Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Atlantic Menhaden Work Group

DATE: April 23, 2025

SUBJECT: Precautionary Management of Chesapeake Bay

Executive Summary

At its August 2024 meeting, the Atlantic Menhaden Management Board (Board) agreed to form a Work Group of Board members to "consider and evaluate options for further precautionary management of Chesapeake Bay menhaden fisheries, including time and area closures to be protective of piscivorous birds and fish during critical points of their life cycle." This charge asserts there is an inadequate supply of menhaden to support overall predatory demand in the Bay. However, the Work Group addressed this charge without determining if there is or is not an adequate supply of menhaden to support predatory demand in the Bay. Instead, it has developed feasible management approaches, and it is the responsibility of the Board to determine if or when it is necessary to implement them. The Work Group represented a balance of different backgrounds, regions, and perspectives; the members were:

Martin Gary (NY, Chair), Ray Kane (MA), Rob LaFrance (CT), Loren Lustig (PA), Joe Cimino (NJ), Allison Colden (MD), Pat Geer (VA), Spud Woodward (GA).

The Work Group met nine times between September 2024 and April 2025 via webinar and in-person to discuss alternatives for precautionary management in Chesapeake Bay that could be considered if the Board chooses to initiate a management document. Additionally, the Work Group created two subgroups, which each met once in September 2024, to begin evaluating data sources for piscivorous bird and fish species, respectively. In addressing the Board task, the Work Group developed the following questions to guide their consideration of potential management approaches:

1. What is the problem any management action would address?
2. What are the priority species to consider, and what are the critical points of their life cycle?
3. What data can be used to support this discussion?
4. For each management strategy discussed, what are the benefits and implications?
5. How would the performance of potential measures be evaluated?

The availability of menhaden may be affected by changes in total abundance, size distribution of the population, and timing of presence and spatial distribution in the Bay, which can be caused by fishing pressure, environmental conditions, habitat suitability, and/or changing predation pressures on a limited spatial and temporal scale. Such changes in menhaden availability may affect the species' ability to fulfill its ecological and/or economic functions. Recent observations of below average commercial fisheries landings and declining population reproductive rates of ospreys within the mainstem Chesapeake Bay suggest that availability of menhaden in Chesapeake Bay is likely changing due to one or more of the above drivers.

Potential Management Approaches

Based on the life history of the predators examined, the nature of Chesapeake Bay menhaden fisheries, and recent changes in menhaden availability, the Work Group discussed a number of precautionary management options that the Board could consider for further action. The approaches listed below could be implemented individually or in combination, depending on the Board's risk tolerance and management goals. A full description of the background information considered and the potential management options under each approach can be found in the Work Group report.

A. Seasonal Closures

Many of the species examined are seasonal inhabitants of Chesapeake Bay, utilizing the area as spawning and nursery grounds. Some species, like striped bass, have population contingents that are full-time residents in the Bay while other individuals leave the Bay to join the coastal migratory stock. Bird predators, particularly osprey, show high consistency in their arrival and departure times in the Chesapeake Bay, with only slight variations from year to year due to weather patterns.

Due to the seasonality of predator demand in the Bay, seasonal closures may be a management option that could reduce menhaden harvest during certain times of the year that are critical to predators' life cycles. This option presumes that decreasing menhaden harvest during these times of year will allow more menhaden to be available as forage for predators. Although, the Work Group noted concerns that implementing seasonal closures may lead to a concentration of harvest effort during other times of the year with unknown or unintended consequences. The Work Group discussed a suite of possible seasonal closure options, which focus primarily on the needs of the osprey population as a proxy for other predators as they exhibit relatively predictable seasonal habits and are showing signs of food stress. Ospreys have the highest and most critical bioenergetic requirements between May 1st and August 15th, and the range of options discussed includes subsets of this timeframe with considerations for the impacts to ospreys and menhaden fisheries.

B. Area Closures

A September 13, 2024, press release by Dr. Bryan Watts of the College of William and Mary's Center for Conservation Biology, compiled the 2024 osprey breeding performance in Chesapeake Bay. The study found all nesting pairs in waters with salinity greater than 10 ppt had some level of deficiency while the upriver sites were considered reference sites having a surplus at 1.36 young per nesting pair. Six of the Bay sites had what was defined as "major deficit" with < 0.6 young/pair.

Based on the results of this study and the Board task, the Work Group discussed a range of spatial closures that may increase the availability of menhaden for ospreys throughout the Bay, particularly in areas that exhibited the highest reproductive deficit. The Work Group considered mapping fishing effort over the 12 study areas to better inform potential targeted closures, but there was not a consensus within the group on the use of this method.

Additional closure options discussed by the Work Group include closure of all Chesapeake Bay (including or excluding existing MOU areas), closures based on fishing effort, or closures based on areas with the most scientific information on osprey reproduction and survival.

C. Effort Controls

The implementation of quota periods or days out provisions could be used to distribute fishing effort more evenly throughout the season. These provisions are similar to management of the Atlantic herring fishery in which quota periods are used to manage catch toward bimonthly, trimester, or seasonal quotas to effectively manage catch to meet the needs of the fishery and bait market demand.

D. Gears Included in Potential Management Actions

The Work Group discussed the possibility of restricting potential seasonal and/or spatial closures to certain gear types or sectors based on landings or potential impacts to other fisheries but did not reach a consensus on the use of this approach. The Board will need to closely consider the applicability of management options across gears and sectors if further action is taken.

E. Decreasing Chesapeake Bay Reduction Fishery Cap

The Board could further reduce the Chesapeake Bay reduction fishery cap, which is currently based on historical landings, to reduce the impacts of reduction fishing in Virginia waters of the Chesapeake Bay. This would presumably leave additional menhaden as forage in Bay waters for all predators. This option could be combined with quota periods or other effort controls to help

distribute effort more evenly throughout the fishing season. In the past, reductions in the Bay cap have reflected recent Bay landings, usually from the previous five years. While more than 5 years have elapsed since the last update of the Bay cap, average landings have been at or near the 51,000 metric ton cap, indicating a reduction based on landings is likely to be small, if there is a reduction at all. Therefore, the Board may need to consider a novel approach to setting the Bay cap based on information provided by the Work Group or from other sources.
Reduction of the Bay cap is a conservative option considering it only impacts the reduction fishery within Chesapeake Bay. Reducing the Bay cap does not impact the quota allocation of the reduction fleet, only the amount of the allocation that may be caught within Chesapeake Bay waters. This option also precludes any negative impacts to bait fisheries which serve crab and lobster fisheries along the coast as it only applies to the reduction fishery. The Work Group also noted that the Bay cap is a precautionary measure and further research is needed to develop a biologically-based cap.

F. Research Recommendations

In reviewing the information to meet its charge, the Work Group identified several areas in need of additional research and data to address questions beneficial to ecological management of menhaden fisheries in Chesapeake Bay and beyond. The resulting research recommendations can be found in the Work Group report.

Work Group Report

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Background

In August 2024, USGS staff presented to the Board a summary of the latest information regarding osprey abundance, spatial and temporal distribution, dietary demands, and timing of fledge in the Chesapeake Bay region, as well as ongoing research and information gaps. Osprey data comes from two primary sources: the North American Breeding Bird Survey and the eBird database. Long term trends show significant population growth from both a continental and regional perspective. Since 1966, osprey abundance has shown a 299% increase in North America, a 587% increase on the Atlantic coast, and a 1,801% increase in Chesapeake Bay. However, since 2012, eBird data estimates show declines in some areas around Chesapeake Bay, particularly in the lower Bay where local reproductive rates have declined sharply since 1975 to below the population maintenance level. There are numerous pressures that may affect osprey reproduction, including food availability, habitat loss leading to greater levels of inter- and intraspecific competition, disease, algal blooms, inexperienced breeders, environmental contaminants, and water depth and clarity. Additionally, abundance indices in other Atlantic and Pacific coast states show similar plateauing and short-term declines since 2012. Osprey diet composition varies by salinity in different regions of the Bay with menhaden being the second-most consumed species in the higher salinity areas, including the lower Bay. Ongoing research in Chesapeake Bay seeks to compare the availability of osprey prey, including menhaden and other fish species, between current and historical populations.

Osprey Residence and Prey Needs in Chesapeake Bay

Ospreys begin to arrive in lower Chesapeake Bay in late February and arrival peaks by mid-March, and slightly later in the more northerly portions of the Bay (Bent 1937; Reese 1991; Watts and Paxton 2007). Most breeders are here by late March. A cutoff for arrival of breeders is typically taken to be 15 April.

Departure schedules for breeding adults and hatch-year birds differ by as much as a month with adults initiating migration in late August through mid-September and hatch-year birds leaving later (Poole 1989; Watts and Paxton 2007). It should be noted that during the early fall there is a mix of resident birds and migrants (from northern breeding populations beyond the Bay).

The most bioenergetically demanding period during the annual cycle is when osprey pairs are raising broods. Historically, this period has been from mid-May through mid-July (B.D. Watts, The Center for Conservation Biology, William and Mary, written communication, December 4, 2024). Figure 1 indicates that the period of highest energy demand at the population level is from mid-May through mid-August. It is important to note that the period of peak demand is not necessarily the period of critical demand. Most broods are lost within the first 2 weeks of development. Their demand is relatively low at that age, but the adults must meet that demand, or they will die. Older chicks have more energetic reserves and can overcome short periods of food deficit; young chicks cannot. It is critical that enough fish be available that can be captured by adults and delivered to the nest during the May period so that broods can make it through this bottleneck.

Ospreys prefer to nest over water when appropriate substrates are available, presumably related to the “escape from ground predator” benefits (Poole 1989). Prior to the 1960s, the majority of nests were on snags and live trees. Since the 1960s, the majority of nests have shifted to human-made structures (Watts et al. 2004; Watts and Paxton 2007). There have been a couple of waves of the appearance of human-made structures including the rapid expansion of aids to navigation during the 1970s, and then later the rapid expansion of private osprey platforms since the 1990s. Thus, there have been shifts in substrate use over time, but the general requirements remain unchanged. Ospreys prefer stable structures that offer protection from predators and are near adequate sources of fish (Poole 1989; Watts and Paxton 2007).

Ospreys exhibit high nest site fidelity. Generally, once a nest site has been established, the pair will use it for many years or until there has been a change to the structure (Poole 1989). If the nest is lost to weather or to human removal, the pair will rebuild the nest. However, if the structure itself is lost or altered in some functional way, the pair is forced to select another structure typically within a short distance of the original nest. If no appropriate structure is available after its loss, the pair will move and find a new place. Nest substrate can certainly be limiting in various parts of the Bay, but more so historically than now due to the proliferation of nestable human-made structures.

In some populations most of the foraging is within site of the nest (< 2 km), but in others it can range much further (15-20 km). Some individuals have preferred hunting areas and spend quite a bit of their time in those areas, while others are much more variable in where they forage. Across pairs, a high proportion of prey come from within 10 km of the nest site (Poole 1989).

