AMENDMENT 8 APPENDIX XXX

SPATIAL/SEASONAL OVERLAP BETWEEN THE MIDWATER TRAWL HERRING FISHERY AND PREDATOR-FOCUSED USER GROUPS

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INTRODUCTION

The Council has identified that a need for Amendment 8 to the Atlantic Herring Fishery Management Plan is "to minimize possible detrimental biological or socioeconomic impacts on other user groups (commercial, recreational, ecotourism) who depend upon adequate local availability of Atlantic herring to support business and recreational interests both at sea and on shore." Alternatives in Amendment 8 include several time/area closures for the Atlantic herring fishery, particularly the midwater trawl (MWT) herring fishery. These closures would likely reduce the potential for user conflicts between the MWT herring fishery and groups that are focused on the predators of herring, including the tuna, groundfish, and striped bass fisheries, as well as commercial whale watching.

The objective of this analysis was to identify the seasons and areas that have been important to the MWT herring fishery and these other user groups, as this is when and where the greatest conflict is expected to occur. For fishery-dependent data, total reported landings were used to represent the 'importance' to a fishery. For commercial whale watching, maps complied from a survey of industry experts served to identify areas of importance.

Midwater trawling for Atlantic herring was previously restricted in 2007 to minimize the localized depletion of forage fish through Amendment 1. That action prohibited MWT herring fishing in Herring Management Area (HMA) 1A during the months of June through September. As such, the current analysis evaluated the overlap between user groups under three different time periods: 1) pre-Amendment 1 (2000-2006); 2) post-Amendment 1 (2007-2015); and 3) recent (2013-2015).

DATA SOURCES

Midwater Trawl Herring Fishery

All trips using MWT to harvest Atlantic herring are reported to NOAA Fisheries via vessel trip reports (VTRs). These reports include one pair of coordinates (lat/lon) for each statistical reporting area fished per trip, assumed to represent the average location of fishing effort. A significant fraction of these trips are also documented by the Northeast Fisheries Observer Program (NEFOP), providing reliable tow-level locations. Using a statistical model of the relationship between VTR and NEFOP positions for this fishery, the Northeast Fisheries Science Center (NEFSC) can provide maps of the estimated location of herring catch by year and month. Essentially, this method integrates the completeness of the VTR census data with the positional accuracy of the NEFOP data (DePiper 2014).

Groundfish Predator Fishery

Based on NEFSC diet data, Atlantic cod, Pollock and spiny dogfish were the "groundfish" species considered to have Atlantic herring as a major part of their diet. VTR records for these species were prepared in an identical way to the MWT herring data, except that no gear distinction was made (i.e., all gears were included).

Striped Bass Fishery

The overlap between the striped bass fishery and the MWT herring fishery cannot be evaluated for several reasons. While only coarse spatial information (statistical reporting areas) is collected from the Massachusetts commercial bass fishery, no spatial information is available to describe where recreational fishing takes place at sea. Regardless, striped bass fishing is prohibited in federal waters, and the MWT fishery is prohibited from operating in Massachusetts state waters. Midwater trawling does occur in Rhode Island state waters, but primarily in December-January when striped bass have migrated out of New England coastal waters. In short, we lack sufficient spatial data to quantify the overlap between these two fisheries, but it is expected to be minimal.

Bluefin Tuna Fishery

While the bluefin tuna fishery is required to report all landings to the Highly Migratory Species (HMS) division of NOAA, these data lack any information about fishing location, apart from very course zones (ten from ME to TX). Seafood dealers that purchase bluefin tuna directly from fishermen are required to report the statistical reporting area where the fish were caught; however, these data are of a spatial resolution too coarse to be useful here. Commercial tuna fishermen with VTR reporting requirements (e.g., groundfishermen) are required to submit coordinates (lat/lon) associated with all commercial fishing trips, including those targeting tuna. Within this group of fishermen, charter/party permit holders report differently (number of fish landed) than general commercial permit holders (pounds of fish landed). Lacking a reasonable method for combining these disparate data types, this analysis focused exclusively on the commercial VTRs, which represent the larger portion of VTR tuna records. Collectively, these commercial tuna VTR records include almost 10,000 trips between 2000 and 2016 (Figure 2), and account for ~10-20% of the total annual bluefin tuna landings reported to HMS in a given year. Although VTR records encompass a relatively small portion of the entire fishery, they represent the only source of data with sufficient spatial resolution to inform this overlap analysis. The raw VTR coordinates were used to represent harvest location, because there are no NEFOP data for this fishery from which to construct a VTR-NEFOP spatial model, as was done with groundfish and herring. Reported bluefin tuna landings from all gear types were included in this analysis.

Commercial Whale Watching

As part of the Northeast U.S. ocean planning process, a survey of 32 industry experts was conducted in 2014 to record the spatial and seasonal distribution of whale watching activity in the Northeast U.S. (Bloesner et al. 2015). Participants were asked to identify "dominant use" areas that represent all the areas routinely visited by most users over the past 3-5 years, as well as the seasons these areas were important.

Several steps were required to prepare the whale watch data, so that it could be used in an overlap analysis with the MWT herring fishery. If a 'dominant use' whale watch area had a season associated with it, it was assigned to specific months using the following definitions:

- Spring = April-June;
- Summer = July-September;
- Fall = October-December.

If no season was associated with an area, it was assumed to apply to all months April-December. No significant whale watching activity was assumed to occur between the months of January-March. Lacking a description of the relative importance of whale watch areas over time, the seasonal/spatial pattern was assumed to be constant across all years.

OVERLAP ANALYSIS

Each data source was subset by month and summarized to a common raster grid with 10 km x 10 km cells (Figure 3 to Figure 6). For fishery-dependent data (herring and groundfish), the average pounds landed per month in each grid cell was divided by the sum of the average annual landings over the entire domain (within the Herring Management Areas), so that the collection of monthly raster grids summed to 1.0. For whale watch data, no quantitative distinction was made between areas; instead, any cell that was identified as 'dominant use' in a given month was assigned a value of 1, with all other areas given a value of 0. As with the fishery data, the monthly whale watch rasters were normalized to sum to 1.0 over the year.

A simple overlap index was then calculated between each pair of normalized datasets (i.e., MWT herring vs. other): for each grid-cell x month combination, the minimum value across the two datasets was identified (Figure 1). This yields a set of monthly rasters that show the relative intensity of spatial and seasonal overlap. Summing the cell values across a set of monthly overlap rasters yields an index value that ranges from 0 (no overlap) to 1 (complete overlap), allowing for a description of the relative change in overlap over time, across seasons or between dataset pairs.

A comparison of each of the relevant alternatives from Amendment 8 was made with respect to the results of the overlap analysis for the full post-Amendment 1 time period (2007-2015; Figure 12), as well as the most recent three years (2013-2015; Figure 13). For each alternative and sub-option, the fraction of the total overlap encompassed by the measure was calculated. It is important to note that this analysis does not address the potential re-allocation of MWT herring effort that is displaced by an alternative.

