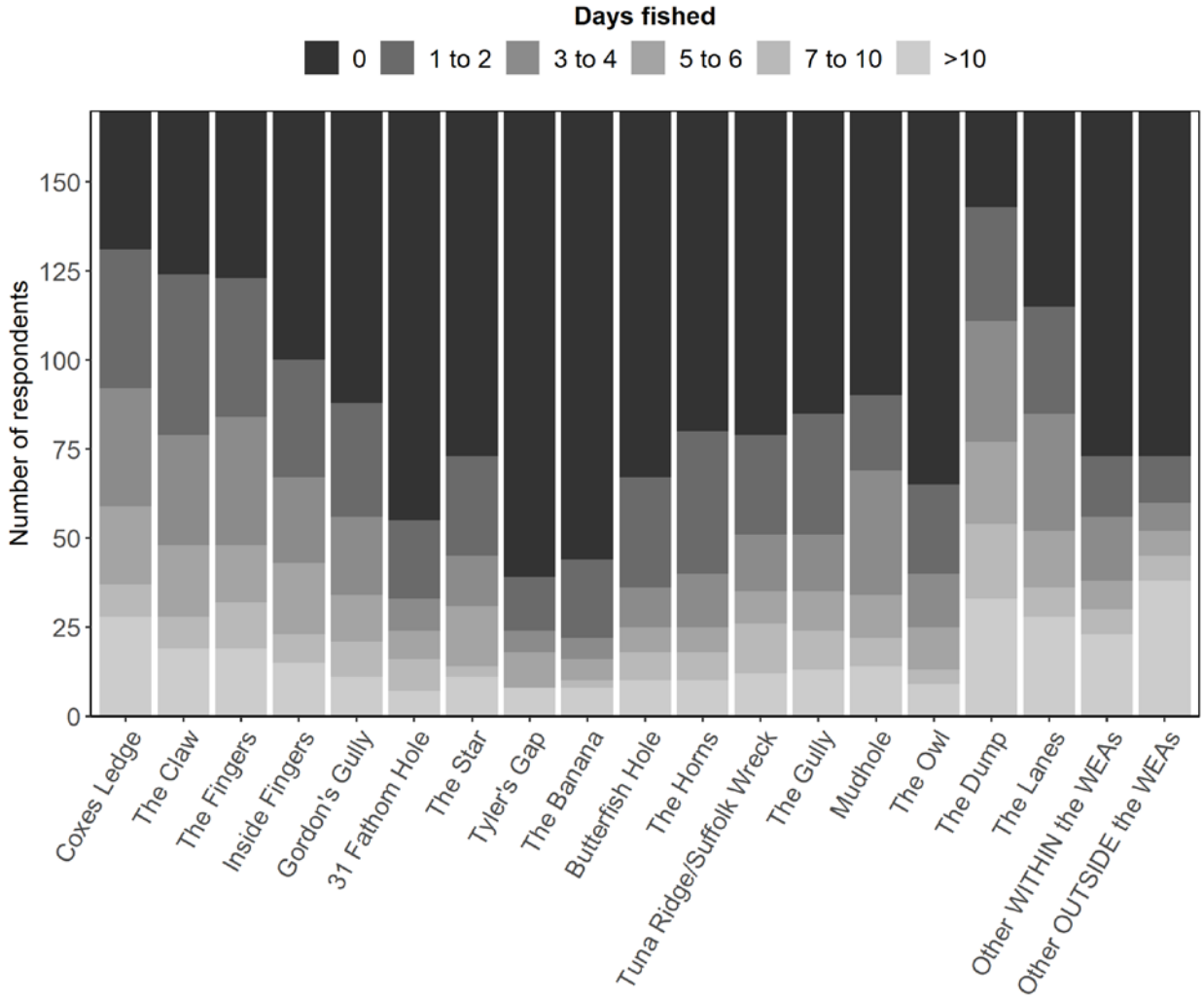

Figure 5 – The number of survey respondents (n = 170) who testified to exerting each category of effort (days fished) in a typical year at named fishing areas in southern New England (SNE). Refer to Figure 1 for the location of each named area. Data represent all 170 respondents who provided information on effort.

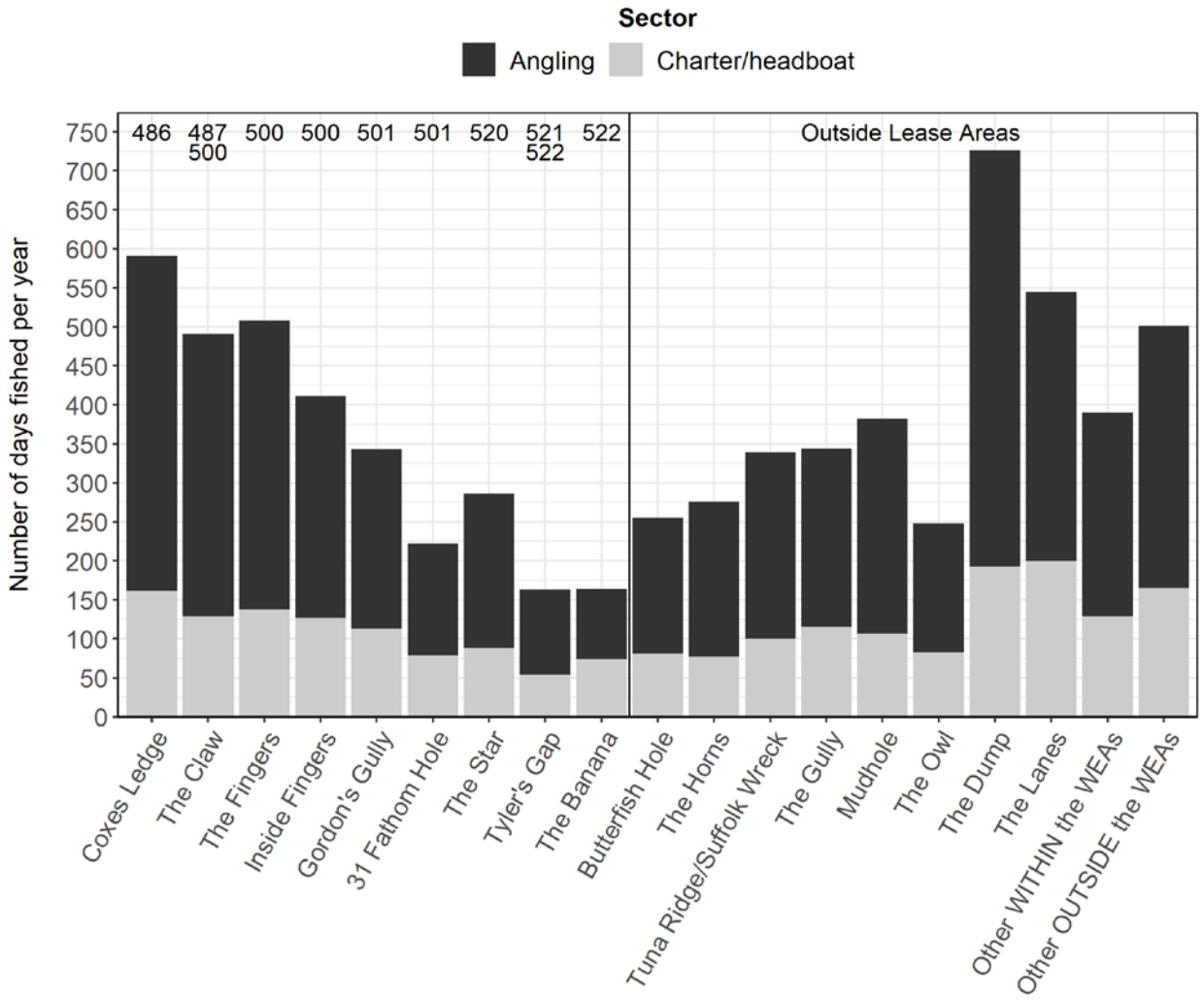

Figure 6 – The minimum number of days fished by 170 survey respondents in each named fishing area in southern New England (SNE) in a typical year. Bars are color-coded to demonstrate the relative amount of effort exerted by respondents holding federal angling or charter/headboat category highly migratory species (HMS) permits. Bars are organized by those areas that are inside (left) and outside (right) the Wind Energy Area from west to east and north to south. The Outer Continental Shelf (OCS) lease number in which each fishing area is located is indicated. Refer to Figure 1 to see the locations of each named fishing area and individual OCS lease areas.