Osprey have evolved a behavioral mechanism to match the brood demand to the available food. Many pairs in Chesapeake Bay hatch three chicks. If there is enough food to provision all of the chicks, then all will develop and grow synchronously and survive. If there is not enough food to sufficiently provision the three chicks, then a dominance hierarchy will form, and subordinate chicks will be fed last and may die. This process is referred to as brood reduction – reducing the brood and associated metabolic demand to match food availability. If the dominant chick does not get enough food, the nest will fail. Brood reduction on a large scale is an indicator of food stress (Poole 1982; Hagan 1986; Eriksson 1986; Bowman et al. 1989; Steidl and Griffin 1991; Machmer and Ydenberg 1998).

For Mobjack Bay, substantial declines in reproductive rates, overall provisioning rates, provisioning rates with menhaden, proportion of the diet comprised of menhaden and diet quality have been documented. An increase in male foraging time and brood reduction has also been observed. Importantly, reproductive rates have transitioned from surplus to deficit (Academia and Watts 2023; Watts et al. 2024) and brood size has declined significantly (Watts et al. 2024; Table 1).

In 2024, 12 study areas were monitored in Chesapeake Bay including 10 within the main stem of the Bay (salinity >10 ppt) and 2 in the lower salinity reaches (<1 ppt). All main stem sites were in reproductive deficit, while the 2 lower salinity reference sites were in reproductive surplus. During the nesting period, osprey are dependent on one to two species for prey. In Mobjack Bay, menhaden comprised nearly 75% of fish provided to broods in the late 1980s (Watts et al. 2024). Currently, it is believed that ospreys nesting in much of the main stem of the Bay are menhaden dependent with menhaden comprising 44% of the osprey diet at Poplar Island and 24% in the lower Bay near the Eastern Shore of Virginia. Osprey in low salinity areas do not depend on menhaden as prey (Glass and Watts 2009; Lazarus et al. 2016), instead relying on fish abundant in these regions, including catfish, gizzard shad, and Atlantic croaker.

Menhaden Fisheries in Chesapeake Bay

The Atlantic menhaden commercial fishery in Chesapeake Bay consists of a reduction fishery and a bait fishery. The Virginia reduction fishery has been in operation for 147 years in Reedville, Virginia, and provides fish meal, fish oil, and fish soluble products. The bait fishery is the primary source for the blue crab pot fisheries and chum bait from Delaware to Florida, as well as a provider to the New England lobster fishery.

Virginia's menhaden quota for 2023 was 388,140,547 pounds (75.21% of coastwide quota); Maryland's quota was 5,965,566 pounds (1.17% of coastwide quota). Virginia further allocates its in-state quota between sectors with the reduction fleet receiving 90.04%, the purse bait sector receiving 8.38% and the non-purse seine bait fisheries receiving 1.58%. Purse seine gears including bait purse seiners comprise the overwhelming percent of Virginia's menhaden harvest over the past five years (2000 – 2024) at 98.4% (88.7% reduction and 9.7% bait). Gill net and pound net harvest for bait are 0.80% and 0.77% respectively. Maryland's commercial fishery is exclusively a bait fishery and is primarily harvested by pound nets. Between 2019-2023, Maryland has landed an average of 35.9% of its total quota, approximately 2.8 million pounds.

Virginia Purse Seine Fisheries

The Virginia purse seine fisheries (both reduction and bait) use spotter aircraft to locate schools of menhaden and direct vessels to the fish. When a school is located, two purse boats, with a net stretched between them, are deployed. The purse boats encircle a portion of the school and close the net to form a purse, or bag. The net is then retrieved to concentrate the catch, and the mother ship comes along the side and pumps the catch into refrigerated holds. Individual sets can vary from 10 mt to more than 100 mt, and large vessels can carry 400-600 mt of refrigerated fish.

Purse Seine Reduction Fishery

The menhaden reduction fishery is seasonal as the presence of menhaden schools is dependent on the temperature of coastal waters. Two fairly distinct fishing seasons occur: the "summer fishery" and the "fall fishery". The summer fishery begins in April with the appearance of schools of menhaden off the North Carolina coast. The fish migrate northward, appearing off southern New England by May-June. The fall fishery begins when migratory fish appear off Virginia and North Carolina. In early fall, this southward migration is initiated by cooling ocean temperatures. By late November-early December, most of the fish are found between Cape Hatteras and Cape Fear, North Carolina.

The Virginia Chesapeake Bay menhaden purse seine season starts the first Monday in May and ends the third Friday in November, while the ocean season (east of the Chesapeake Bay Bridge Tunnel) ends the Thursday before Christmas (Code of Virginia, § 28.2-410). In 2024, the Bay season was May 3 through November 15, or 197 days, and the ocean season through December 19 (231 days). The presence of menhaden schools is dependent on water temperature, as such, catch and effort varies across the season. The industry logs daily activity on the Captain's Daily Fishing Reports (CDFRs), which include information on vessel, date, time, location, estimated catch, reporting area and weather conditions for each set.

In general, there has been a decline in the overall effort in the reduction sector since the early 2000's with effort in the Bay accounting for just under half the total effort (49.29%) over the past five years (Figure 2), though effort in the Bay is capped at 51,000 metric tons based on the current Chesapeake Bay reduction fishing cap established in Amendment 3 to the Atlantic menhaden FMP. Over the past ten years (2015-2024), 49.50% of the reduction Bay effort and

46.09% of the Bay harvest occurred prior to July 15 (Figure 3, Tables 2 and 3). However, this is highly variable with the past two years' catch and effort significantly below average until the end of June (Table 3), after June both years were near or above the 5-year and 25-year averages (Figures 4 and 5, Table 3).

Spatially, each net set is reported to one of 7 areas in the Bay and 2 areas in Virginia's coastal waters (Figure 6). Catch and effort are greatest in the northwest area of Smith Point, with 33.20% of effort and 27.96% of harvest over the five most recent years (2020-2024) (Figure 7). Through July the Smith Point area has the highest activity, after which activity is highest in areas of the lower Bay near the mouth and along the Eastern Shore (Oceanview, Cape Charles, and York River) August 1 through September 15 (Figure 7). Activity in the Bay wanes beginning in October with less than 4% of the total bay effort occurring the remainder of the season.

Purse Seine Bait Fishery

The purse seine bait fishery catch and effort shows similar trends, with 2023 weekly harvest reports well below average through the week ending July 21, while 2024 reports were similarly below average nearly the entire season (through the week of November 8) (Figure 8). Purse seine catches are typically low the first two weeks in May but pick up substantially through the end of the month and into July. This increasing harvest trend was not observed in 2023 until late June (Figure 8). These below average and significantly below average purse seine harvest reports early in the 2023 and 2024 seasons warrant further examination given the latter part of the season was at or above normal.

Activity of the purse seine bait fishery is distributed differently than the reduction sector with effort rising steadily in late May and remaining consistent through July, following by a steady decline through October (Figure 7). The Smith Point reporting area again dominates catch (34.25%) and effort (37.87%), followed by Cape Charles (C=23.24%, E=16.68%), Silver Beach (C=15.47%, E=12.62%), and the northeasterly area, Pocomoke Sounds with 11.71% of the catch and 14.72% of the effort over the most recent 5-year time period (Figure 7).

Overlap with Osprey Study Areas[1]

Of the 6,257 menhaden Bay purse seine net sets reported on the CDFR's between 2020 and 2024, only 113 net sets (1.81%) occurred in just four of the Watts et al. 2024 osprey study areas (Fleeton Bay, Mobjack Bay, Eastern Shore, and Piankatank River) (Figure 9 and Table 5). The osprey workgroup indicates that May and June are the most sensitive times for osprey (USGS,

[1] Members of the external Osprey Work Group cautioned the Board Work Group against using the Watts et al. 2024 study areas in this manner as they assume menhaden biomass is static and that the effects of menhaden harvest are restricted to the local area of harvest

personal communication, ASMFC Menhaden Board Meeting, August 2024). The CDFRs indicate that 8.41% of the May effort occurred in one three study areas: Fleeton Bay – 59 sets or 7.88%; Eastern Shore – 3 net sets or 0.40%; and Piankatank River – 1 net set (0.13%) (Figure 7 and Table 5). June had 1.15% of the purse seine net sets in proximity to the Fleeton Bay (N=7, 0.54%) and Eastern Shore osprey study areas (N=7, 0.62%) (Table 5). Mobjack Bay has been the center of attention regarding recent osprey nesting studies, however only 22 menhaden purse seine net sets occurred in the osprey study areas over the past five years, and none during the critical May to June window for osprey (Table 5). Most of that Mobjack Bay purse seine effort occurred in August of 2021 (N=14) and 2022 (N=7).

Non-Purse Seine Bait Fisheries

Menhaden from bait fisheries is primarily harvested by pound nets, gill nets, and haul seines. Virginia's non-purse bait harvest is dominated by gill nets (50.84%) and pound nets (48.95%) with haul seines at 0.15% over the past five years. The pound net fishery in the Chesapeake Bay region is carried out by numerous small, non-refrigerated vessels. Maximum hold capacity of these pound net vessels is 9 mt or less, but daily catches are usually well below vessel capacity and are limited by the number of fish encountered in the fixed gear. The majority of these fish supply the local blue crab fishery.

Pound Net Fisheries

Pound nets comprise 0.16% of the overall menhaden harvest annually in Virginia (average= 2.10 million lbs) and 97.23% in Maryland (average=2.24 million lbs) over the past five years. Annual catch-per-unit effort (CPUE) measured as lbs per net-day has been relatively stable on the Potomac River (2,434 lbs per net day) with the exception of 2023 and 2024 when CPUE declined sharply. Similar estimates in Virginia and Maryland have been significantly below the 10-year average (MD = 2,242 lbs per net-day, VA=2,053 lbs per net day) for both 2023 and 2024 (Figure 10). On a monthly basis, menhaden first appear in pound net catches in March, peak during the summer months, with a steady decline in harvest into the fall (Figure 11). Harvest for the last two years (2023 and 2024) was generally at or below both the 5 and 10-year averages in Maryland, while Virginia's monthly harvest was significantly below average April through October, 2024 (Figure 11).

As shown in Figure 12, pound net distribution in the Chesapeake Bay is primarily located on the lower Eastern Shore and Northern Neck on the western side of the Bay with a small number of pounds in Virginia Beach, northern Eastern Shore, and the tributaries. VMRC harvest reporting areas were used to represent spatial coverage by month (Figure 13). Pound net harvest tracks the location of pound nets well, with 83.62% of all harvest (2020-2024) occurring in the Chesapeake Bay Upper West Area (CBUW) with the Rappahannock River at 10.42% (Figure 13).

Overlap with Osprey Study Areas

Of the 136 Virginia licensed pound nets in 2024, 10 occurred within the Fleeton Bay osprey study area with another 22 just to the north (Figures 12 and 13). Eight pound nets were located in the Eastern Shore osprey study area and 6 in proximity to the Lynnhaven study area. The MRC reporting area CBUW (Chesapeake Bay Upper West) (Figure 13) is where the bulk of the pound net harvest originates (83.62%) – Fleeton Bay occurs in that reporting area. Over the past 5 years (2020-2024), 37.54% of all pound net harvest was reported from this area during March to June (Figure 13).