RESULTS

Summary of overlaps: The level of overlap between the MWT herring fishery and all predator users analyzed dropped significantly in 2007 with the passing of Amendment 1 (Figure 10). The seasonal profile of overlap has also changed since 2007 (Figure 11), with less overlap in summer months in recent years. These changes in seasonal overlap are due, in part, to Amendment 1, but also to changes in the distribution of predator-based activities caused by modifications to the spatial management system (e.g., groundfish closed areas).

Overlap with commercial groundfish fishery: In all three time periods, the greatest amount of overlap between the MWT herring and groundfish predator fisheries occurred near Cape Ann in October-November (Figure 7). Prior to Amendment 1, significant overlap also occurred in this area during the summer months; however, this interaction has been minimal since 2007. In the recent time period, the most important herring-groundfish overlap *outside of* HMA 1A occurred

along the northern edge of Georges Bank in May, off outer Cape Cod in July-August, the Great South Channel in September, and near Block Island in December-January.

Overlap with bluefin tuna fishery: In all three time periods, the overlap between the MWT herring and bluefin tuna fisheries was greatest during October near Cape Ann (Figure 8). Prior to Amendment 1, overlap between these two fisheries also occurred in HMA 1A during July-September. More recently, there has also been relatively high overlap along the northern edge of Georges Bank during November.