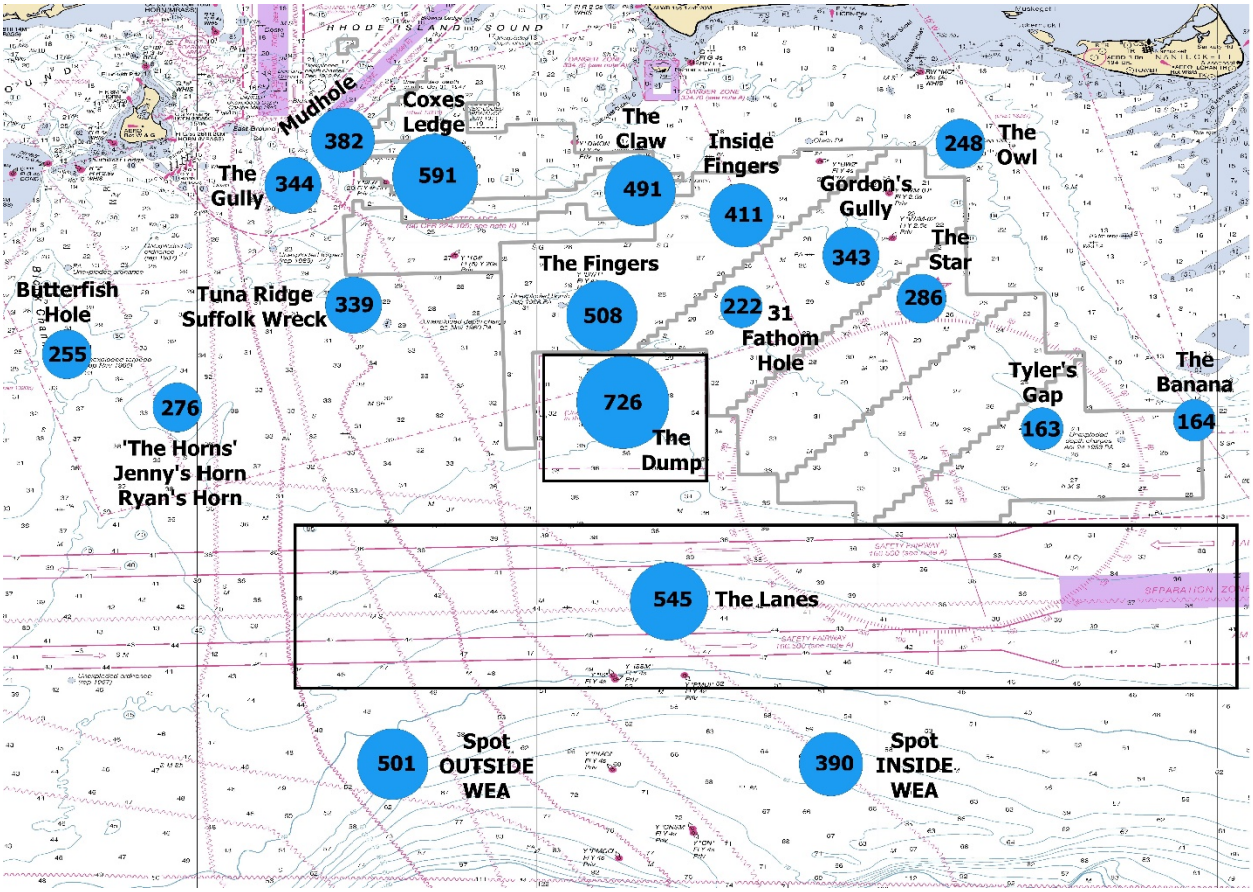

Figure 7 – The cumulative number of days (number inside each circle) the 170 survey respondents holding federal angling or charter/headboat highly migratory species (HMS) permits testified to fishing in each named area in a typical year. The Wind Energy Area (WEA) is outlined in gray. Note that circles for "spot INSIDE WEA" and "spot OUTSIDE WEA" are placed in random locations on the map and represent those broad categories of the survey.

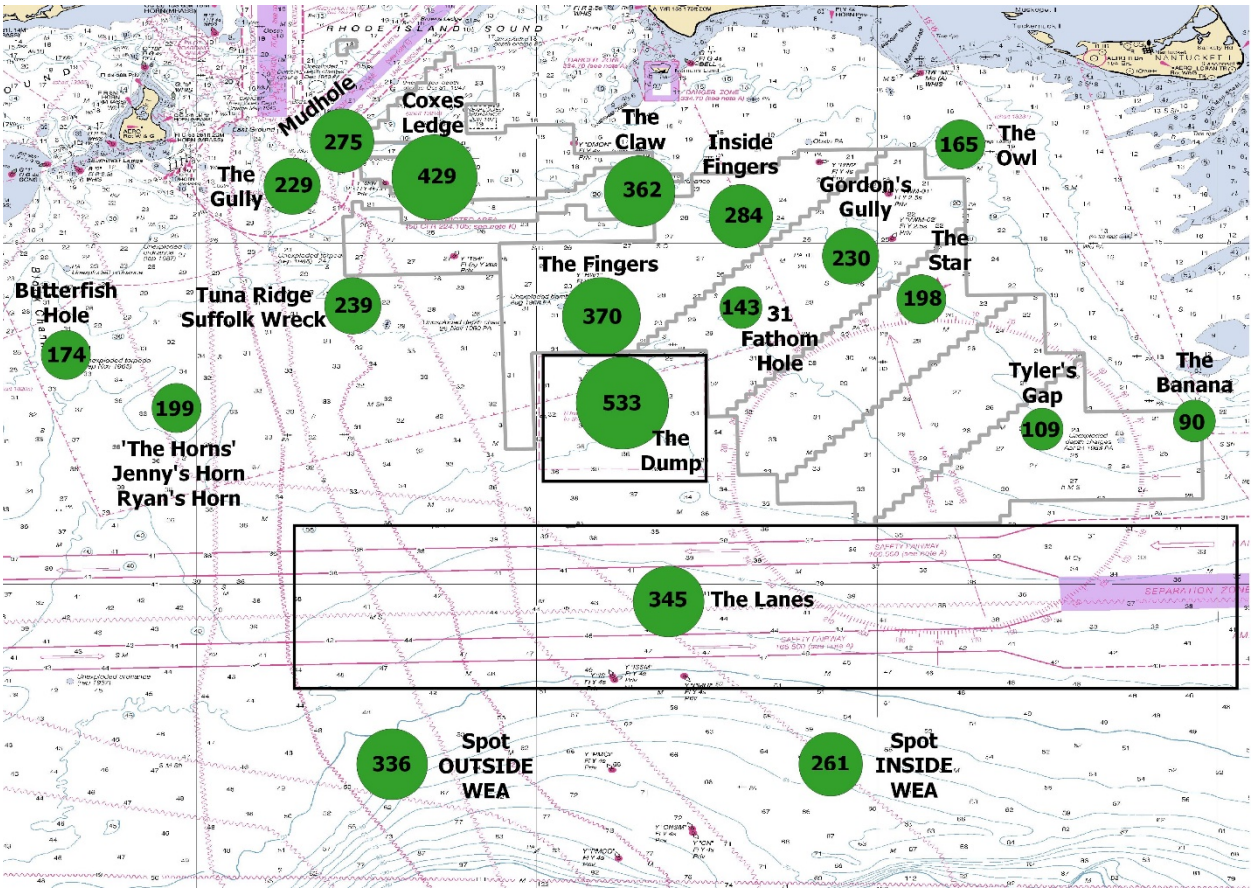

Figure 8 – The cumulative number of days (number inside each circle) the 136 survey respondents holding federal angling category highly migratory species (HMS) permits testified to fishing in each named area in a typical year. The Wind Energy Area (WEA) is outlined in gray. Note that circles for “spot INSIDE WEA” and “spot OUTSIDE WEA” are placed in random locations on the map and represent those broad categories of the survey.

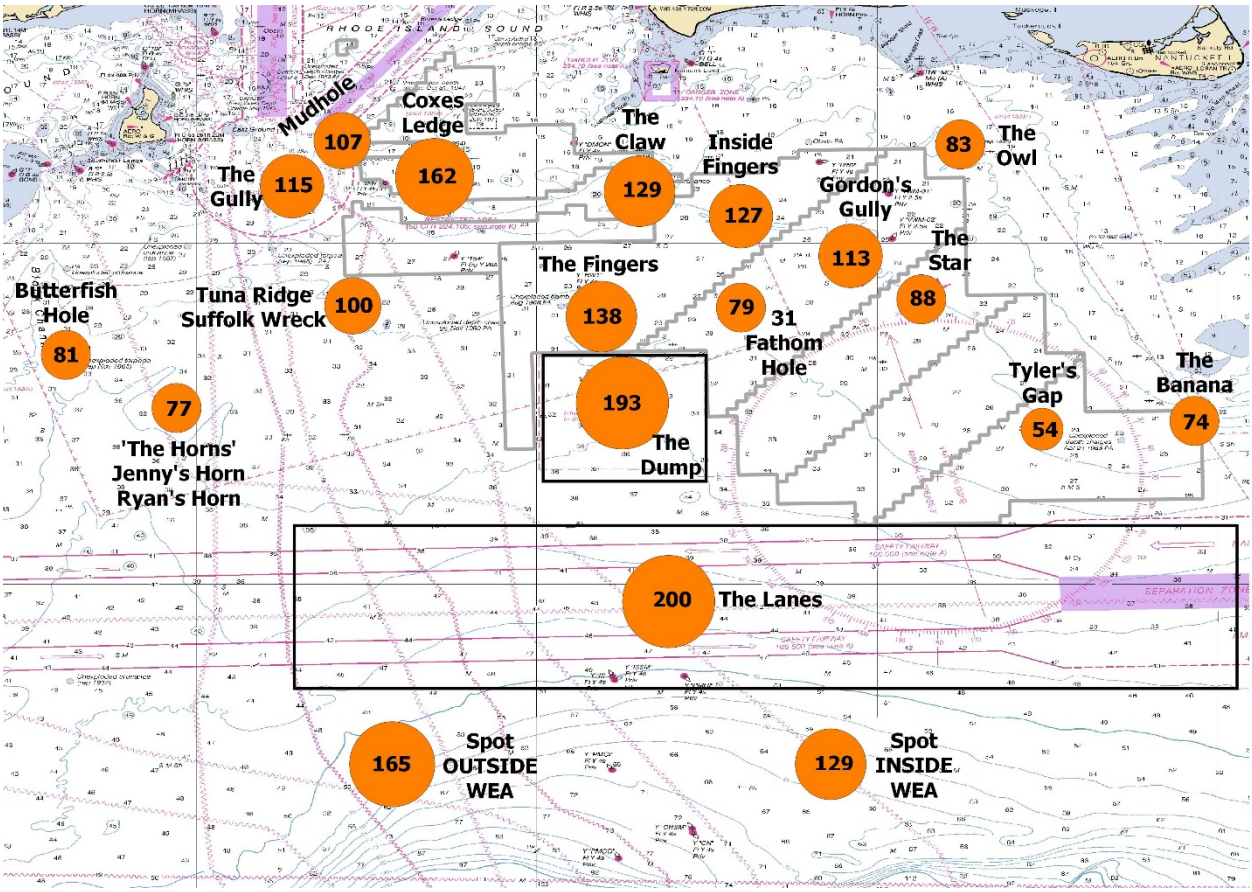

Figure 9 – The cumulative number of days (number inside each circle) the 34 survey respondents holding federal charter/headboat highly migratory species (HMS) permits testified to fishing in each named area in a typical year. The Wind Energy Area (WEA) is outlined in gray. Note that circles for "spot INSIDE WEA" and "spot OUTSIDE WEA" are placed in random locations on the map and represent those broad categories of the survey.