Gill Net Fisheries

Gill nets comprise 0.15% of the overall menhaden harvest annually in Virginia (average= 2.06 million lbs) and 2.73% in Maryland (average=62,988 lbs) over the past five years (Figure 14). Maryland harvest has averaged 206,508 lbs annually over the past ten years but has observed significantly lower harvest since 2021. Virginia has averaged 2,132,885 lbs the past ten years but significantly below that value in 2023 and 2024 (Figure 14). Gill net harvest of menhaden is primarily February to April in Virginia waters and March to April in Maryland (Figure 15). Catches appear to be delayed somewhat in Maryland with the peak month of harvest in April. The 2024 harvest for nearly every month was significantly below the 5 and 10-year averages in Virginia waters.

Spatial distribution of gill net activities is more dispersed than pound nets. In Virginia, Western Upper Bay (CBUW) dominates harvest during the peak months of March and April and comprises 32.92% of the total gill net harvest. The Eastern Upper Bay (CBUE) represented 20.30% of the 5-year total but harvest was down in that area in 2024 compared to previous years.

Overlap with Osprey Study Areas

Menhaden harvest from gill nets is more complicated than that from pound nets. In Virginia, various types of gill nets are utilized (anchored, staked, drift, etc), targeting a number of species (bluefish, blue catfish, croaker, black and red drum, striped bass, Spanish mackerel, speckled trout, gizzard shad, and menhaden) throughout the year. Maryland banned the use of anchored and staked gill nets in 1992. Drift gill nets are permitted but must be attended at all times.

Menhaden are mostly caught with anchored gill nets in the spring months (March to May) in Virginia's western Bay (CBLW and CBUW - (Figure 16) with 68.71% of the 5-year harvest occurring during that three-month period (Figure 16). The Eastern Shore osprey study area is included in the CBUE reporting area with 9.48% of the overall harvest, with the lower Chesapeake Bay reporting area at 3.15% (Figure 16). The York River reports 15.05% of the overall menhaden harvest with gill nets, James River has less than 0.7%, the Poquoson River at 0.53%, Piankatank River at < 0.5%, and Rappahannock River at 6.41%. Overall, the Mobjack Bay gill net harvested was 7.52% over the past five-years, with 6.07% of that harvest in March and April. The single highest month of harvest in Mobjack Bay occurred in March 2021 (Figure 17).

Background on Additional Piscivorous Bird and Fish Predators

Cormorants and Pelicans

Double-crested cormorants and brown pelicans are two additional predators of menhaden whose numbers are increasing in Chesapeake Bay. Atlantic menhaden make up 50-55% of the diet of cormorants and 74% of the diet of brown pelicans by weight. Other important fish for cormorants were spot (8-27% of diet) and Atlantic croaker (13-16% of diet). For brown pelicans, bay anchovies were also important (14% of their diet)(Watts and Duerr 2009). Breeding of the Double-crested Cormorant in Virginia was first confirmed in 1978 on a small, vegetated island in the James River near Hopewell. Colonization of Virginia represents an expansion beyond the historic range following a low during the DDT era (1940s-1972). After 1984, the Virginia population expanded rapidly to 5 colonies by 1995 containing more than 400 pairs. The seaside of the Delmarva was not colonized until 1995. Between 1993 and 2018 the population has increased by 1416% from 354 to 5,012 pairs. Most of this increase is accounted for by the rapid expansion of the Shanks Island colony. The colony has expanded from 6 pairs in 1993 to 907 pairs in 2003 to 1, 636 in 2008 to 2,369 in 2013 to 5,012 in 2018. This trend continued until 2023, when erosion significantly deteriorated Shanks Island, leading to a significant drop in cormorants located within Virginia to just over 3000 breeding pairs (Watts et al. 2019).

Double-crested cormorants live in the Chesapeake Bay area year-round, but winter is an especially important time, as they overwinter around the bay and along the south Atlantic. There are two migration dates; initial arrival in the spring, with the earliest departure for spring migration around March 26th, and the latest around May 12th and departure for the winter, where some populations migrate south to wintering grounds in the fall, with the average departure date for fall migration around October 1st (Watts et al. 2019).

The Brown Pelican was first found breeding in Virginia on Fisherman Island in 1987. During this same year, birds were also found nesting on Metomkin Island. Colonization of Virginia represents a northward range expansion from North Carolina that extends beyond the historic range and follows recovery of southeastern populations from contaminants. Since its discovery, the Shanks Island colony has grown exponentially apparently fueled by continued immigration. In 1993, there were only 53 pairs documented in this colony. By 1999, the colony supported 913 breeding pairs. The colony reached a peak in 2013 with 1,857 pairs and has now declined to 1,753 pairs. The Wreck Island colony has shifted south on the island over the past couple of years, expanding dramatically and now including 1,493 pairs (Watts et al. 2019).

Virginia is the northernmost state that supports a year-round brown pelican population, especially further south in the state near Virginia Beach and at the mouth of the Chesapeake Bay. Nesting and egg laying occurs between March and May, with females laying 2 to 3 eggs per clutch. Eggs then take about 30 days to hatch, and first flight takes around 75 days (Watts et al. 2019).

Striped Bass, Cobia, Red Drum, Spanish Mackerel, Spotted Seatrout, Weakfish and Blue Catfish

The present Ecological Reference Point (ERP) assessment models developed for Atlantic menhaden consider only four predatory fish species (striped bass, bluefish, weakfish, and spiny dogfish), with striped bass fitting the models best. These species have historical significance in the Chesapeake Bay and have been well studied. The latest coastwide assessments indicate striped bass is overfished, bluefish are presently rebuilding, weakfish are depleted due to high levels of natural mortality, and spiny dogfish reproductive output is declining but stabilizing (ASMFC, 2024).

Commercial and recreational harvest for all these species (with the exception of spiny dogfish) have shown a negative trend for the last ten to twenty years in the Chesapeake Bay (Figures 1 and 2). To the contrary, other migratory species, such as cobia, red drum, spotted seatrout and Spanish mackerel have increased in abundance and length of residency in the bay due to warming water temperatures (Figures 18 and 19). In addition to these estuarine species, the introduced blue catfish population is expanding (Figure 20), causing concerns for the Bay states due to its diet of important species such as blue crabs, alosines, and menhaden. As the Bay's population of these traditional species declines, so does their ecological demand for forage species such as menhaden. As other species abundance increases, their forage demands will increase but the overall effect of this species shift on predatory demand of piscivorous fishes on menhaden is unknown.

Abundance of Key Bay Predators

Commercial and recreational harvest data can be used to reflect the abundance of a species within the Chesapeake Bay in recent years. Blue catfish numbers are up as much as 287% (MD) and 72% (VA) compared to the 20-year average (Figure 20 and Table 4). Both states have seen a doubling of recreational cobia catch compared to the 20-year average with Virginia seeing a 76% increase in commercial harvest. Red drum commercial harvest is strictly controlled by the Red Drum Fishery Management Plan (ASMFC, 2022) with recreational catch trending upwards - especially in Virginia. Spanish mackerel and spotted seatrout have seen some of the largest increases in catch in recent years with mackerel increasing 129% commercially in VA and recreational catch up 157% (VA) and 192% (MD). Seatrout has observed a 70% increase commercially (VA) and with recreational catch up 46% (MD) and 57% (VA) over the past 20 years (Table 4, Figures 18-20).

Commercial harvest data from ACCSP and recreational total catch information (A+B1+B2) from MRIP were explored back to 1990. Three of the four species used to model the Menhaden ERP assessment have shown declines in both commercial harvest and recreational catch during the past 5-years compared to the 10-year and 20-year averages (Table 4, Figures 18 and 19). Commercial striped bass harvest has declined 28% in VA and 19% in MD, with declines of 58% and 27% respectively in the recreational catch. Bluefish recreational catch has declined 65% (MD) and 25% (VA) compared to the 20-year average, while commercial harvest has declined 77% (MD) and 50% (VA) (Table 4). Weakfish have observed the largest decline with recent years 88% (MD) and 66% (VA) below the 20-year commercial average and 84% (MD) and 29% (VA) below the 20-year recreational catch. Spiny dogfish has a mixed signal with recreational catch increasing in Maryland (24%) as is commercial harvest in Virginia (77%) (Table 4). However, only 2.39% of the Virginia dogfish harvest has occurred in the Bay over the past five years (2000 – 2024), with the bulk coming from coastal waters (95.88%) and seaside tributaries and lagoons (1.73%).

The predators included in the ERP assessment model were chosen because of their dependence on menhaden as forage, though the relative dependence on menhaden varies by species with striped bass having the largest relative dependence (15.9% by weight; 11.7% by number) and weakfish having the smallest relative dependence (<1%) (Bonzek et al. 2022).
Other species with increasing abundance in Chesapeake Bay that may be influencing forage species demand have few to no Chesapeake Bay diet studies and no fishery independent surveys designed to monitor their abundance. However, diet studies from southern states (North Carolina to Georgia) with a longer history of surveys and diet studies may clarify the

forage demand of these species. All of the species increasing in abundance in Chesapeake Bay are known to prey on menhaden, with the relative importance varying by season or ontogeny. Large spotted seatrout and Spanish mackerel had the highest diet composition of menhaden (31.5% and 40%, respectively) followed by small red drum (27.4%), and cobia (1.53%). A study of the upper portions of Virginia major tributaries (James, York and Rappahannock Rivers) found menhaden comprised 0.425 to 5.00% of blue catfish diet by weight (Schmitt, et al. 2018).

Diet Studies in Chesapeake Bay

The VIMS Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) and Northeast Area Monitoring and Assessment Program (NEAMAP) are the most comprehensive diet studies of ecologically, commercially, and recreationally important fishes in the Chesapeake Bay and adjacent coastal waters. The ChesMMAP began in 2002 and samples four times a year (March, June, September, and November) in the mainstem bay from the head of the Bay at Poole's Island, MD to the mouth of the Bay just outside the Chesapeake Bay Bridge Tunnel. (ChesMMAP 2024). NEAMAP began conducting both a spring and fall survey in 2008, sampling from Cape Cod, MA south to Cape Hatteras, NC, targeting both juvenile and adult fishes (NEAMAP 2024). Both surveys develop age specific abundance estimates of various species for stock assessments, as well as complete annual representative ageing and gut contents on a suite of species. The diet data were instrumental in developing the ERP predator prey models for menhaden. Included below are a diet summary of those ERP predators. A summary of the menhaden percent of diet for each of the species below along with location and time of the study and reference appear in Table 6.

Striped Bass diet in the Bay is known to consist of numerous species from mollusks, annelids (worms), Arthropods (shrimp, crabs, mysids, etc.) and a number of finfishes (CHESMMAP, 2024). From the stomach contents collected from 2002 to 2020 cruises, diet composition of striped bass consists of 63.2% fish by weight (%W), 17.0%W and 26.1% by number (%N) for crustaceans, 11.7%W and 9.9%N for worms, 6.2%W miscellaneous items, and 1.9%W mollusks (Bonzek et al. 2022). Bay Anchovy comprises the largest portion of the diet with 33.0% by weight(%W) and 33.8% by numbers (%N). Mysids are second with 7.3% by weight and 12.2% by number. Menhaden comprise 15.9% of Striped Bass diet by weight and 11.7% by number during this 19- year period. (Bonzek et al. 2022).