Overlap with the whale watch industry: Prior to Amendment 1, the greatest overlap between the MWT herring fishery and commercial whale watch operators occurred in several areas within HMA 1A from May-November (Figure 9). As with the other user groups focused on herring predators, the summer HMA 1A overlap no longer exists and currently the area with the greatest overlap is near Cape Ann during October-November. It should be noted that any inference about the change over time in overlap with whale watching comes entirely from the MWT herring dataset, as the spatial/seasonal pattern for whale watching was assumed time-invariant.

Overlap relative to the alternatives: Alternative 3 (year-round prohibition of MWT herring fishing in HMA 1A) and the widest shoreline buffer alternatives (Alt 5 and Alt 6) with the year-round sub-option encompassed the largest portion of overlap with the groundfish predator fisheries (up to 20-45%; Figure 12 and Figure 13). For the commercial tuna fishery, Alternative 3 by far encompassed the greatest portion overlap with the MWT herring fishery (50-60%), with all other alternatives covering <20%. Similarly, Alternative 3 encompassed >90% of the overlap with the whale watching industry, with all other alternatives covering <10%.

REFERENCES

Bloesner J, Chen C, Gates M, Lipsky A & Longley-Wood K (2015). *Characterization of Coastal and Marine Recreational Activity in the U.S. Northeast*. Report to the Northeast Regional Planning Body. 251 p. https://www.openchannels.org/literature/1445270045.

DePiper GS (2014). *Statistically Assessing the Precision of Self-reported VTR Fishing Locations*. Woods Hole, MA: U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NE-229. 22 p.

Figure 1 - Three examples of overlap calculation between the MWT herring fishery and a predator-user: A) no overlap; B) complete overlap; and C) some overlap

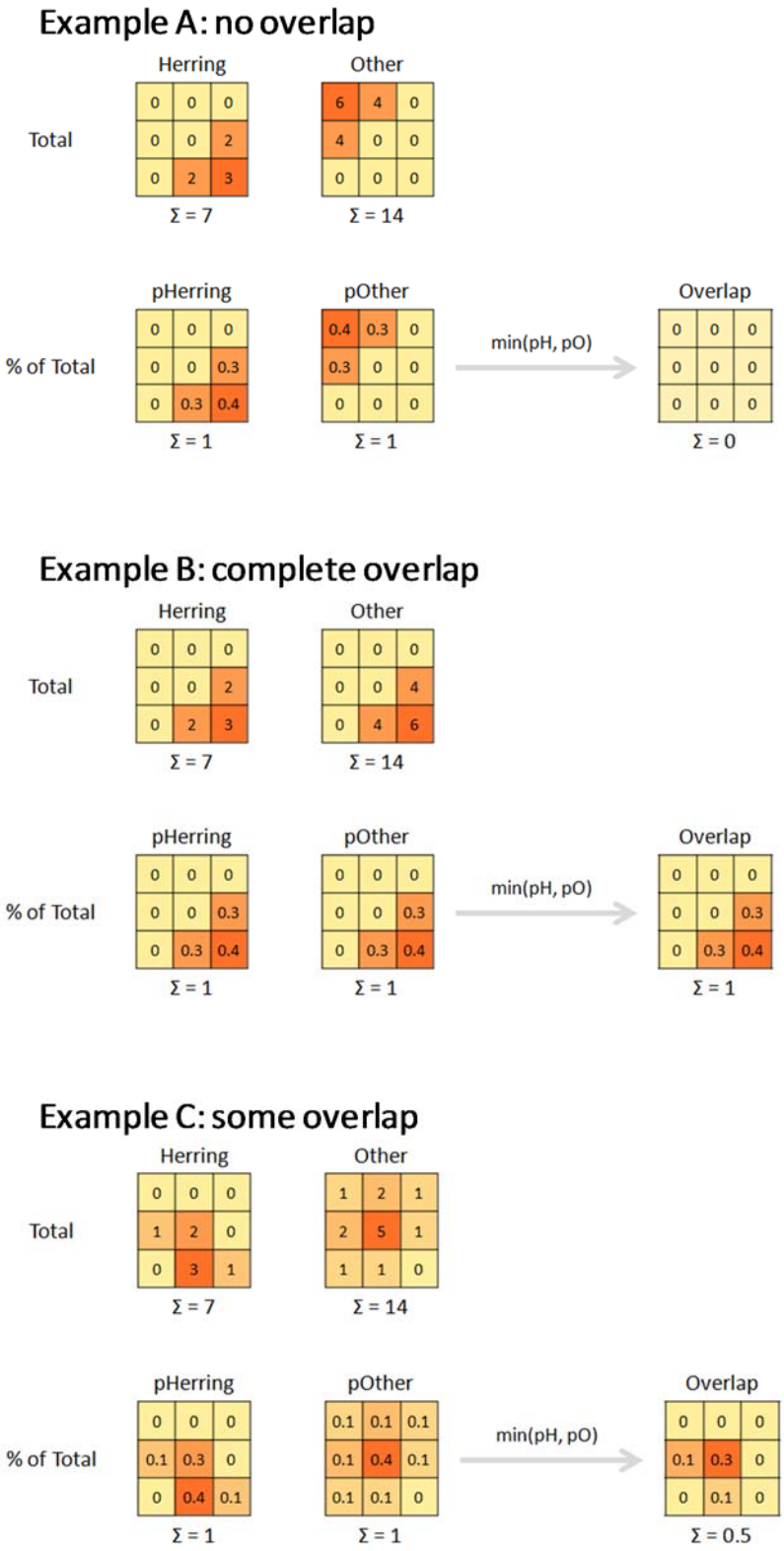
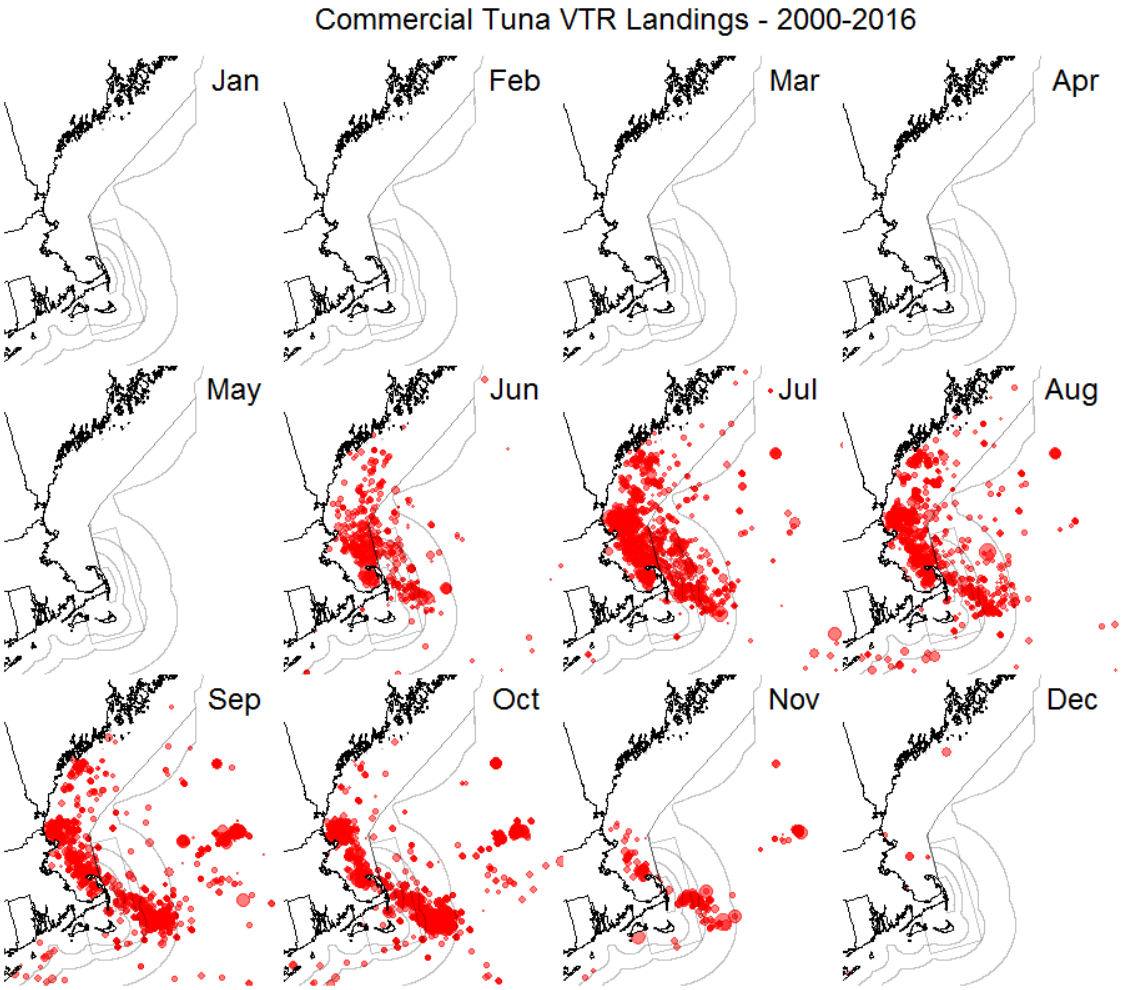