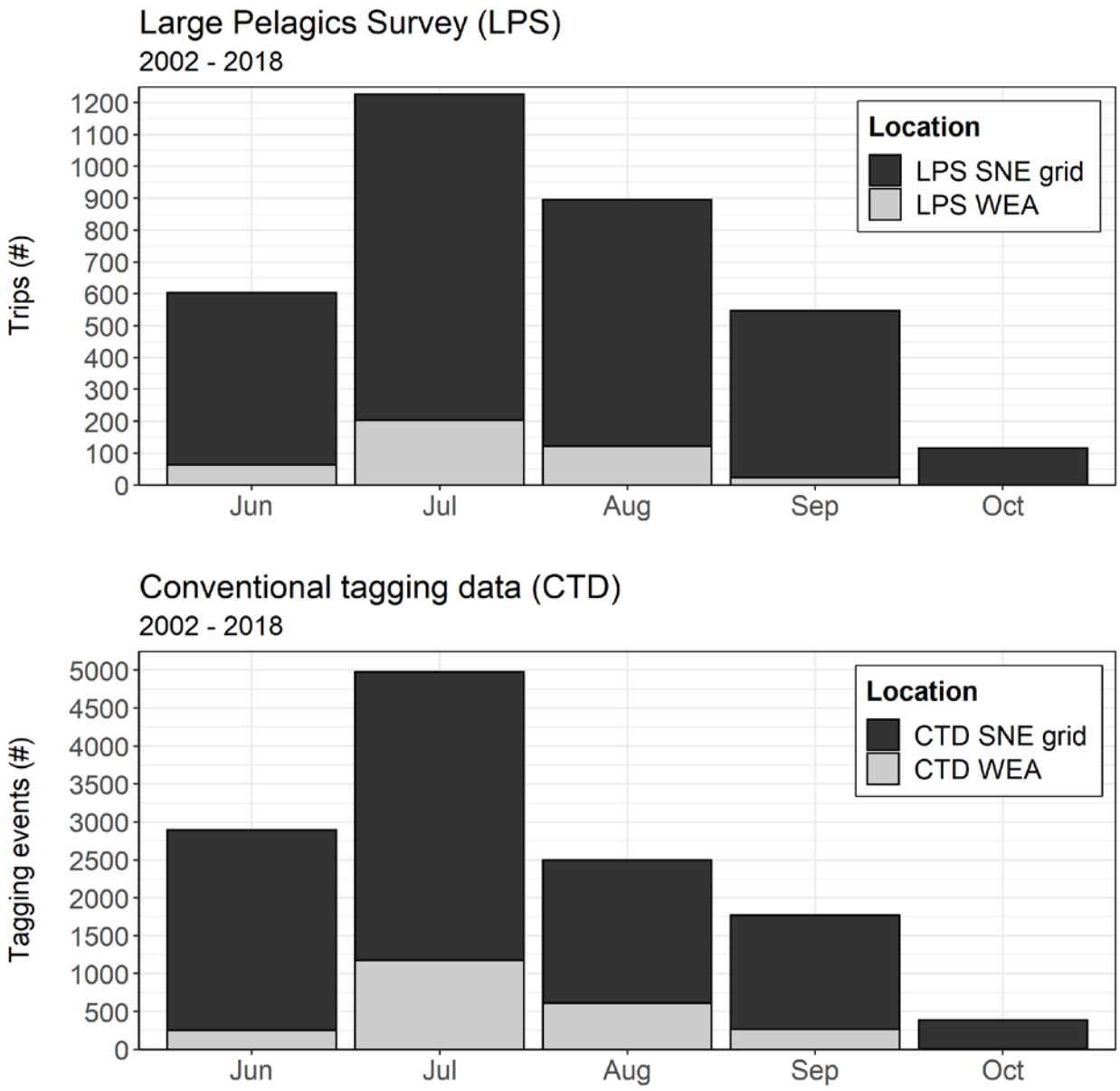

Figure 10 – Monthly recreational fishing effort for highly migratory species (HMS) in the southern New England (SNE) grid and Wind Energy Area (WEA) based on the number of trips monitored by the Large Pelagics Intercept Survey (LPS; top) and the number of tagging events evident in the conventional tagging data (CTD; bottom) from 2002 – 2018. Note that nine tagging events that occurred in March (n = 2), April (n = 4), May (n = 2), and November (n = 1) are not presented.

Figure 11 – The number of trips that captured highly migratory species (HMS) within each species group in the southern New England (SNE) grid and Wind Energy Area (WEA) as reported by the Large Pelagics Intercept Survey (LPS) from 2002 – 2018.

Figure 12 – The total catch (number of fish) of each category of highly migratory species (HMS) in the southern New England (SNE) grid and Wind Energy Area (WEA) as reported by the Large Pelagics Intercept Survey (LPS) from 2002 – 2018.

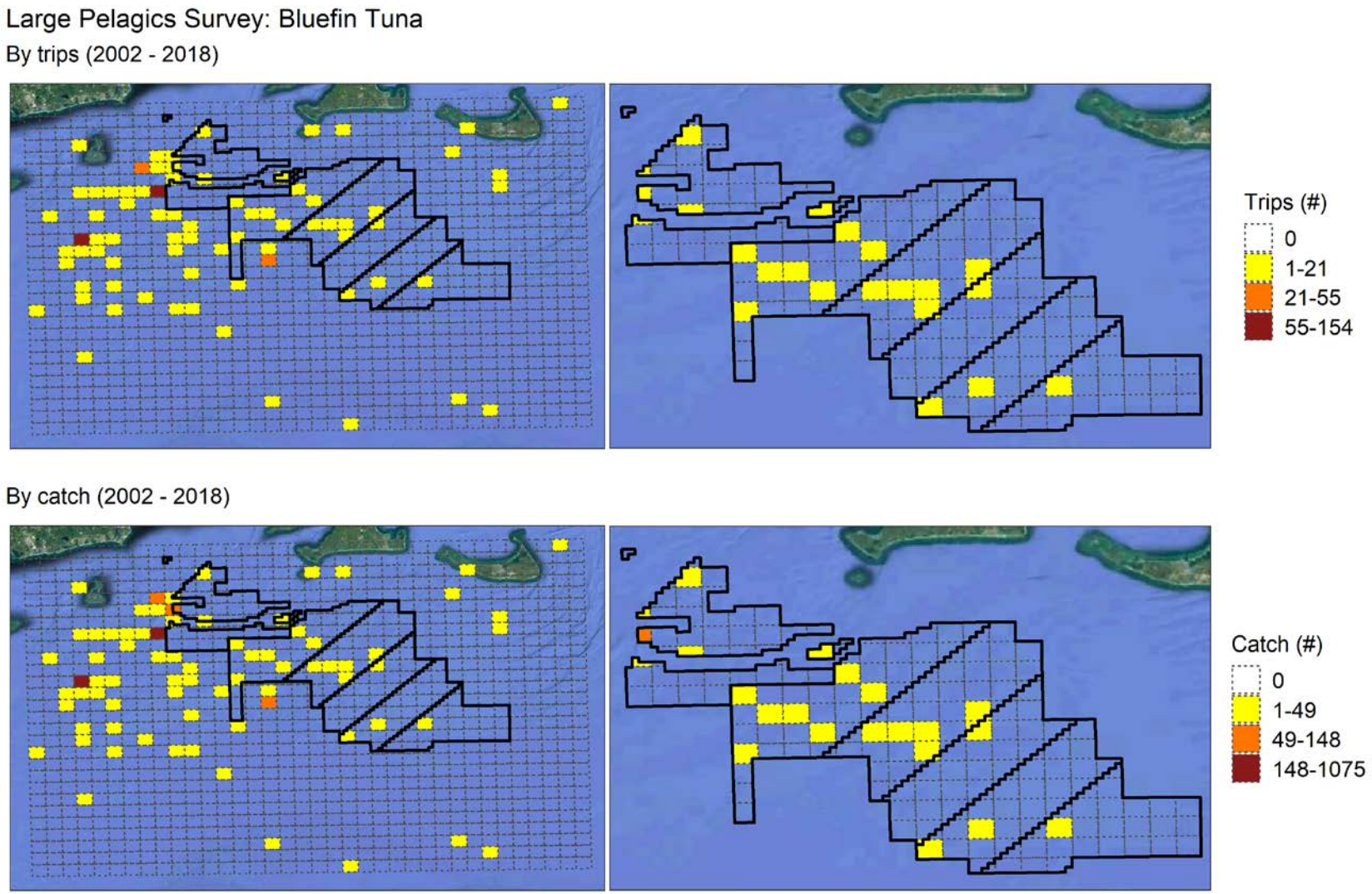

Figure 13 – Distribution of recreational fishing effort for bluefin tuna over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of trips (top) and catch (bottom) reported in the Large Pelagics Intercept Survey (LPS) data from 2002 – 2018.