Bluefish are highly piscivorous with CHESMMAP data from 2000-2021 indicating bay anchovy constitutes 53.4% of the diet by weight (%W) and 52.0% by number (%N). Spot constitute 9.3%W and 5.8%W, with all fish species representing 88.9%W and 83.0%Wr (Bonzek et al. 2022). Menhaden comprise 5.0%W and 4.7%N (Bonzek et al. 2022).

Weakfish diet data from CHESMMAP (2000-2021) suggest the diet is primarily fishes (68.3%) and crustaceans (25.6%) by volume. By numbers, fishes comprise 53.3% and crustaceans 39.9% (primarily mysids at 21.8%). Bay Anchovy are 31.3% of the diet by number and 40.5% by volume. Menhaden make up only a small portion of the weakfish diet < 1% (possibly due to truncation of the weakfish size range associated with high natural mortality of Age 1+ fishes) (Bonzek et al. 2022).

Spiny Dogfish do not typically venture far into the bay (< 2.5% of harvest) and are generally observed in coastal waters by NEAMAP. Diet information collected from spiny dogfish indicates roughly half of their diet by both weight (%W) and numbers (%N) were fishes. Menhaden (7.8%W, 5.1%N), striped bass (2.3%W), butterfish (2.1%W, 2.1%N) and scup (2.2%W, 2.0%N) are the most prevalent identified fishes, with longfin squid (9.7%W, 7.1%N) and bloodworm species (10.1%W, 10.6%N) the most prevalent invertebrates over a 10-year period (2007 – 2016) (Bonzek et al. 2017).

Other species with increasing abundance that may be influencing forage species demand have little to no Chesapeake Bay diet studies. None of these species have effective fishery independent surveys in the Bay to monitor abundance or diet composition. States to the south (GA to NC) have numerous studies in the literature that may clarify the forage demand of these species.

Cobia: Commercial and recreational cobia harvest has increased substantial over the past 10 years (Figures 18 and 19). The species feeds mostly on crabs (blue crab and lady crabs) with the relative importance of those species (index of relative importance) 2-3 orders of magnitude higher than any other species (Arendt et al. 2001). This study found these two species comprising 76.82% of the diet by numbers and 78.62% by volume. Menhaden were found to be 0.14% of the diet by numbers and 1.53% by volume (Arendt et al. 2001).

Red Drum are opportunistic feeders, and diet can shift with changes in age, habitat, season variability, and fluctuations in prey availability. In North Carolina red drum diet composition is comprised primarily of decapod crustacea (shrimp and crabs) and finfishes. Age 0-1 fish (100-400mm) eat primarily penaeid shrimp 30.7%W, menhaden 27.4%W and blue crabs at 9.6%W, with all decapod crustacea at 42.6%W and finfishes at 55.8%W (Facendola and Scharf, 2012). Diets in Age1-2 fish (400-700 mm) is shifted primarily to blue crabs (35%W), menhaden (15.4%W), Pinfish (10.1%W), and only 1.1%W of penaeid shrimp, with the percent of finfishes increasing to 61.1%W (Facendola and Scharf, 2012). In a study of larger fish (> 750 mm) diets consisted mainly of blue crabs (50.7%W), menhaden (11.9%W), and shrimp (3.0%W), with all finfish totaling 38.8%W and all decapod crustacean at 56.7%W (Peacock, 2014). These and other studies had similar species composition in the diet for fishes typically found in the Bay, including spot, croaker, mullet, tonguefish and mullet.

Spotted Seatrout: As juvenile spotted seatrout grow (greater than 30 mm in length), the dominant prey shifts to penaeid and palaemonid shrimps, which remain important in the diet of adults (McMichael and Peters 1989). As adult spotted seatrout increase in size, pelagic fishes and penaeid shrimps become increasingly important in their diet (Mercer 1984). Diet analysis of spotted seatrout in the lower Cape Fear River, North Carolina, revealed that Atlantic menhaden and brown shrimp are the dominant prey items of spotted seatrout during the summer and fall, and other important prey species included pinfish, spot, and striped mullet, indicating that spotted seatrout are mainly piscivorous after reaching age 1 (Tayloe and Scharf 2006). By size in coastal Georgia, small spotted seatrout < 300 mm consume primarily grass shrimp (13.2%N) and menhaden (9.4%N). Medium fish (301-500 mm) primary food items were fish (56.8%N), specifically menhaden (15.6%N,) with penaeid shrimp (12.1%N) the most prevalent invertebrate. Large specimens (> 500 mm) were exclusively piscivorous with menhaden at 31.5%N (Music and Pafford, 1984). For all size classes combined fishes comprises 41.8%N of diet (menhaden 20.1%N), with crustacean at 9.2%N (penaeid shrimp at 13.1%N and grass shrimp at 7.6%N) (Music and Pafford, 1984).

Spanish Mackerel: Nearly exclusively piscivorous, particularly at large size classes. A study off the Georgia coast found the fish portion of the diet of juveniles (9-42cm) to be 97.9% by weight (%W) and 89.6% by number (%N), with anchovy species comprising the bulk (64.9%W and 39.5%N, with an occurrence rate, of 44.5%) (Finucane et al. 1990). A study from North and South Carolina samples found fishes to be a similar portion of the diet (97.7%W) with anchovy species consisting of 29.7%W, nematodes 1.5%W, squid species 0.4%W, and digested fish material at 58.7%W (Saloman and Naughton, 1983). A study off Cape Canaveral, FL found fishes to comprise 93.5% of diet by weight (%W) and 86.7% by number (%N), with key species being anchovies (21.3%N, 22.6%W) clupeids – including menhaden (5.3%N, 22.6%W) and squid species (13.3%N, 6.5%W) (Naughton and Saloman, 1981). A recent NOAA study in the Gulf of Mexico indicated that age 0-1 Spanish mackerel diet can consist of up to 40%W Gulf menhaden (over 5-year classes) while Age 1+ mackerel diet is around 20%W menhaden (Berenshtein et al. 2021).

Often menhaden are not easily identified in gut contents and may be labeled as "clupeids" or "unidentified fish". A study in the Northern Gulf of Mexico/America to quantify the importance of Gulf menhaden as a prey item found the estimated contribution of identifiable menhaden to the diets of all predators generally ranged between 2% and 3% (Sagarese et al. 2016). Diet compositions were then adjusted for unidentified prey using the proportion of fish species biomass in the ecosystem, indicating five predator groups with a relatively large dependence on Gulf menhaden prey were juvenile King Mackerel, juvenile and adult Spanish Mackerel, Red Drum, and Blacktip Sharks (Sagarese et al. 2016).

Blue Catfish were introduced to the Chesapeake Bay upper tributaries in Virginia beginning in 1973 to 1985 to enhance trophy fishing opportunities for freshwater anglers. The species has a much higher salinity tolerance (typically found at 17 ppt) then native catfish species and become piscivorous at a smaller size and age. They have been very prolific (Figure 20) spreading to nearly all tributaries of both the western and eastern side of the bay. They are an omnivorous, or trophic generalist species of fish. Because of this, their diet varies by waterbody, salinity and the availability of prey items, but studies indicate that their diet most often consists of small fish, crayfish, mollusks, and plant matter. At larger sizes, Blue Catfish become increasingly piscivorous, and transition to primarily consuming other fish. A study of the upper portions of Virginia major tributaries (James, York and Rappahannock Rivers) found menhaden comprised 0.425 to 5.00% of blue catfish diet by weight (Schmitt, et al. 2018).

Species Health

A standardized health condition index could be used to examine if striped bass and other piscivores are stressed in the Bay. One of the simplest methods is the Fulton's Condition Factor (k_c) which has been used for over 100 years. (Fulton, 1911; Stevenson and Woods, 2006). While this analysis can track the relative condition of fish over the season and interannually, the opportunistic foraging habits of many of the species described above precludes the direct relation of health indices to fluctuations in menhaden biomass or availability.

Condition factors may vary seasonally during spawning and when stressed by environmental conditions such as water temperature or low dissolved oxygen, as well as species specific physiological and morphological differences. For this exercise, an annual factor is produced from a number of datasets from the Maryland Department of Natural Resources, Potomac River Fisheries Commission, and Virginia Marine Resources Commission for striped bass and other known predators of menhaden in the Bay.

<u>Fulton's Condition Factor</u>

The Factor is simple to compute and only requires length (in cm) and weight (in grams). A factor of 1.0 is considered normal for most finfishes with 1.2 very healthy, and below 0.8 under stress. The formula is:

$k_c = (\text{Weight} / \text{Length}^3) * 100,$ Weight in grams, Length in cm

Eight data sources were used to develop annual condition factors for striped bass. A total of 298,232 individual striped bass were evaluated with the average annual number of samples from the projects ranging from 243 to 3473. A cursory review of the samples was conducted with outliers from the linear length vs weight curve removed from the analysis .

Striped Bass Health: The use of Fulton's Condition Factor as a measure of the Bay's Striped Bass population health would indicate the fish are not starving and would be considered healthy (Figure 21). These datasets represent the entire Chesapeake Bay, numerous gear types, across all months in any given year. The time series was examined back to 1990 when Striped Bass were still under a moratorium. In general, these data suggest the Bay's striped bass are healthy, with k_c's above the 0.8 threshold on an annual basis (Figure 21). Conditions appear to be trending upward and often exceeding the very healthy 1.2 threshold for data collected primarily during cool water months (October – March) (Figures 21 and 22). These data all show similar trends and appear to capture expected declines in k_c during warm weather months (when fish are most stressed) suggesting this reflects expected seasonal dynamics in foraging behavior and physiological stress (Figure 22).

Health of other Bay Predators: Similar methods were applied to other Bay predatory species to develop Fulton's Condition Factor for each. Only information from VMRC projects was used for this exercise. Long-term blue catfish and spiny dogfish length/weight data was not available at this time. Red drum, spotted seatrout, and weakfish all had k_c values fluctuating around the normal threshold of 1.0 or above (Figure 23). Interestingly, the pelagic species (bluefish, cobia and Spanish Mackerel) all have k_c values typically well below the 1.0 normal threshold, with the median for bluefish at 0.93 (range from 0.83 to 122). Cobia ranged from 0.80 and 1.37 (median=0.90). Spanish mackerel was much lower with k_c values ranging from 0.49 to 0.89, median = 0.54 (Figure 23). Given the k_c values were generally stable for each of these species over the time series, there may be morphological differences with pelagic species compared to sciaenids that requiring scaling the condition threshold for specific species.

In general, the health index measured by Fulton's Condition Factor, seems to be slightly increasing or stable for all species, suggesting the health of these species over time has not changed substantially.

Potential Management Approaches

Based on the life history of predators examined, the nature of Chesapeake Bay menhaden fisheries, and recent changes in menhaden availability, the Work Group discussed a number of precautionary management options the Board could consider for further action. The options listed below could be implemented individually or in combination, depending on the Board's risk tolerance and management goals.