Figure 2 - Spatial distribution VTR-reported bluefin tuna landings, 2000-2016



Note: The size of the bubbles is proportional to the pounds landed. The purpose of this figure is to demonstrate the volume of tuna VTR data used in this analysis. Because this fishery is spatially concentrated at certain times of year (many overlapping VTR points), the summarized raster layers representing total annual landings are dominated by just a few 10 km x 10 km grid cells (Figure 5).

Figure 3 - Average annual reported landings (lbs/km^2) of Atlantic herring by MWT trawl, as estimated by VTR-NEFOP spatial model

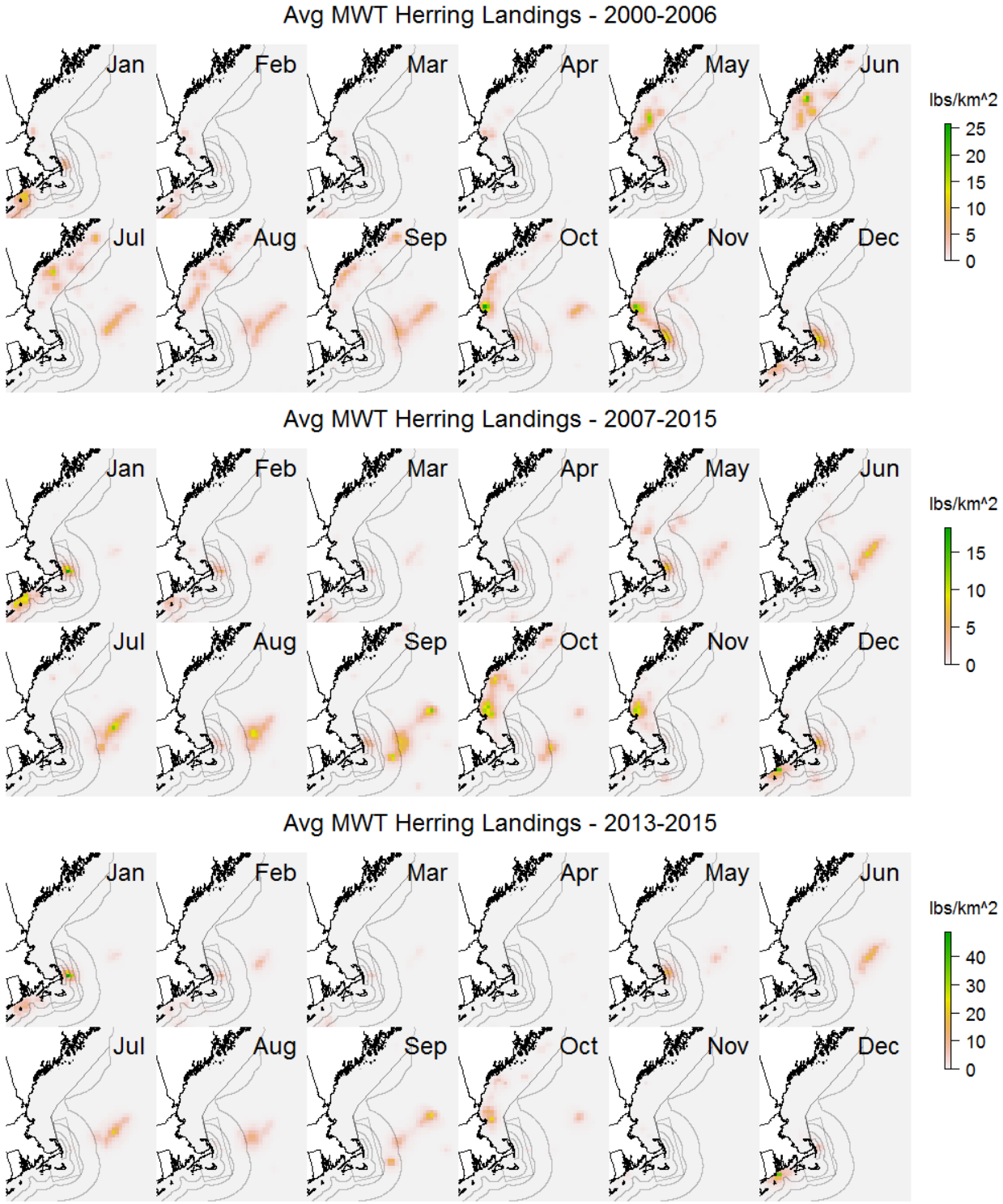


Figure 4 - Average annual reported landings (lbs / km^2) of groundfish predators of herring, as estimated by VTR-NEFOP spatial model

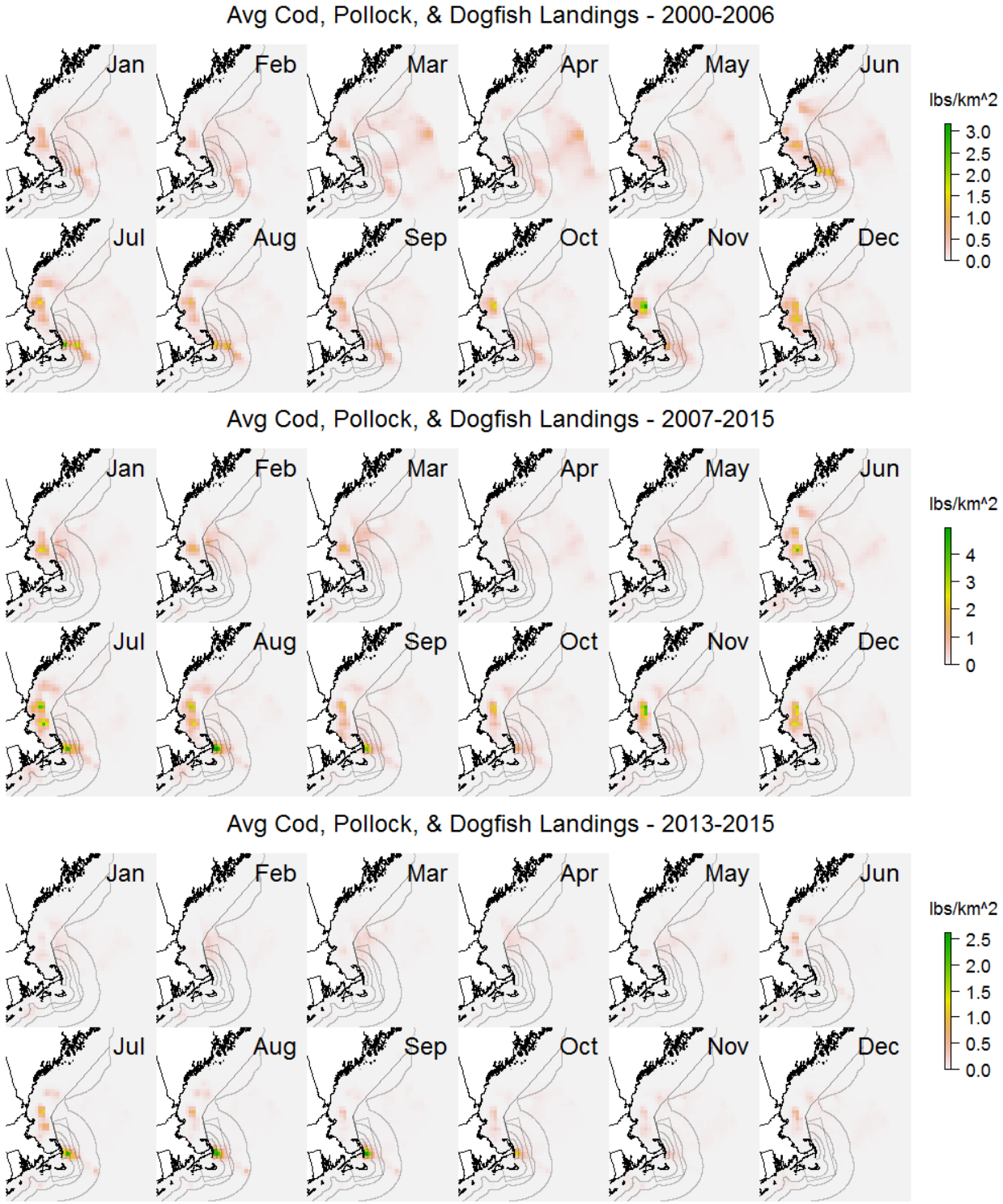


Figure 5 - Average annual reported landings (lbs/km^2) of bluefin tuna, as reported by VTR and summarized to the 10km x 10km grid