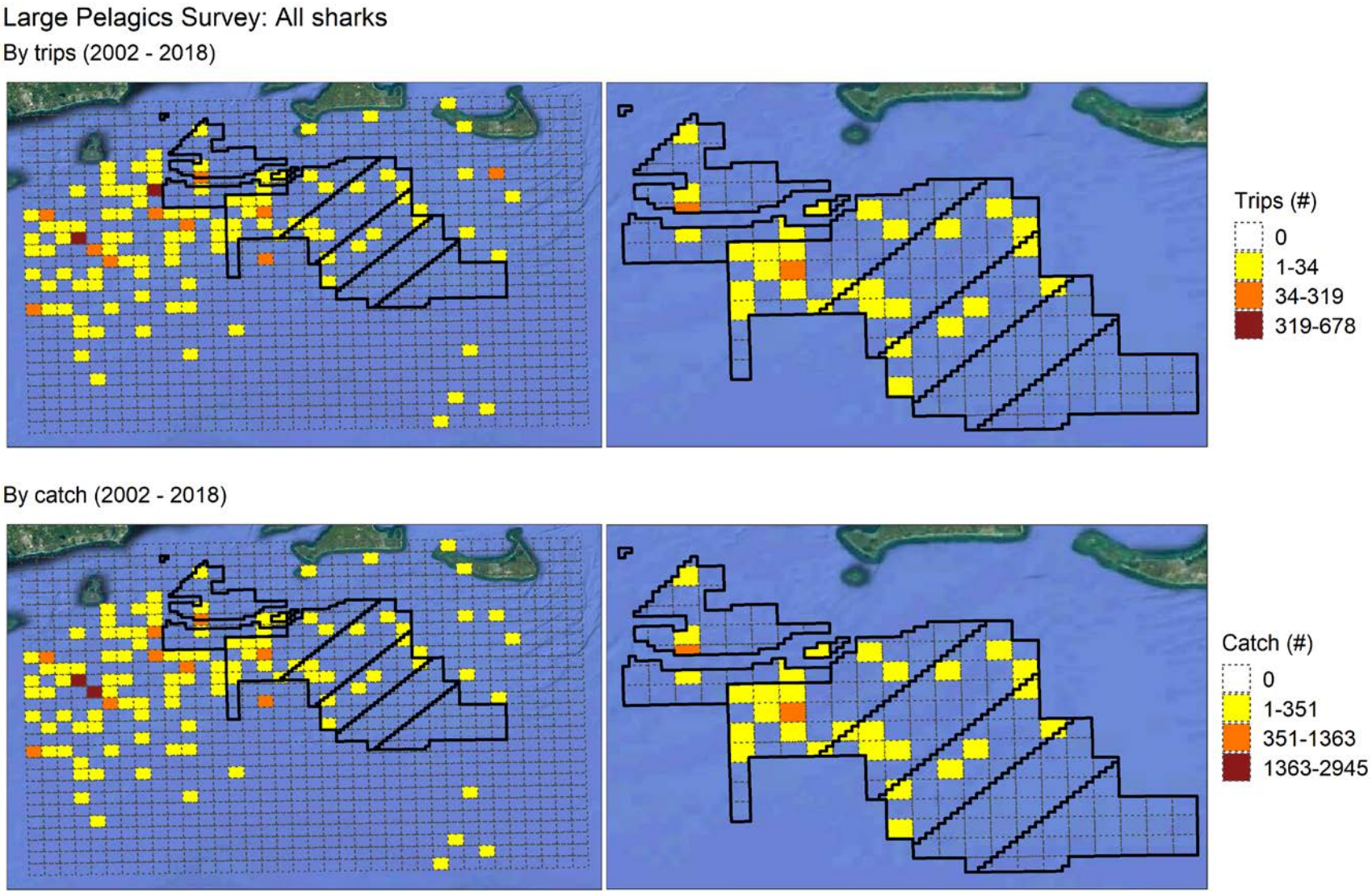

Figure 14 – Distribution of recreational fishing effort for all sharks over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of trips (top) and catch (bottom) as reported in the Large Pelagics Intercept Survey (LPS) data from 2002 – 2018. Refer to Table 7 for a list of species represented in the figure.

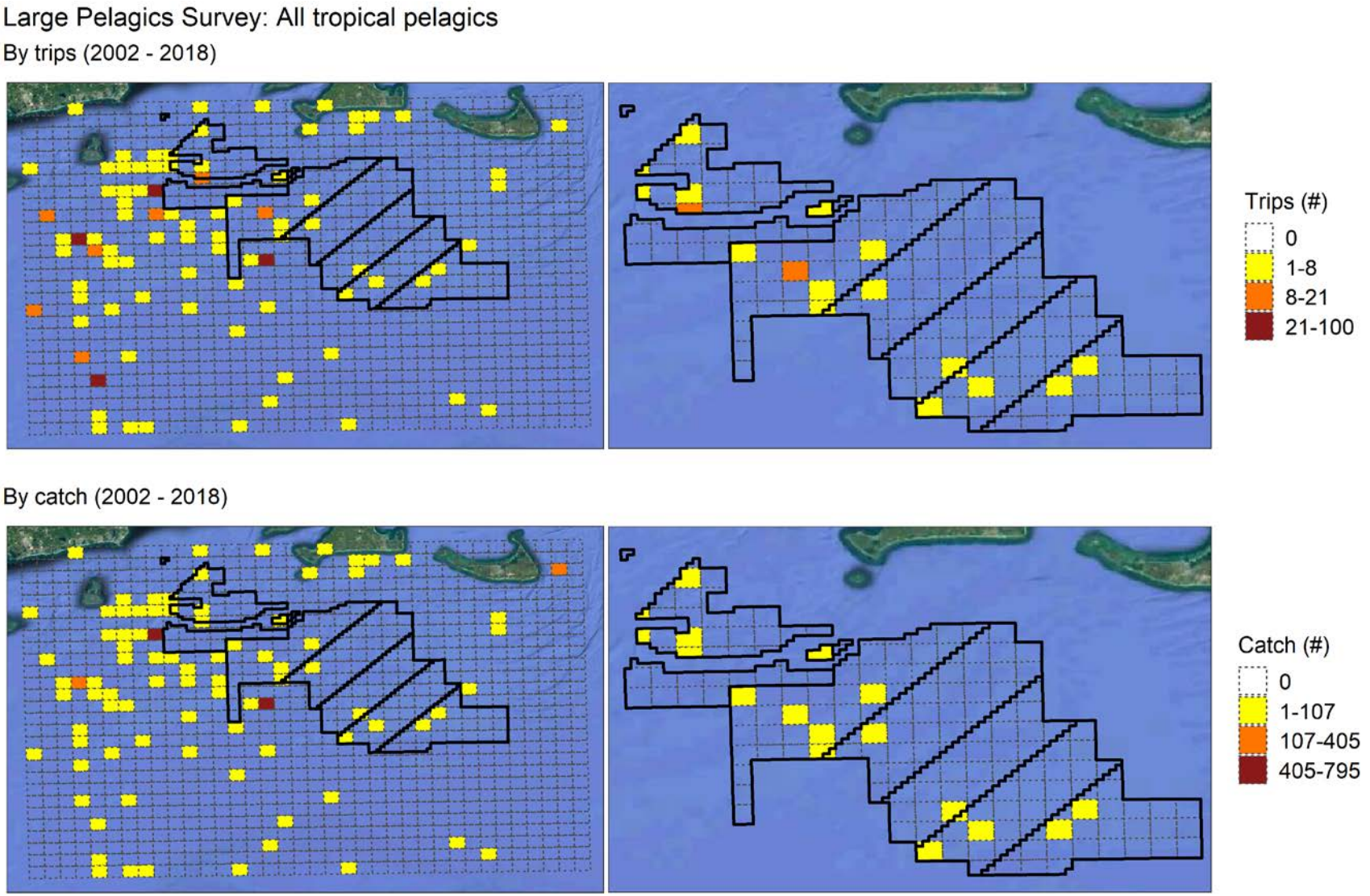

Figure 15 – Distribution of recreational fishing effort for tropical pelagics over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of trips (top) and catch (bottom) as reported in the Large Pelagics Intercept Survey (LPS) data from 2002 – 2018. Refer to Table 7 for a list of species represented in the figure.