Seasonal Closures

Benefits and challenges of potential strategies discussed are summarized below for several potential scenarios:

1. May 15 – August 15: This period covers the period of highest energy demand for the osprey population in Chesapeake Bay. Cormorants, striped bass, and red drum are also present in Chesapeake Bay during this time. Between 2020-2024, 60.72% (Table 3) of the cumulative reduction harvest of menhaden in Chesapeake Bay occurred during this time. Purse seines harvesting bait had a cumulative harvest for that same time period of 47.51%.. Virginia's gill net and pound net fisheries harvest 43.42% and 49.28% of the annual harvest during this time period.

2. May 1 – June 30: This period covers the period of critical demand for early chick survival for osprey in Chesapeake Bay. Cormorants, striped bass, red drum, and cobia are also present in Chesapeake Bay during this time. Between 2020-2024, 29.36% of the cumulative reduction harvest of menhaden in Chesapeake Bay occurred during this time. Bait purse seines harvested 22.08% of its annual average during these two months, with gill nets at 60.14% and pound nets at 21.41%.

3. May 1 – May 31: This period is a smaller subset of the options listed above to cover the first two weeks of the typical hatching season. This period would impact 10.69% of the purse seine reduction sector's annual Bay harvest (2020-2024) and 3.74% of the purse seine bait harvest based on the past 5 years. Gill nets are typically catching menhaden in the early spring with a May closure impacting 9.26% of the average annual harvest. The pound net harvest for the month of May in Virginia is 13.55% of the annual harvest. The pound net harvest for the month of May in Maryland is 5.76%.

Area Closures

Spatial Analysis of Fishing Activity

To explore if menhaden may play a role in the deficiencies outlined in Watts (2024), Captain Daily Fishing Reports (CDFRs) from menhaden purse seine activities were mapped against these 12 areas (Figure 9). Male osprey are known to travel up to 10 km from their nest while hunting for food (Pool, 1989). If the precise location of these 571 nests was available, a 10km buffer could be placed around each nest to determine the timing and level of fishing activity occurring in these 12 study areas. Unfortunately, the location of the sprey nests is not available at this time so similar polygons representing the 12 areas were created (as they appear in Dr. Watt's September 13th press release) (Figure 9).

It should be noted that members of the external osprey Work Group, which included representatives from USGS, USFWS, Maryland National Capital Park & Planning Commission and Dr. Watts from the College of William and Mary cautioned the Work Group against using the Watts et al. 2024 study areas in this manner as they assume menhaden biomass is static and that the effects of menhaden harvest are restricted to the local area of harvest. Instead, they suggest that the high concentration of reduction fishery net sets at the mouth of Chesapeake Bay could act as an 'intercept' fishery, preventing the ingress of large numbers of fish into Chesapeake Bay during key points of the season. Fishery-dependent data from daily CDFR's suggests that reduction fishing effort near the mouth of the Bay is concentrated during August and September compared to the upper Bay in May and June. Fishery-dependent data from daily CDFR's suggests that reduction fishing effort near the mouth of the Bay is concentrated during August and September compared to the upper Bay in May and June (Figures 6 and 7). This could suggest that reduction harvest is not limiting menhaden ingress, but surveys of menhaden migration and biomass in the Bay would be required to determine whether these trends are driven by menhaden availability or fishing operations.

Management Area Restrictions

Chapter 4 of Title 28.2 of the Code of Virginia addresses the taking of menhaden with purse seines. Closed areas are defined in § 28.2-409 and excludes most tributaries, bays and creeks off the mainstem Bay. The Bay season is defined as the first Monday in May until the third Friday in November (§ 28.2-410). In April 2023 a memorandum of understanding was signed between industry and VMRC to agree not to deploy or set a net around particularly sensitive areas. A one-half nautical mile buffer was created on either side of the Chesapeake Bay Bridge Tunnel (CBBT) to reduce user conflicts with recreational anglers. Two one-nautical mile buffers were established from the shoreline: 1) along the Eastern Shore of the Chesapeake Bay from the Occohannock Creek south to the CBBT; and 2) From the James T. Wilson Fishing Pier (Buckroe Beach) south along the Hampton Roads Bridge Tunnel to Sandbridge Fishing Pier in Virginia Beach. Since being established, the purse fisheries have a 98.85% compliance rate in 2023 and a 99.47% in 2024 based on the location coordinates reported on the CDFRs.

Based on the areas of operation of menhaden fisheries, the Work Group discussed the following spatial closure options. These spatial closures can be considered on their own or in combination with seasonal closures and/or effort controls.

1. All Chesapeake Bay
    a. Virginia waters of Chesapeake Bay as defined by § 28.2-409 of the Code of Virginia and excluding areas covered by MOU
2. CDFR areas at the mouth of the Bay (Ocean View and Cape Charles)
3. By landings in CDFR reporting areas
4. Watts (2024) study locations
5. Mobjack Bay – Mobjack Bay is the most well-studied area for osprey in the lower Chesapeake Bay with considerable historical and recent data. Declining osprey reproductive rates, provisioning rates, provisioning of menhaden, diet quality, brood reduction, and an increase in male osprey foraging time have all been observed in Mobjack Bay.
6. Fleeton Bay – most likely to be impacted by all menhaden fisheries; purse seine, gillnet, and pound net fishing effort

Effort Controls

The implementation of quota periods or days out provisions could be used to distribute fishing effort more evenly throughout the season. These provisions are similar to management of the Atlantic herring fishery in which quota periods are used to manage catch toward bimonthly, trimester, or seasonal quotas to effectively manage catch to meet the needs of the fishery and bait market demand.

Gears Included in Seasonal and/or Area Closures

The application of seasonal or spatial closures to Chesapeake Bay menhaden bait fisheries, particularly pound nets and gill nets, would likely have significant economic and follow-on fishery impacts. Bait harvested in Chesapeake Bay typically supports in-state blue crab fisheries as well as crab and lobster fisheries along the Atlantic coast. It is unknown whether other states or sources of bait would be available to backfill the landings that would not occur under closures of bait fisheries in the Bay, depending on the magnitude of the closures. These fisheries are also promulgated by small-scale and/or stationary gears with limited capacity (due to regulation or safety concerns) to move fishing efforts offshore. These actions could also impact the ability of watermen to land other species from non-directed gears, resulting in unintended economic impacts to other fisheries. The Board must weigh what would likely be an economic hardship for menhaden bait harvesters and those dependent on that bait for other fisheries with the potential for biological implications for their predators. A time or area closure could mean the reduction fleet has farther to travel to harvest fish at added expense. Further the purse seine skiffs that set the purse seine nets are only 40 ft in length and are subject to the same safety concerns as other bait harvesters when seas exceed 3 ft. The work group is unable at this time to provide a full analysis of the impacts these closures could have on the reduction fishery.

Decreasing Chesapeake Bay Reduction Fishery Cap

Recognition of the potential impacts of reduction fishing in Chesapeake Bay have been reflected in ASMFC's management of the menhaden fishery for at least two decades. In 2005, Addendum II to Amendment 1 instituted a harvest cap on the reduction fishery in the Chesapeake Bay. This cap was based on average landings from 2000-2004 and was set for the 2006-2010 fishing seasons. Addendum III (2006) to Amendment 1 revised the cap to 109,020 mt, based on average landings from 2001-2005, for the 2006-2010 fishing seasons. Addendum IV (2009) extended the cap through 2011-2013 at the same levels as established in Addendum III. Amendment 2 (2012) reduced the Chesapeake Bay cap by 20% to 87,216 mt. Amendment 3 (2017) reduced the Chesapeake Bay cap to 51,000 mt, based on average landings from 2012-2016. In 2019, the Commonwealth of Virginia was found out of compliance by ASMFC for failing to update the Bay cap to the new level of 51,000 metric tons. The decision was appealed to the Department of Commerce where the Secretary upheld the ASMFC action. Virginia updated their regulations and came into compliance prior to the start of the fishing season. The development of the Bay cap, the Board's continued action to update the cap, and the actions of the Department of Commerce reinforce that managing reduction harvest within the Chesapeake Bay is appropriate and necessary.

The Board could further reduce the Chesapeake Bay reduction fishery cap, which is currently based on historical landings from the 5 years prior to enactment. This would presumably leave additional menhaden as forage in Bay waters for all predators. Landings in recent years have been at or near the full Bay cap; therefore, the Board would need to consider a novel approach to setting the Bay cap based on information provided by the Work Group or from other sources if this option is implemented.

Research Recommendations

In reviewing data and information to meet its charge, the Work Group identified several areas in need of additional research and data to address questions beneficial to ecological management of menhaden fisheries in Chesapeake Bay and beyond. Those research recommendations are as follows:

1. Investigate menhaden environmental condition preferences to analyze potential shift in seasonal availability
2. Diet studies on other key predators in Chesapeake Bay (fish, birds, mammals, etc.)
3. Survey of menhaden abundance and biomass in Chesapeake Bay
4. Investigate osprey in other estuaries to determine if there are similar issues
5. ERP Work Group continue to explore inclusion of other predator species in future assessments
6. Study specific osprey areas with major deficiencies in reproductive output relative to menhaden fisheries (e.g. Mobjack and Fleeton Bays)

Additionally, the external osprey Work Group provided research recommendations to the Board Work Group which are as follows:

1. Execute a menhaden biomass survey in the Chesapeake Bay
2. Evaluate long-term datasets for osprey breeding performance
3. Relate historical data with menhaden abundance estimates
4. Create an economical metric of food stress to measure at scale
5. Develop an osprey-menhaden CPUE model

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Tables

Table 1. Estimates of osprey population reproductive rates and brood size 1970's to 2021. Source: Watts et al., 2024

Parameter	1974-75	1985	2006-07	2021	F-statistic	p-value
Nests (N)	75	68	132	68		
Clutch Size	2.7 $\pm$ 0.08	3.0 $\pm$ 0.09	3.0 $\pm$ 0.27	2.7 $\pm$ 0.09	2.2	0.084
Reproductive Rate	1.7 $\pm$ 0.10	1.4 $\pm$ 0.11	0.8 $\pm$ 0.08	0.3 $\pm$ 0.11	34.9	<0.001
Brood Size	2.0 $\pm$ 0.10	1.8 $\pm$ 0.10	1.5 $\pm$ 0.09	1.2 $\pm$ 0.17	10	<0.001
Estimated reproductive rate required for a stable population within the Chesapeake Bay is 1.15						

Table 2. Semi-monthly purse seine reduction Bay effort by year (2015-2024) compared to the ten-year average. Shaded cells indicate a how a specific period and year compared to the ten-year average. Source: NOAA CDFRs.