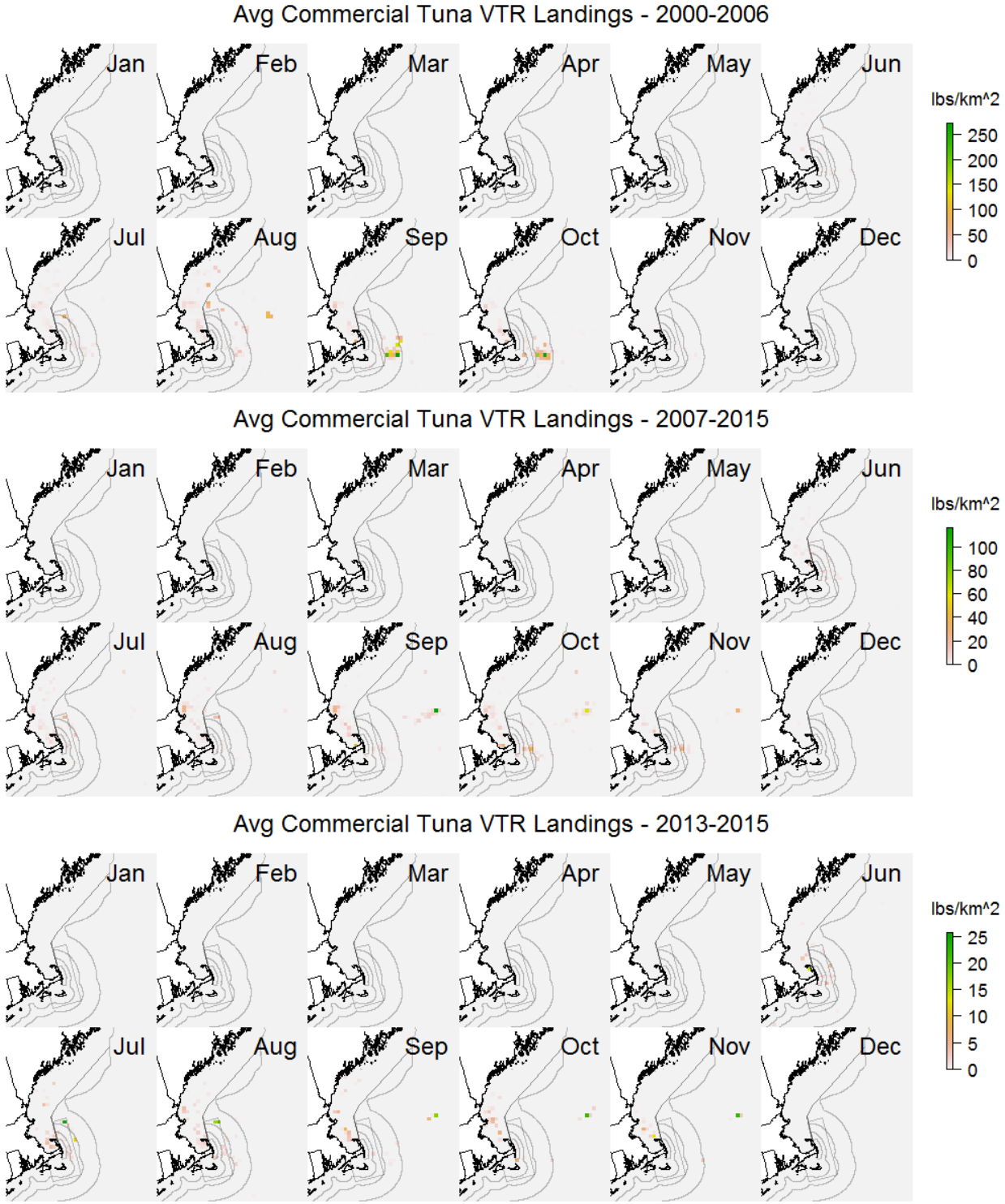


Figure 6 - Dominant use whale watch areas by month, as recorded by Bloesner (2015)

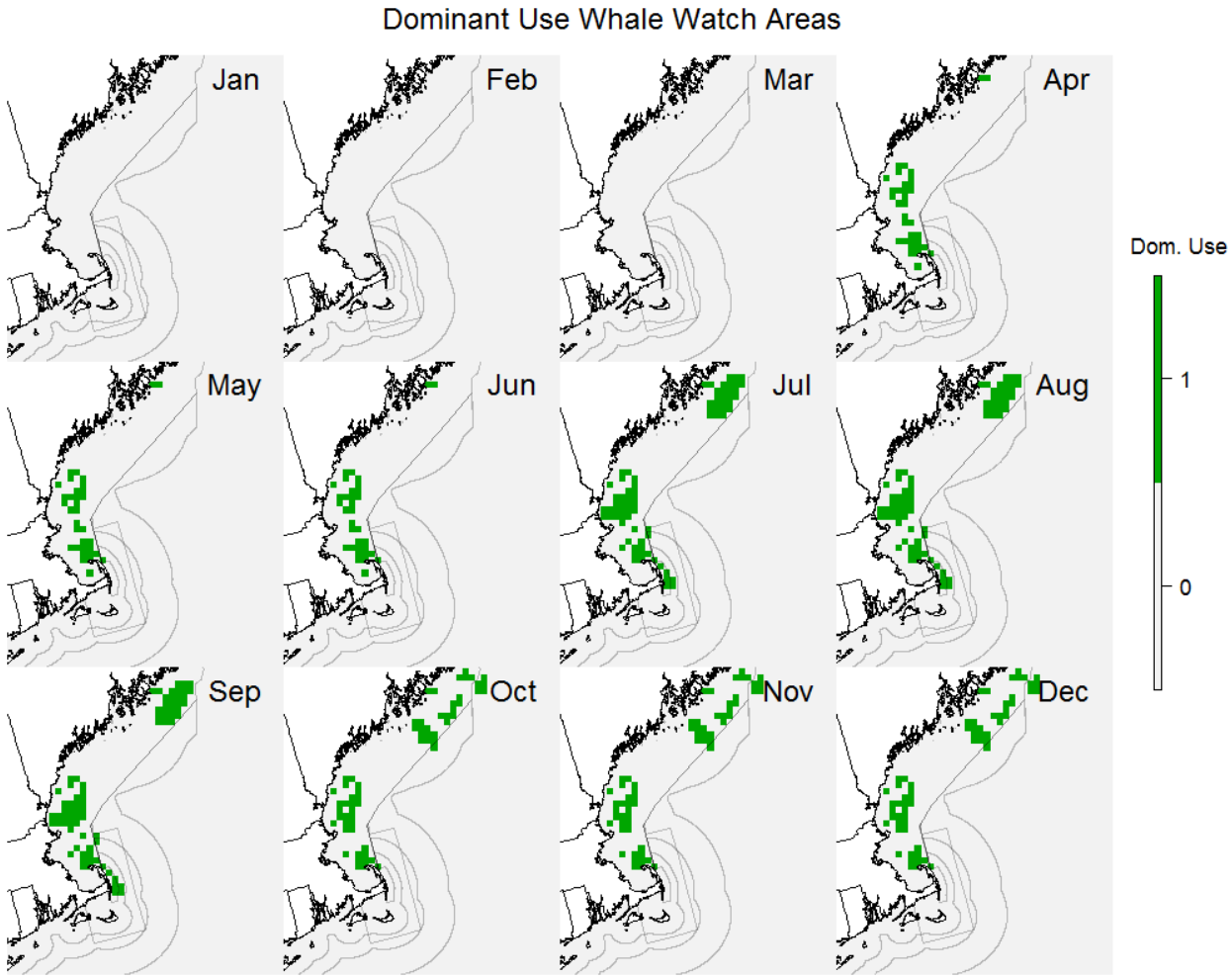


Figure 7 - Overlap between the MWT herring fishery and the fishery for groundfish predators of herring (cod, pollock and dogfish)