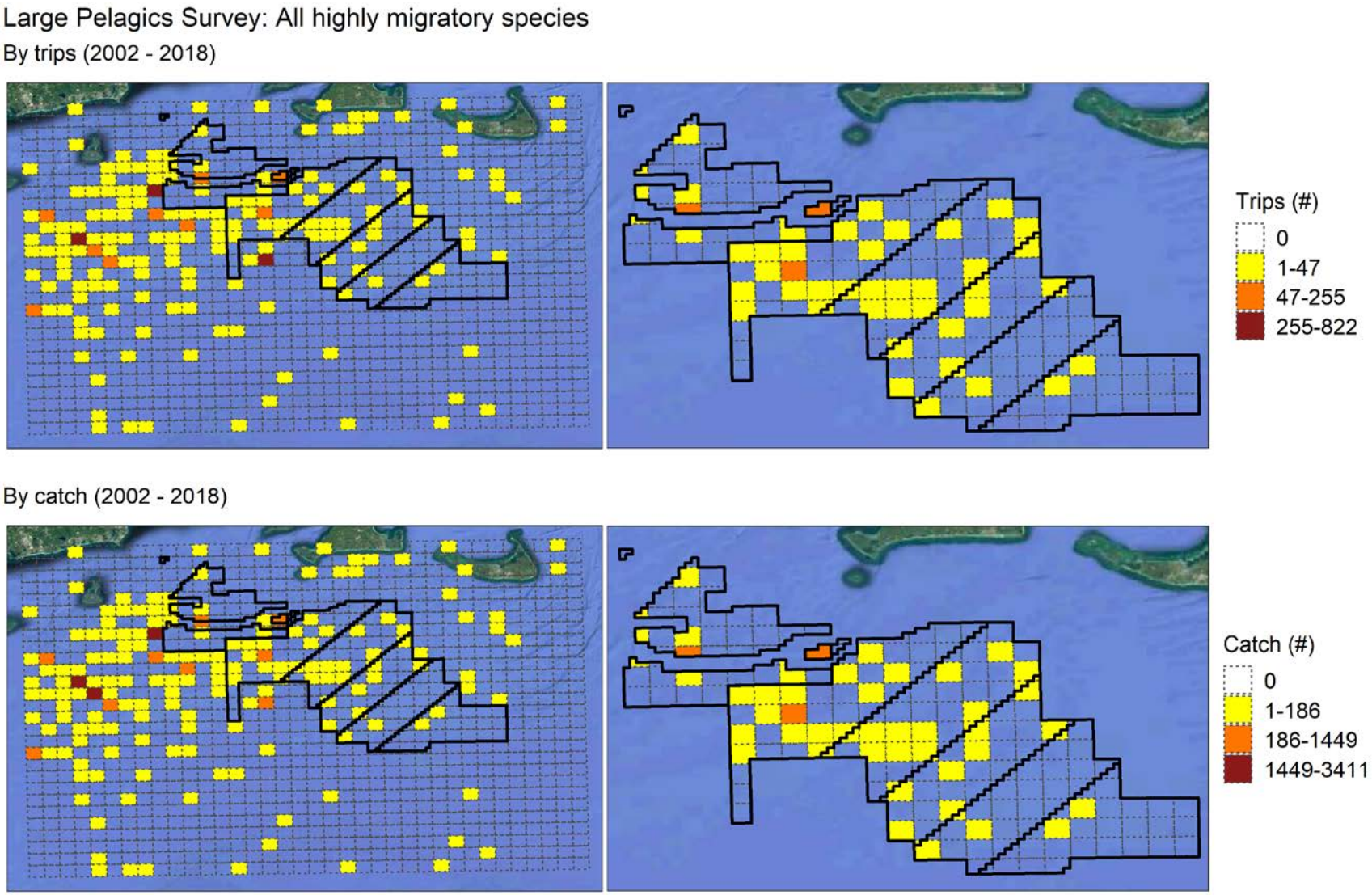

Figure 16 – Distribution of recreational fishing effort for all highly migratory species over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of trips (top) and catch (bottom) as reported in the Large Pelagics Intercept Survey (LPS) data from 2002 – 2018. Refer to Table 7 for a list of species represented in the figure.

Figure 17 – The total number of conventional tagging events for each category of highly migratory species (HMS) in the southern New England (SNE) grid and Wind Energy Area (WEA) from 1954 – 2019.

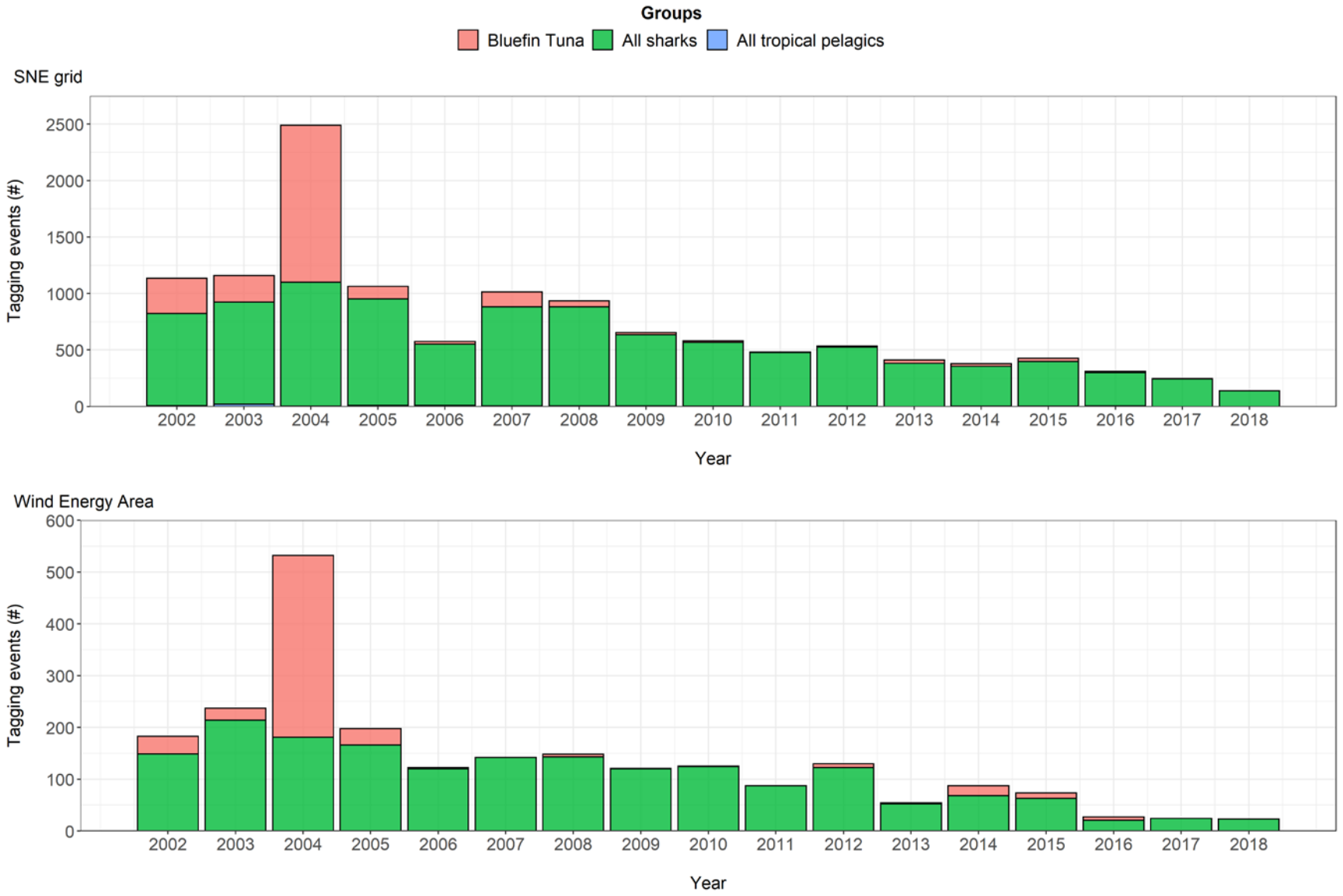

Figure 18 – The total number of conventional tagging events for each category of highly migratory species (HMS) in the southern New England (SNE) grid and Wind Energy Area (WEA) from 2002 – 2018.

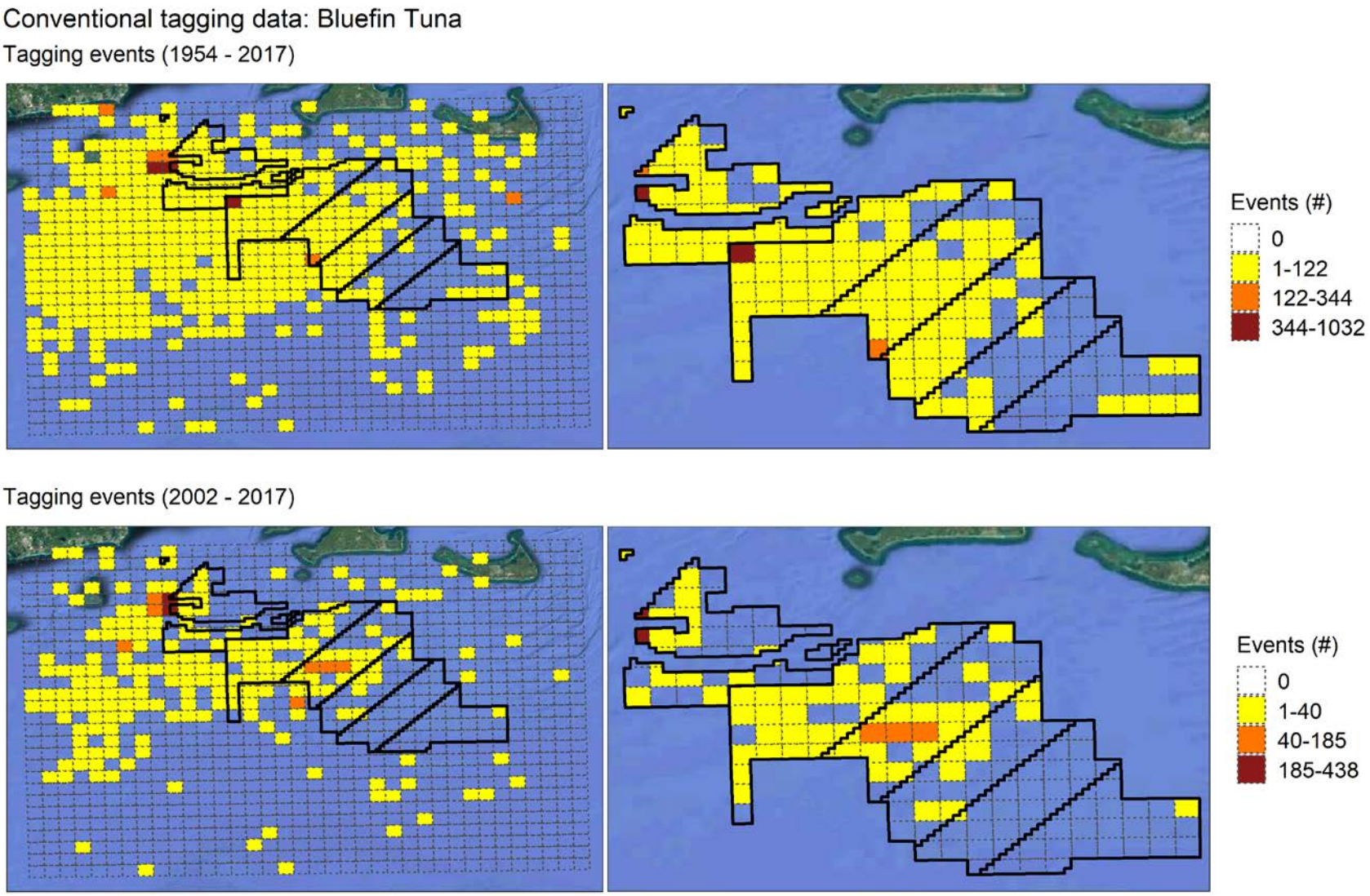

Figure 19 – Distribution of recreational fishing effort for bluefin tuna over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of conventional tagging data (CTD) over the full time series of records (top) and from 2002 – 2017 (bottom). Note that no tagging data for bluefin tuna were available in these areas in 2018.