Temporal Distribution of Reduction Purse Seine Effort 2015-2024

	Year										2015-2024 Net Sets		
Period	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	N	Avg $_{2015\text{-}24}$	Pct
15-May	208	4	0	48	206	128	117	39	0	4	754	75.4	6.23%
31-May	288	428	29	217	412	108	229	100	2	22	1,835	183.5	15.17%
15-Jun	207	275	221	199	77	121	85	346	92	106	1,729	172.9	14.30%
30-Jun	101	130	82	138	60	60	113	96	175	92	1,047	104.7	8.66%
15-Jul	87	13	77	108	6	20	23	104	64	125	627	62.7	5.18%
31-Jul	36	7	74	9	0	72	236	132	311	268	1,145	114.5	9.47%
15-Aug	75	59	43	58	146	108	231	235	95	232	1,282	128.2	10.60%
31-Aug	72	80	73	70	225	122	166	260	210	185	1,463	146.3	12.10%
15-Sep	75	154	27	58	197	66	112	119	103	59	970	97.0	8.02%
30-Sep	77	25	0	26	200	5	92	37	97	128	687	68.7	5.68%
15-Oct	36	20	13	30	47	28	5	0	6	5	190	19.0	1.57%
31-Oct	9	56	19	5	3	43	0	0	1	3	139	13.9	1.15%
15-Nov	1	93	10	0	0	82	9	0	21	0	216	21.6	1.79%
30-Nov	0	2	0	1	0	2	0	0	0	0	5	0.5	0.04%
15-Dec	0	0	0	2	0	4	0	0	0	0	6	0.6	0.05%
Total	1,272	1,346	668	969	1,579	969	1,418	1,468	1,177	1,229	12,095	1209.5	

Below Avg (2015-2024)
Significantly Below Avg
Significantly Above Avg

Table 3. Purse seine reduction Bay harvest shown as cumulative percent across the season for the past five years (2020-2024). Source: NOAA CDFRs.

Purse Harvest by Date Relative to the Annual Harvest (as CumPct)								
		Year				Overall Average		
Date	2020	2021	2022	2023	2024	2020-24	2015-24	2000-24
15-May	12.34%	4.24%	2.08%	0.00%	0.02%	2.45%	4.27%	2.45%
31-May	20.32%	13.62%	5.02%	0.01%	0.38%	10.69%	18.08%	11.49%
15-Jun	28.92%	16.91%	21.77%	3.39%	5.30%	19.79%	28.09%	19.79%
30-Jun	33.15%	27.76%	30.96%	12.69%	13.40%	29.36%	40.19%	30.01%
15-Jul	35.33%	29.48%	46.23%	20.95%	22.62%	36.13%	46.09%	36.13%
31-Jul	44.73%	49.68%	55.46%	49.87%	46.25%	48.02%	56.91%	48.63%
15-Aug	55.52%	70.63%	67.08%	58.85%	65.03%	60.72%	68.08%	60.72%
31-Aug	73.02%	83.05%	84.91%	76.31%	84.82%	74.91%	81.21%	75.38%
15-Sep	80.56%	93.33%	97.00%	88.22%	92.22%	84.55%	90.54%	84.55%
30-Sep	81.02%	99.15%	100.00%	97.53%	99.69%	90.69%	95.88%	91.11%
15-Oct	83.47%	99.63%		97.69%	99.98%	94.66%	97.51%	94.66%
31-Oct	90.25%	99.69%		97.72%	100.00%	97.54%	98.88%	97.95%
15-Nov	99.33%	100.00%		100.00%		99.74%	99.91%	99.74%
30-Nov	100.00%					100.00%	100.00%	100.00%
Red Cells are at least 15% below the 5-year average								

Table 4. Menhaden purse seine fishing effort (number of net sets) in proximity to the 12 osprey nesting locations (N=571 nests) in 2024. Sources: Osprey Nesting Efficiency: Watts, 2024. Menhaden Fishing Effort: NOAA CDFRs.

				Purse Seine Sets in Proximity to Osprey Study Areas															
	Osprey Nesting Deficiency			May		Jun		Jul		Aug		Sep		Oct		Nov		Total	
Location	Color	Status	Rate	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Fleeton Bay		Major	< 0.6	59	7.88%	7	0.54%	9	0.66%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	75	1.20%
Mobjack Bay		Major	< 0.6	0	0.00%	0	0.00%	0	0.00%	21	1.14%	1	0.12%	0	0.00%	0	0.00%	22	0.35%
Eastern Shore		Moderate	0.6 - 0.8	3	0.40%	8	0.62%	3	0.22%	1	0.05%	0	0.00%	0	0.00%	0	0.00%	15	0.24%
Piankatank R		Minor	0.8 - 0.9	1	0.13%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	0.02%
Poquoson R		Major	< 0.6	0	0.00%		0.00%		0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
York R		Major	< 0.6	0	0.00%		0.00%		0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Subtotal by Area and % of Total Effort				63	8.41%	15	1.17%	12	0.89%	22	1.19%	1	0.12%	0	0.00%	0	0.00%	113	1.81%
Total Purse Seine Sets 2020-2024				749		1,286		1,355		1,844		818		91		114		6257	
Choptank R (MD)		Major	< 0.6	Purse Seines Prohibited															
Patuxent R (MD)		Major	< 0.6																
Upper Rappahannock R		Surplus	> 1.1																
Upper James R		Surplus	> 1.1																
Elizabeth R		Moderate	0.6 - 0.8																
Lynhaven R		Minor	0.8 - 0.9																

Table 5. Commercial harvest in pounds and recreational catch (A+B1+B2) in number of fish by year, species, and Bay state. Sources: ACCSP and MRP.

Commercial Harvest in Pounds by Species and State								
	BLUEFISH*		**SPINY DOGFISH***		**STRIPED BASS***		**WEAKFISH***	
YEAR	**MD**	**VA**	**MD**	**VA**	**MD**	**VA**	**MD**	**VA**
2019	22,990	192,431	678,625	6,113,834	1,747,499	1,389,039	912	39,724
2020	21,011	164,151	396,076	6,010,225	1,589,350	924,116	1,622	41,527
2021	11,063	123,721	442,508	3,597,475	1,610,800	1,123,353	897	28,952
2022	10,285	182,901	0	4,568,864	1,601,070	1,102,622	1,048	29,521
2023	16,422	142,025	850,527	6,018,055	1,705,809	1,179,060	1,498	33,356
Avg(90-23)	102,026	451,956	1,342,668	2,294,812	1,854,123	1,218,711	93,460	573,591
Avg(04-23)	72,291	323,993	640,888	2,975,707	2,033,468	1,579,655	9,797	102,308
Avg(14-23)	37,464	170,892	876,021	4,322,315	1,768,500	1,264,451	1,189	29,659
Avg(19-23)	16,354	161,046	473,547	5,261,691	1,650,906	1,143,638	1,195	34,616
5yr vs 20yr	-77.38%	-50.29%	-26.11%	76.82%	-18.81%	-27.60%	-87.80%	-66.16%
5yr vs 10yr	-56.35%	-5.76%	-45.94%	21.73%	-6.65%	-9.55%	0.53%	16.71%

Recreational Catch (A+B1+B2) in Numbers of Fish by Species and State								
	BLUEFISH*		**SPINY DOGFISH***		**STRIPED BASS***		**WEAKFISH***	
	MD	**VA**	**MD**	**VA**	**MD**	**VA**	**MD**	**VA**
2019	311,736	723,012	24,015	13,113	7,745,291	699,617	17,929	840,088
2020	445,093	434,589	59,813	27,631	7,772,516	973,698	730	303,924
2021	242,964	448,744	13,692	4,179	4,479,971	600,768	9,756	279,865
2022	453,830	1,360,375	17,128	3,175	3,931,722	377,008	9,486	334,404
2023	615,459	430,776	59,591	137,804	3,635,178	629,242	52,803	230,594
Avg(90-23)	1,209,118	875,212	29,679	39,751	6,602,198	1,760,484	456,290	946,230
Avg(04-23)	1,198,840	903,227	28,154	42,398	7,582,510	1,567,275	113,529	561,252
Avg(14-23)	518,240	687,756	25,157	22,043	7,972,787	1,037,445	67,332	476,353
Avg(19-23)	413,816	679,499	34,848	37,180	5,512,936	656,067	18,141	397,775
5yr vs 20yr	-65.48%	-24.77%	23.78%	-12.31%	-27.29%	-58.14%	-84.02%	-29.13%
5yr vs 10yr	-20.15%	-1.20%	38.52%	68.67%	-30.85%	-36.76%	-73.06%	-16.50%

Table 5. (Continued) Commercial harvest in pounds and recreational catch (A+B1+B2) in number of fish by year, species, and Bay state. Sources: ACCSP and MRP.

Commercial Harvest in Pounds by Species and State										
	BLUE CATFISH		COBIA		RED DRUM		SPANISH MACKEREL		SPOTTED SEATROUT	
YEAR	MD	VA	MD	VA	MD	VA	MD	VA	MD	VA
2019	2,093,539	3,020,489	0	38,711	0	2,616	0	213,290	0	135,729
2020	1,805,310	2,475,379	0	30,728	0	8,257	7,111	81,662	0	67,794
2021	2,209,281	3,110,369	0	30,798	0	18,671	6,006	173,514	0	52,692
2022	2,637,344	3,579,156	313	38,601	0	18,056	6,658	240,453	0	75,516
2023		3,987,460	0	31,277	0	16,885	0	199,843	0	75,868
Avg(90-23)	504,448	1,104,963	186	15,134	659	7,144	7,932	140,522	2,821	35,807
Avg(04-23)	876,108	1,877,376	56	19,353	565	7,824	4,191	79,214	182	47,963
Avg(14-23)	1,722,301	2,978,777	31	31,530	130	8,991	4,379	101,439	0	60,165
Avg(19-23)	2,186,369	3,234,571	63	34,023	0	12,897	3,955	181,752	0	81,520
5yr vs 20yr	149.55%	72.29%	11.99%	75.81%	-100.00%	64.83%	-5.62%	129.44%	-100.00%	69.96%
5yr vs 10yr	26.94%	8.59%	100.00%	7.91%	-100.00%	43.44%	-9.67%	79.17%		35.49%

Recreational Catch (A+B1+B2) in Numbers of Fish by Species and State										
	BLUE CATFISH		COBIA		RED DRUM		SPANISH MACKEREL		SPOTTED SEATROUT	
YEAR	MD	VA	MD	VA	MD	VA	MD	VA	MD	VA
2019	743,596	2,339,025	251	226,324	6,998	606,226	168,596	414,441	371,100	3,114,208
2020	866,136	3,957,508	8,962	184,039	259,318	765,369	212,144	210,155	246,192	3,301,962
2021	632,878	1,113,286	16,775	235,244	20,005	1,505,470	237,737	452,598	101,964	3,399,938
2022	697,576	946,615	0	115,074	15,382	930,447	72,140	240,866	105,980	2,538,250
2023	1,292,298	1,725,268	0	214,053	102,338	1,268,608	74,183	565,362	68,570	3,960,041
Avg(90-23)	190,086	723,473	1,213	64,271	59,213	532,454	35,287	125,479	99,016	1,375,702
Avg(04-23)	306,803	1,123,705	1,951	95,689	94,200	713,407	52,360	146,656	123,013	2,079,124
Avg(14-23)	591,053	1,755,239	3,903	158,367	47,728	823,441	86,575	229,508	157,311	2,894,368
Avg(19-23)	846,497	2,016,340	5,198	194,947	80,808	1,015,224	152,960	376,684	178,761	3,262,880
5yr vs 20yr	175.91%	79.44%	166.35%	103.73%	-14.22%	42.31%	192.13%	156.85%	45.32%	56.94%
5yr vs 10yr	43.22%	14.88%	33.18%	23.10%	69.31%	23.29%	76.68%	64.13%	13.64%	12.73%

Table 6. Diet studies of Chesapeake Bay piscivorous fishes with reference to the relevance of menhaden to the diet.