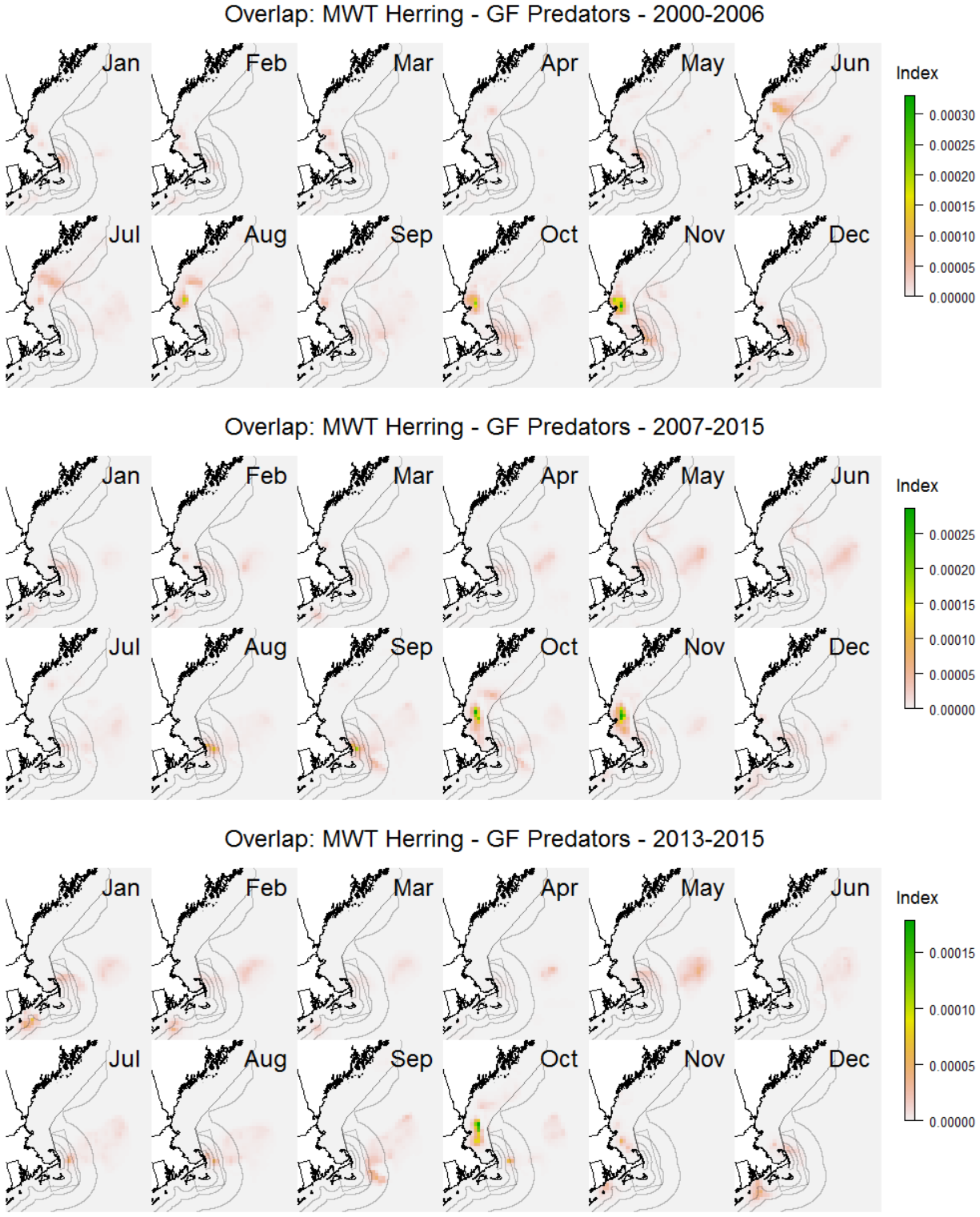


Figure 8 - Overlap between the MWT herring and the commercial tuna fisheries

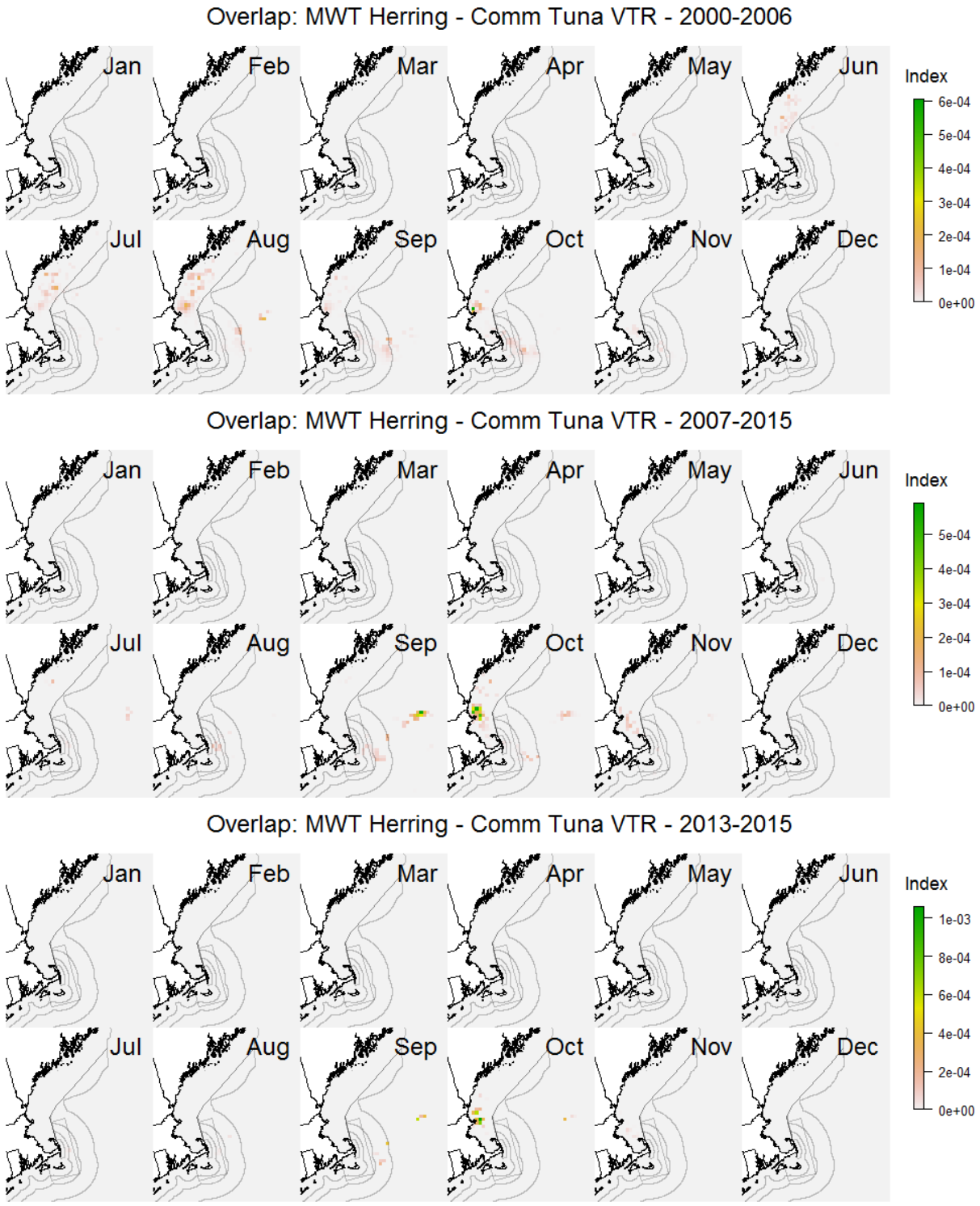


Figure 9 - Overlap between the MWT herring fishery and commercial whale watch operations