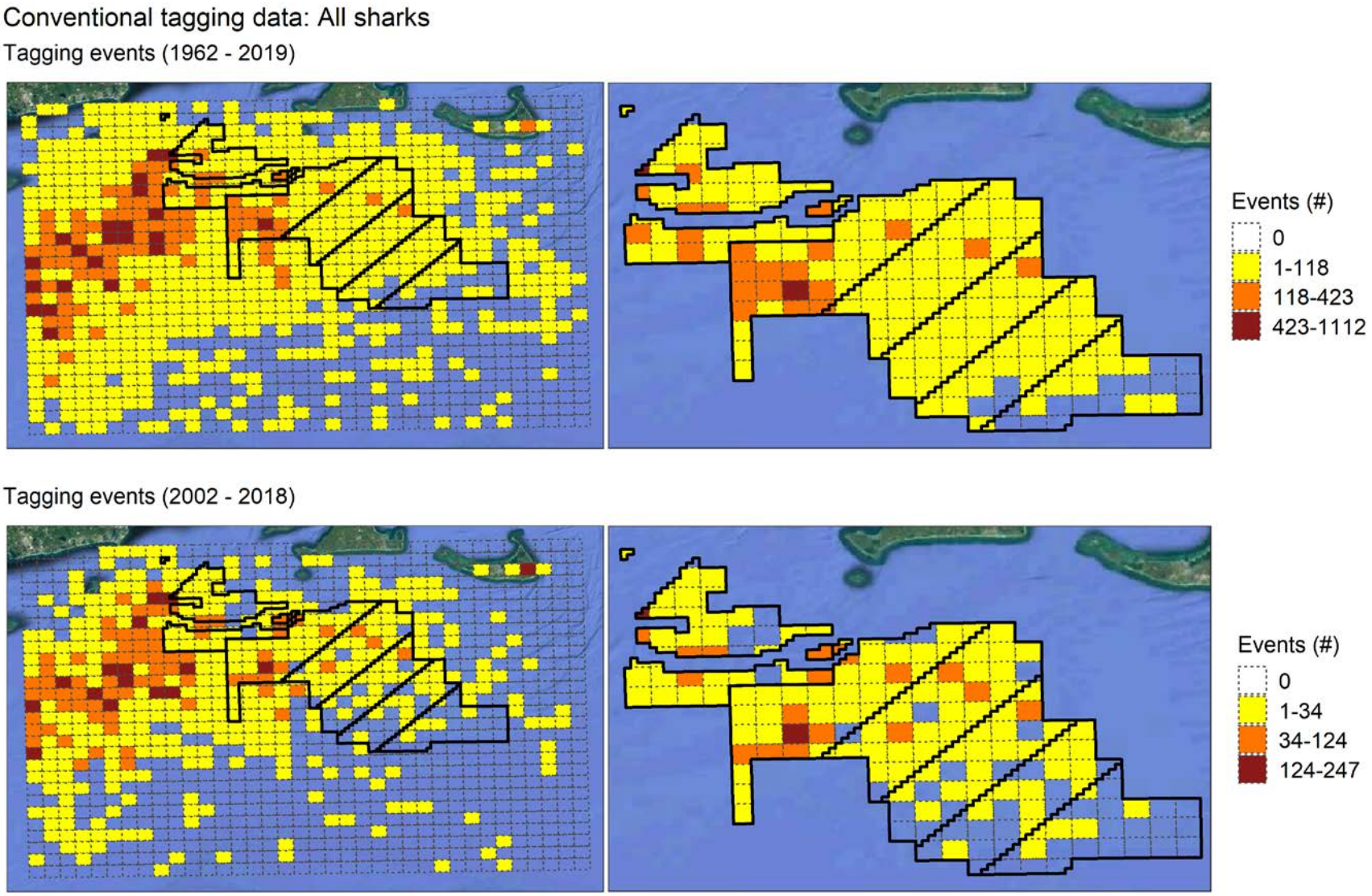

Figure 20 – Distribution of recreational fishing effort for all sharks over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of conventional tagging data (CTD) over the full time series of records (top) and from 2002 – 2018 (bottom). Refer to Table 7 for a list of species represented in the figure.

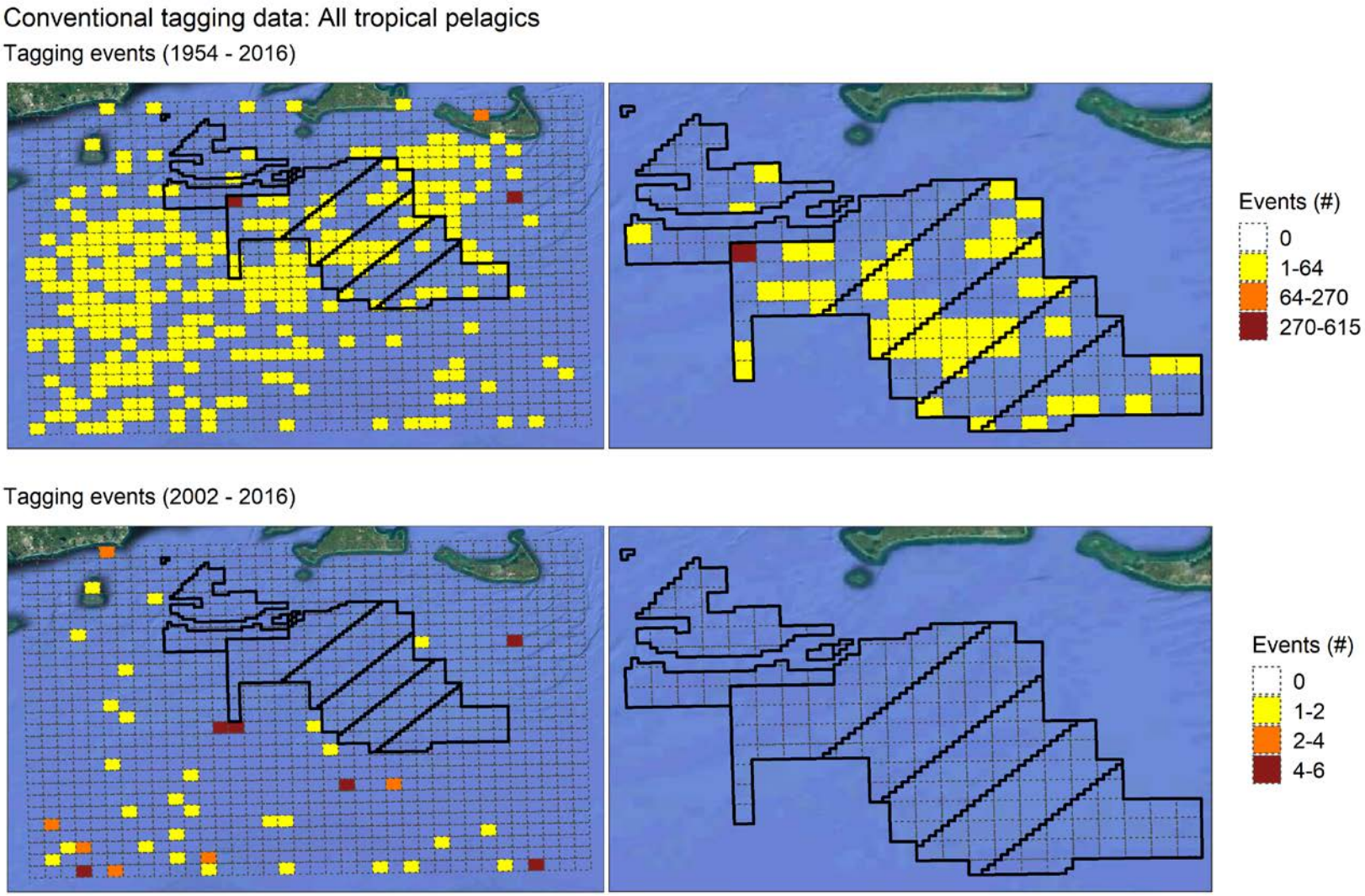

Figure 21 – Distribution of recreational fishing effort for tropical pelagics over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of conventional tagging data (CTD) over the full time series of records (top) and from 2002 – 2016 (bottom). Note that no tagging data for tropical pelagics were available in these areas in 2017 and 2018. Refer to Table 7 for a list of species represented in the figure.