Species	Menhaden ERP	Age or Size	Menhaden % of Diet: Weight	Menhaden % of Diet: Number	Years	Source/Location	Reference
Striped Bass	Yes		15.9%	11.7%	2002-2020	ChesMMAP / Bay	Bonzek et al. 2021
Bluefish	Yes		5.1%	4.7%	2002-2020	ChesMMAP / Bay	Bonzek et al. 2021
Weakfish	Yes		< 1.0%	< 1.0%	2002-2022	ChesMMAP / Bay	Bonzek et al. 2021
Spiny Dogfish	Yes		7.8%	5.1%	2002-2022	NEAMAP / Ocean	Bonzek et al. 2007
Cobia	No		1.5%	0.1%	Jun-Jul 1997	Chesapeake Bay	Arendt et al. 2001
	No		5.2%		2013-2016	James R.	Hilling et al. 2023
	No		0.4%			James R.	Schmidt et al. 2019
Blue Catfish	No		3.5%		2013-2016	Pamunkey R	Schmidt et al. 2019
	No		5.0%			Mattaponi R	Schmidt et al. 2019
	No		1.1%			Rappahannock R	Schmidt et al. 2019
		100-400mm	27.4%		2007-2009		Facendola and Scharf, 2012
Red Drum		400-700mm	15.4%			New River, NC	
	No	> 750mm	11.9%		2007-2010, 2011-2012	NC DMF Longline Survey	Peacock, 2014
		< 300mm		9.4%			
		301-500mm		15.6%			
Spotted Seatrout	No	> 500mm		31.5%	1978-1983	Coastal Georgia	Music and Pafford, 1984
		Combined		20.1%			
		All Clupeids	22.6%*	5.3%	1978-1979	Cape Canaveral, FL	Naughton and Saloman, 1981
Spanish mackerel		Age0-1	40.0%				
	No	Age1+	20.0%		1980-2016	Gulf of Mexico	Berenshtein et al. 2021
*: Includes all Clupeids							

Figures

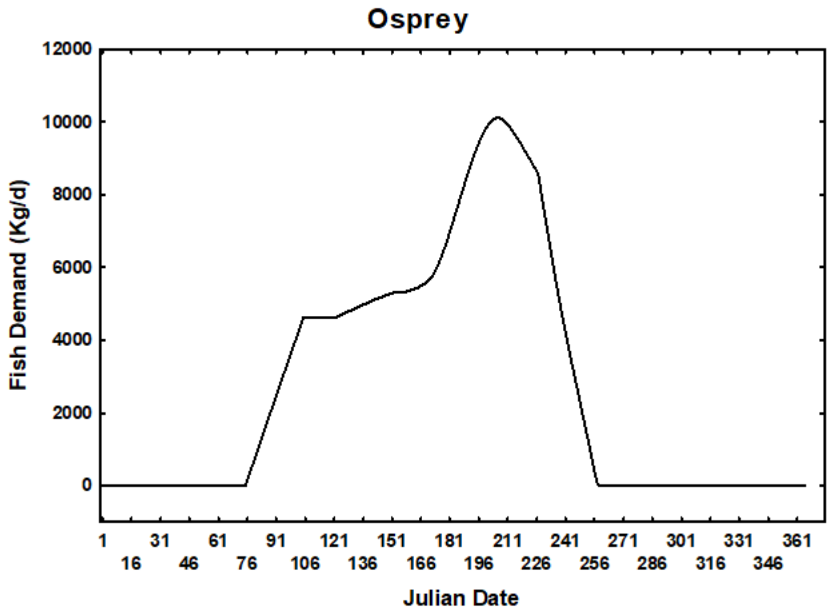


Figure 1. Seasonality of population-level metabolic demand for osprey in Chesapeake Bay. The period of highest energy demand is mid-May through mid-August. (B. Watts, unpublished data).

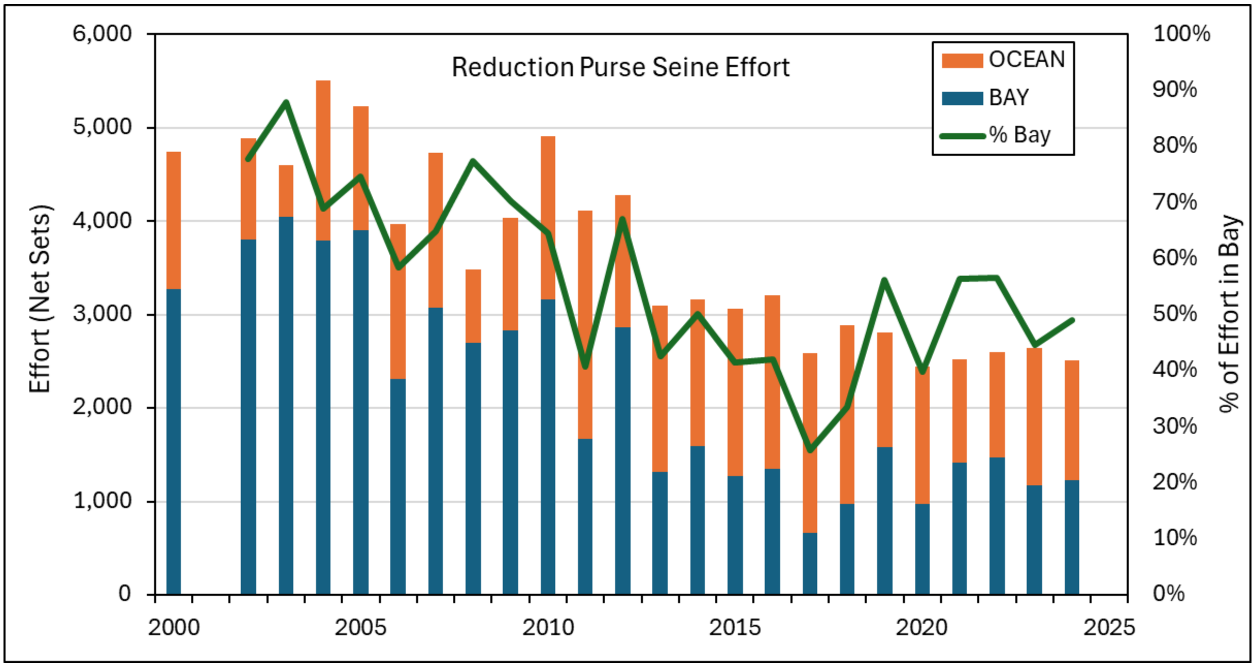


Figure 2. Virginia purse seine reduction effort separated into Bay and Ocean net sets.

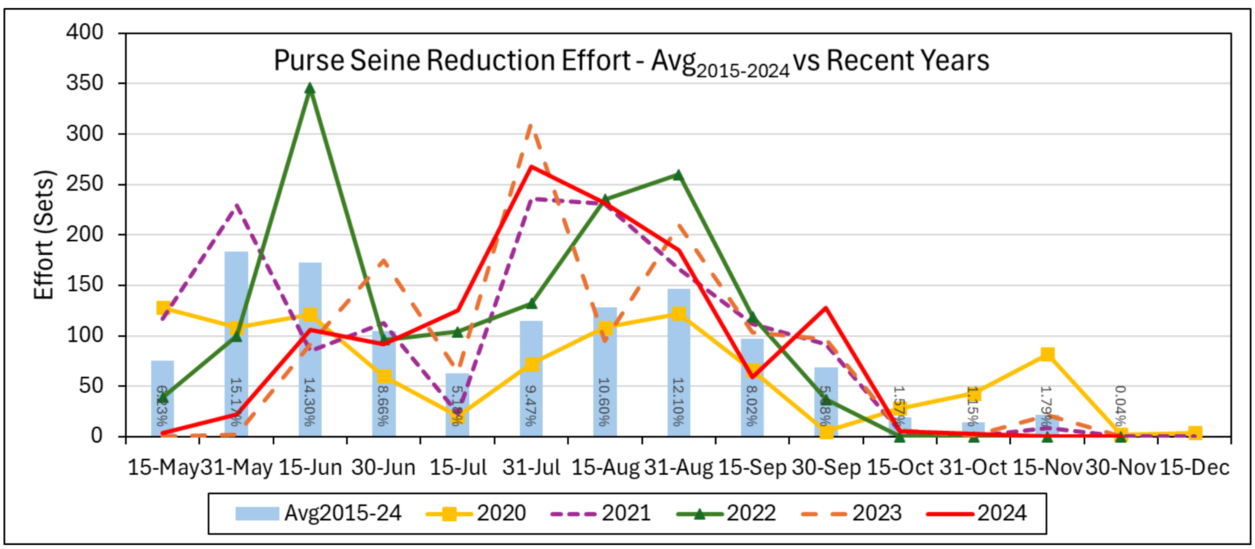


Figure 3. Semi-monthly purse seine reduction ten-year average(2015-2024) compared to the last 5 years (2020-2024). Percentages on the bar the percent of effort for that semi-monthly time period compared to the entire season.

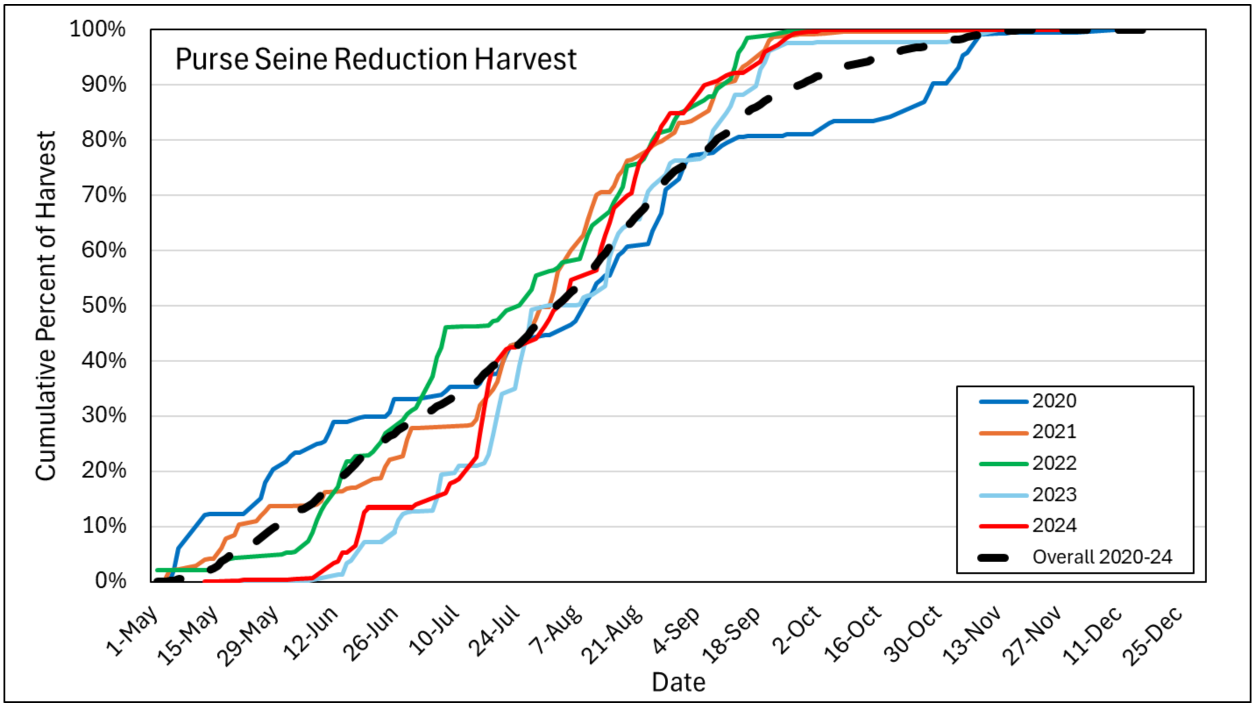


Figure 4. Cumulative percent of purse seine reduction harvest over the season for the most recent 5 years compared to the 5-year average.