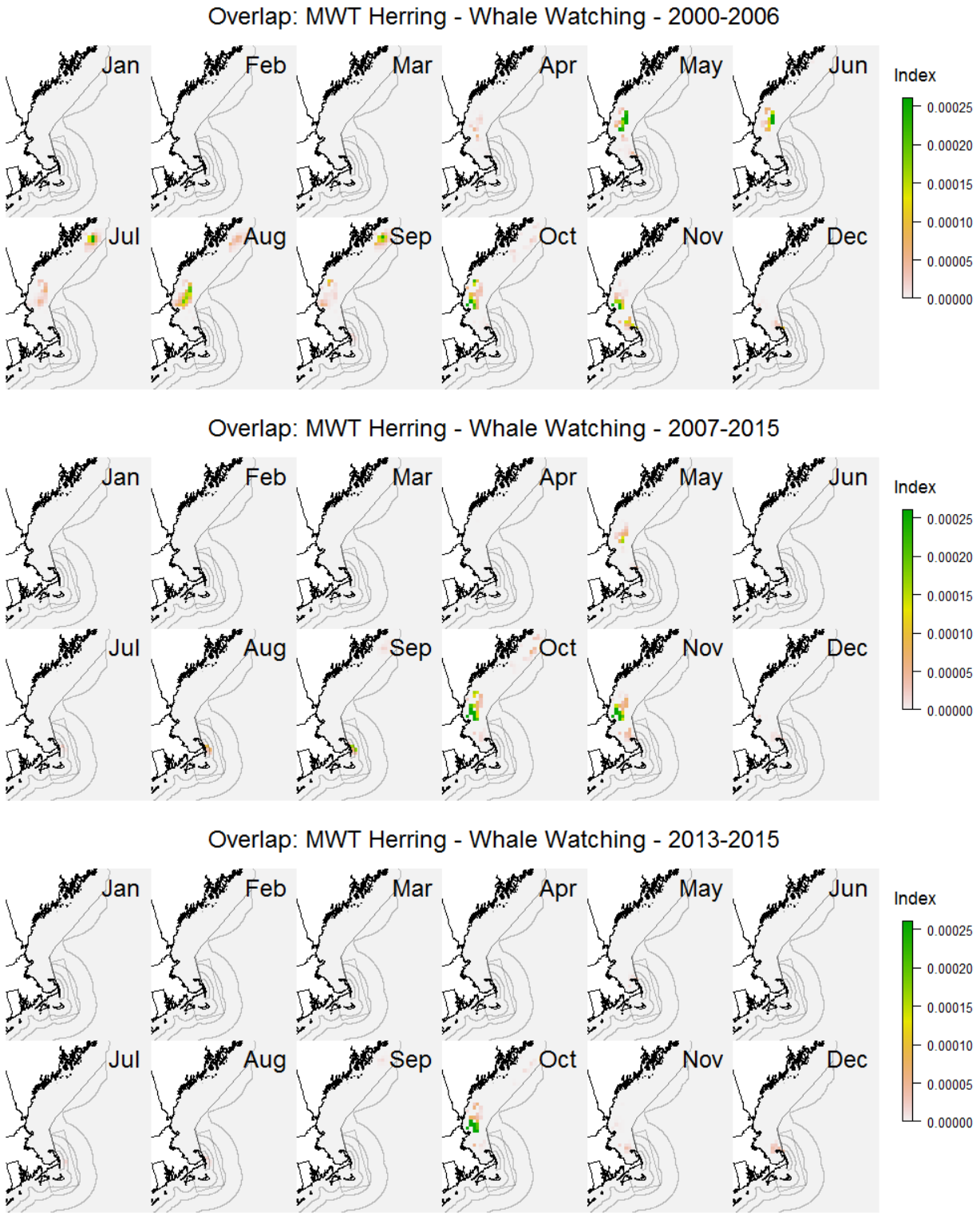


Figure 10 - Annual index of overlap between the MWT herring fishery and other predator-focused user groups

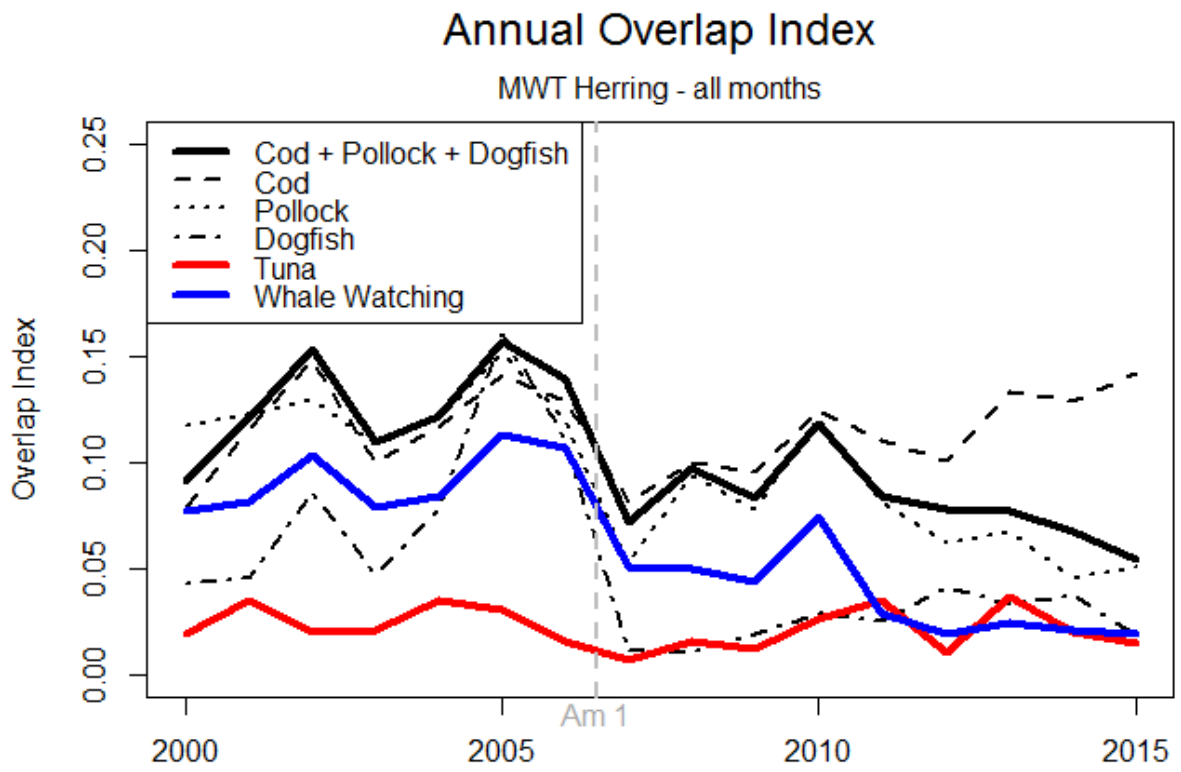


Figure 11 - Seasonal index of overlap between the MWT herring fishery and other predator-focused user groups, under three different time periods