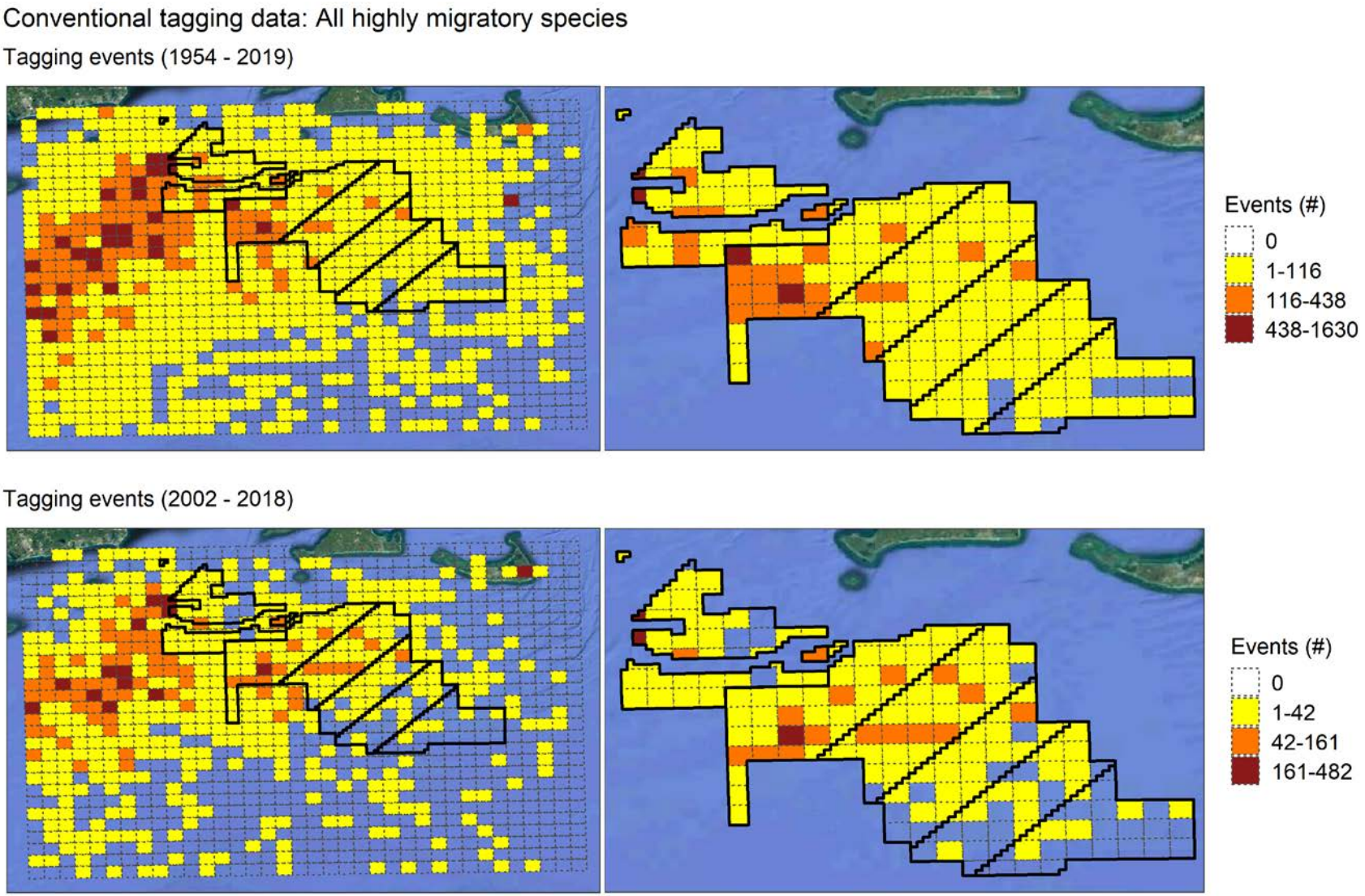

Figure 22 – Distribution of recreational fishing effort for all highly migratory species over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on interpolation of conventional tagging data (CTD) over the full time series of records (top) and from 2002 – 2018 (bottom). Refer to Table 7 for a list of species represented in the figure.

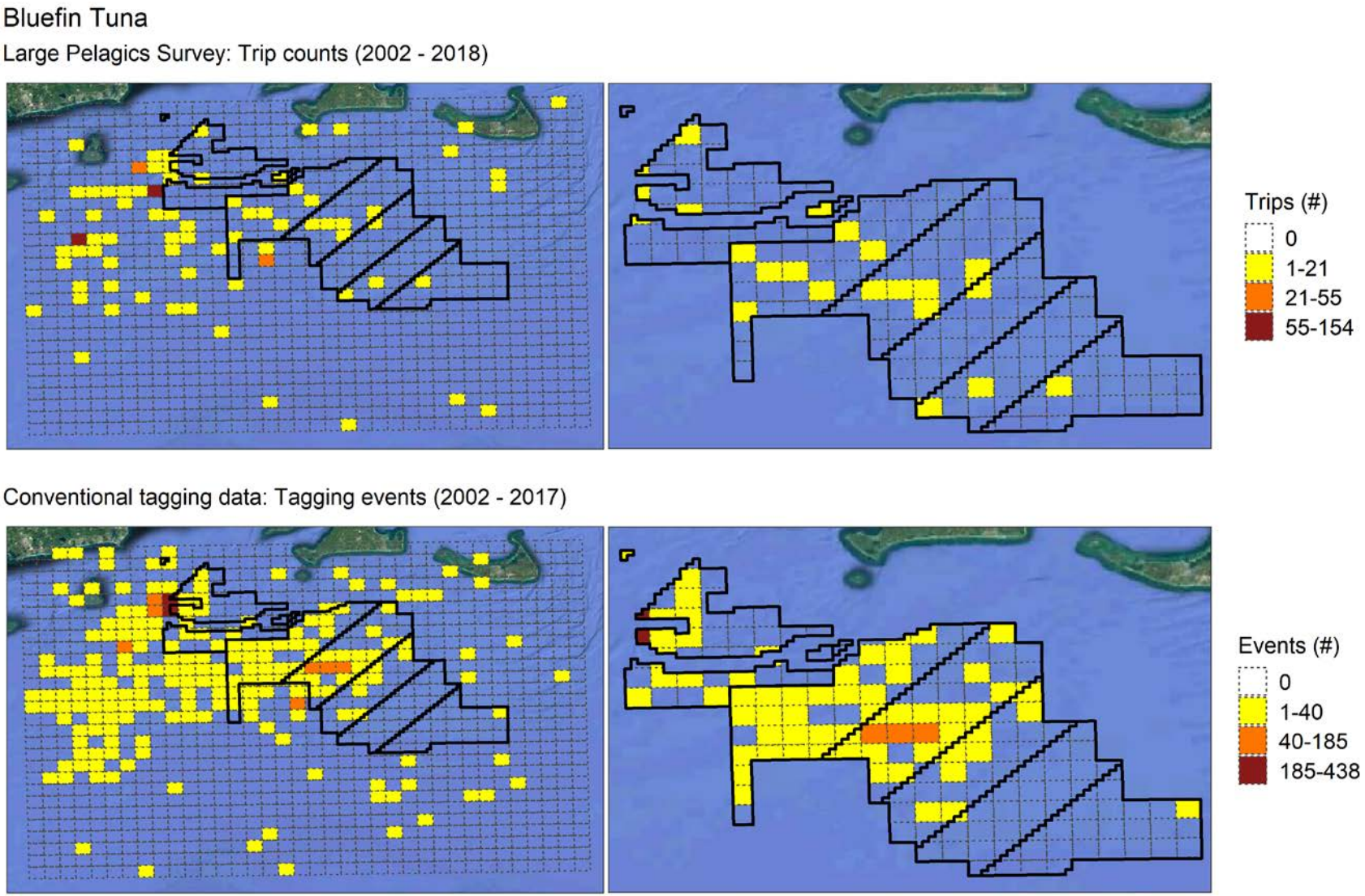

Figure 23 – Comparison of the distribution of recreational fishing effort for bluefin tuna over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on the Large Pelagics Intercept Survey (LPS; top) and conventional tagging data (CTD; bottom) from 2002 – 2018. Note that no tagging data for bluefin tuna were available in 2018.

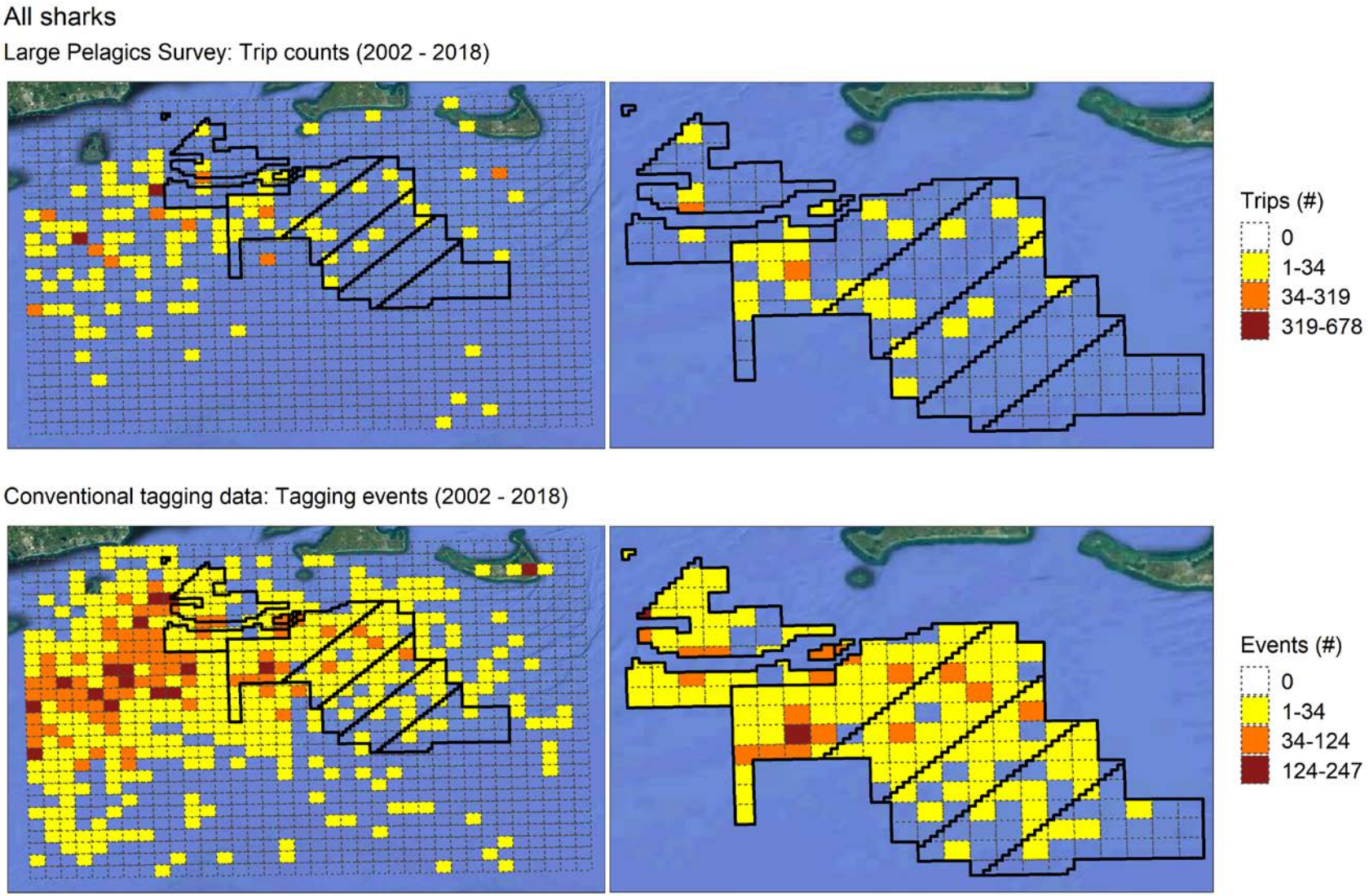

Figure 24 – Comparison of the distribution of recreational fishing effort for all sharks over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on the Large Pelagics Intercept Survey (LPS; top) and conventional tagging data (CTD; bottom) from 2002 – 2018. Refer to Table 7 for a list of species represented in the figure.