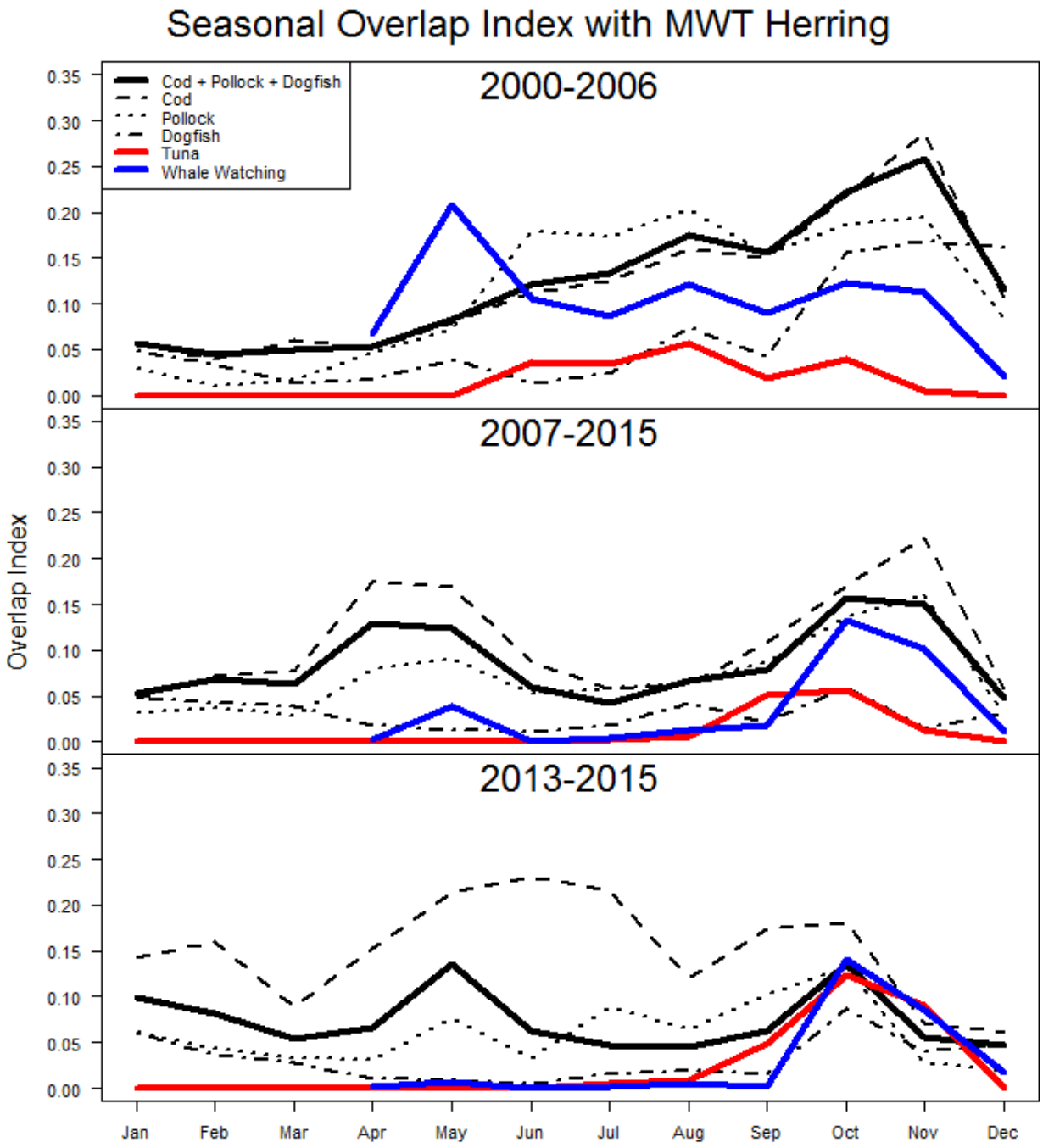


Figure 12 - Percent of the total overlap between the MWT herring fishery and predator-focused user groups encompassed by each alternative, 2007-2015

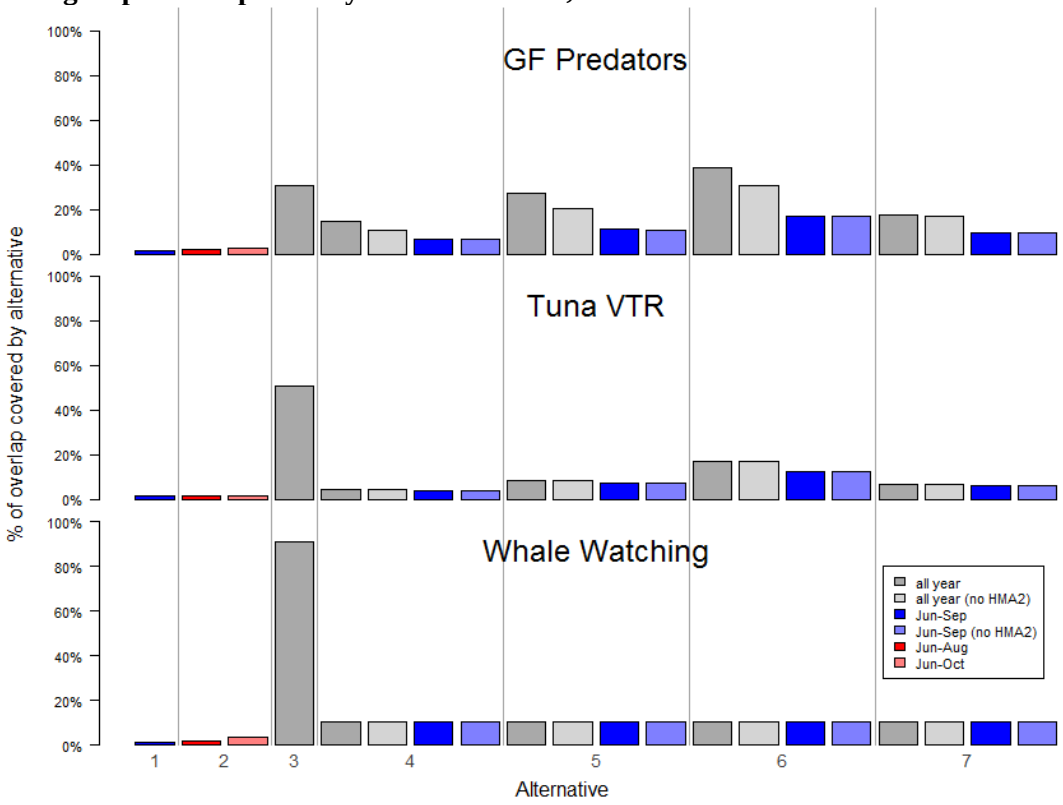


Figure 13 - Percent of the total overlap between the MWT herring fishery and predator-focused user groups encompassed by each alternative, 2013-2015