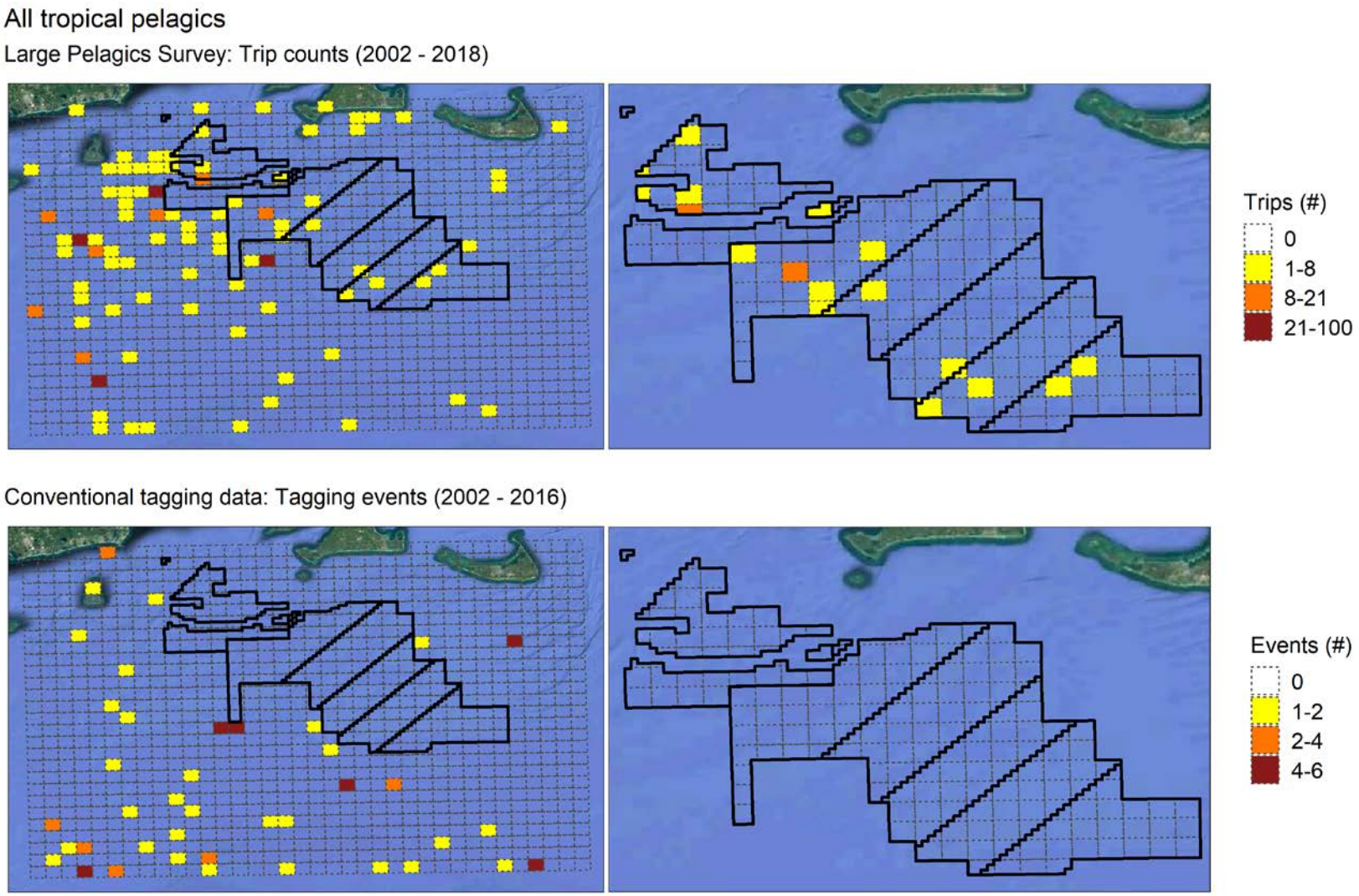

Figure 25 – Comparison of the distribution of recreational fishing effort for tropical pelagics over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on the Large Pelagics Intercept Survey (LPS; top) and conventional tagging data (CTD; bottom) from 2002 – 2016. Note that no tagging data for tropical pelagics were available in 2017 and 2018. Refer to Table 7 for a list of species represented in the figure.

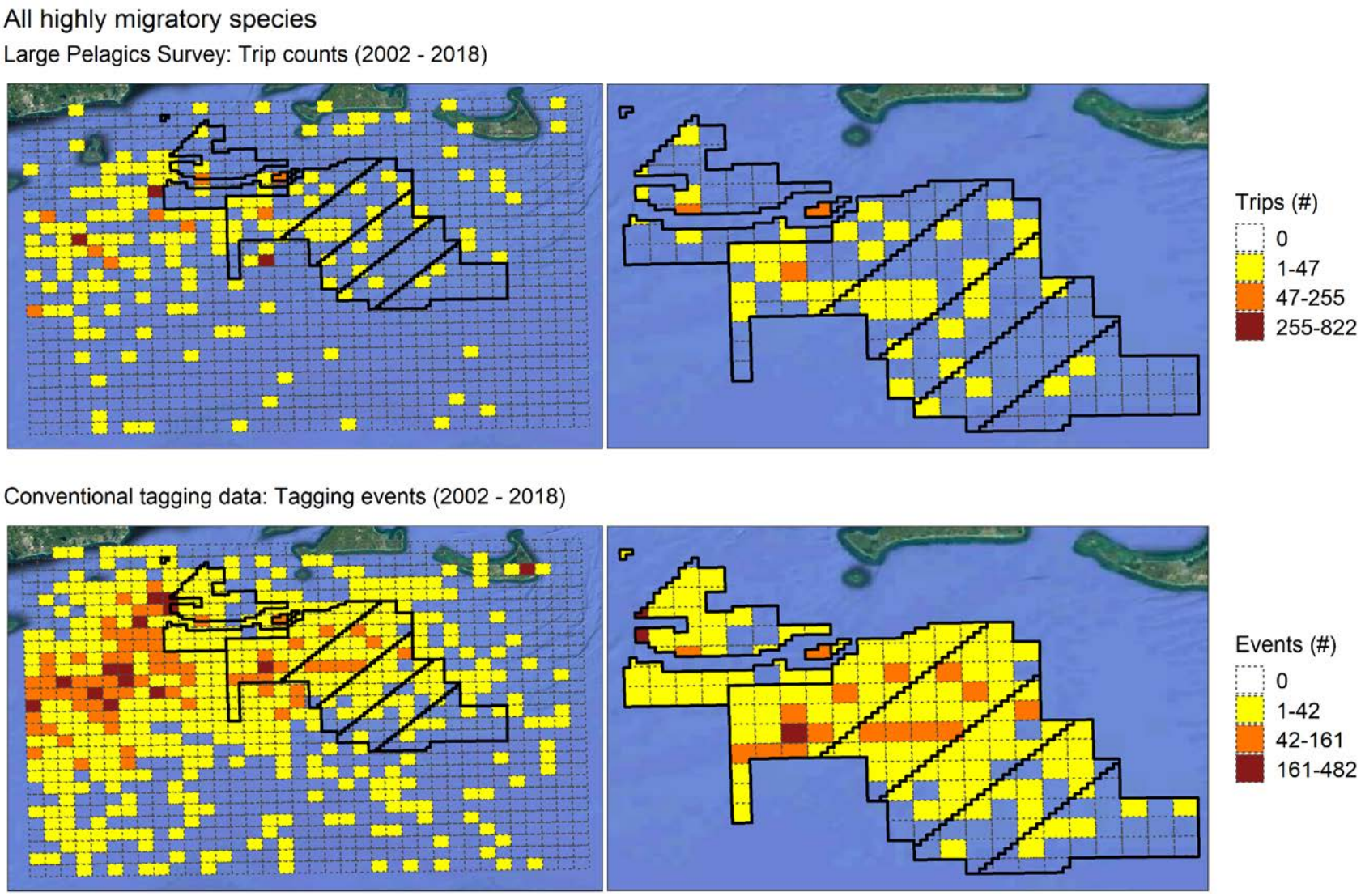

Figure 26 – Comparison of the distribution of recreational fishing effort for all highly migratory species (HMS) over the southern New England (SNE) grid (left) and Wind Energy Area (WEA; right) based on the Large Pelagics Intercept Survey (LPS; top) and conventional tagging data (CTD; bottom) from 2002 – 2018. Refer to Table 7 for a list of species represented in the figure.