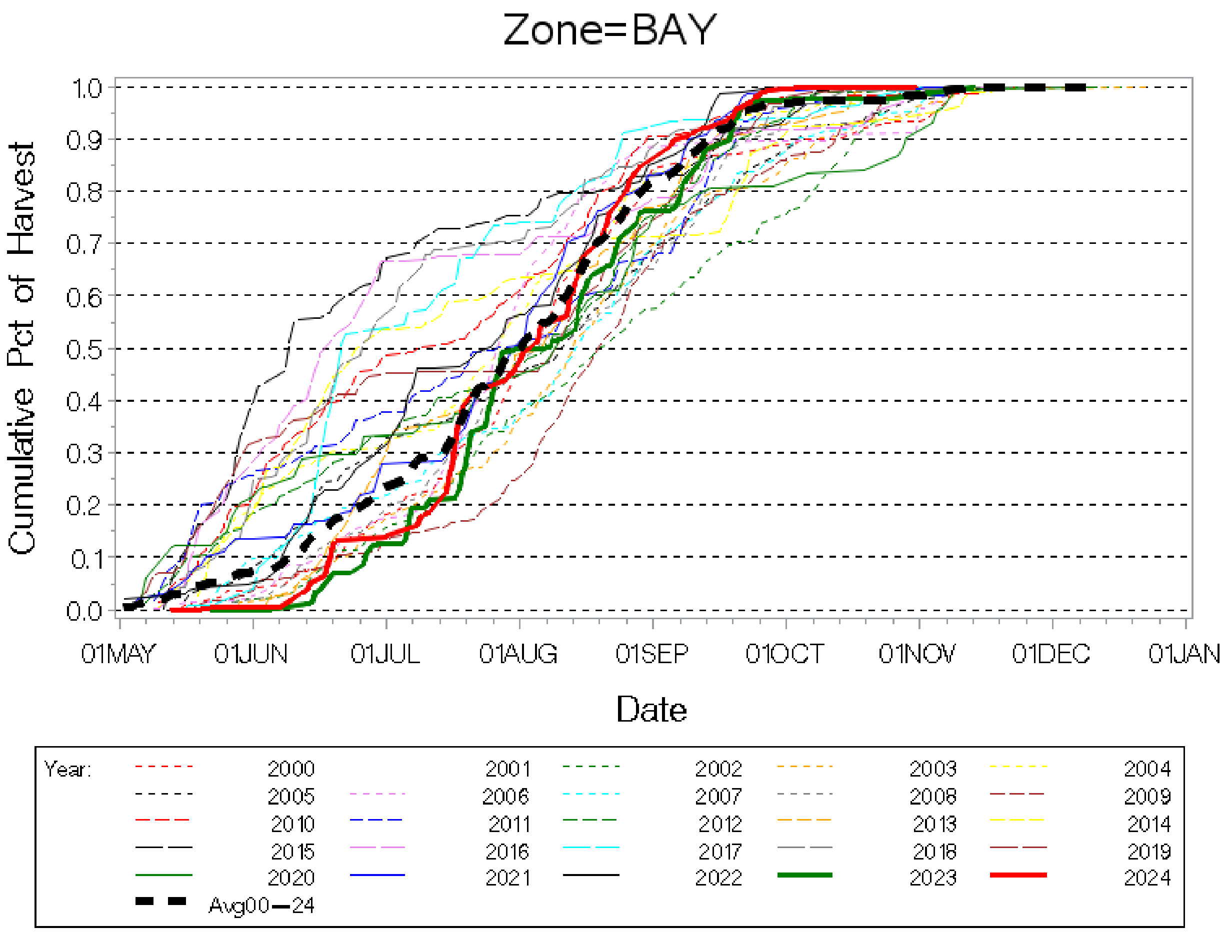
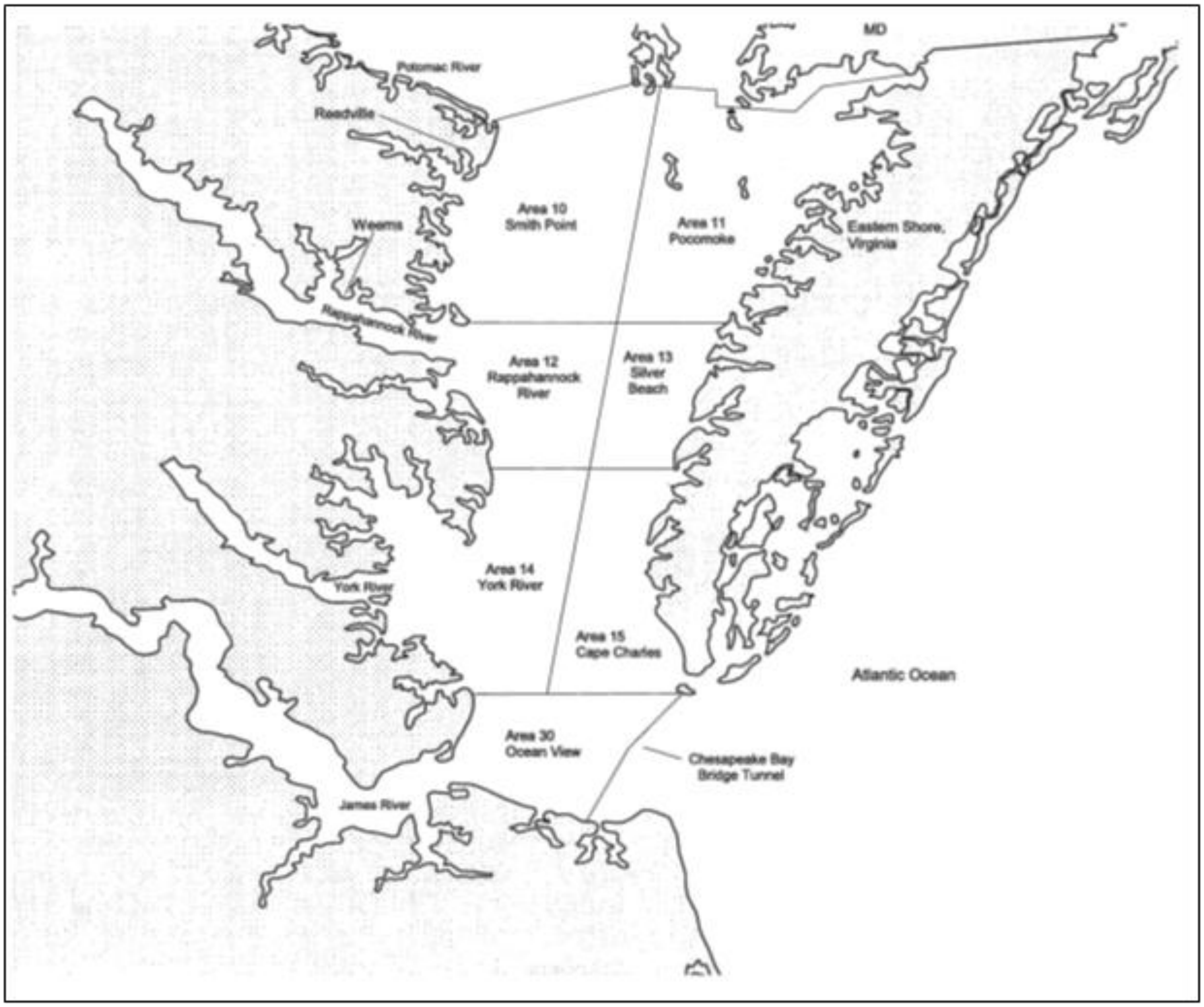
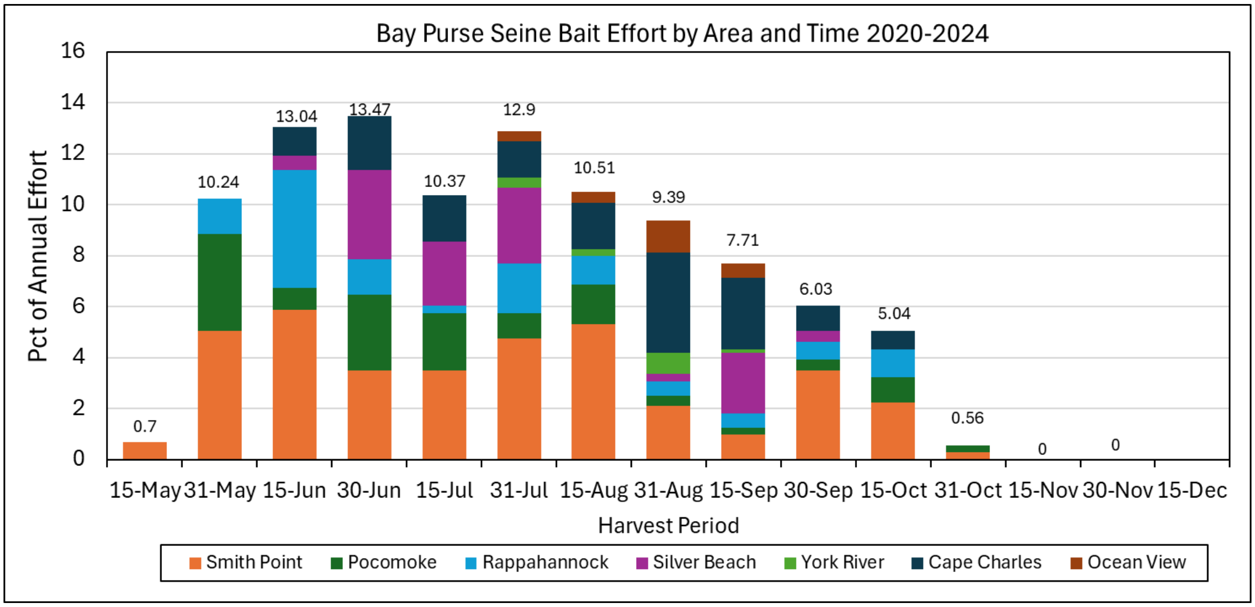


Figure 5. Cumulative percent of purse seine reduction harvest over the season for the most the past 25 years (2000 – 2024). Black dashed line is the 25-year average.



<table>
<tr><th colspan="6">CDFR Program Virginia Reporting Areas</th></tr>
<tr><td colspan="6">Chesapeake Bay</td></tr>
<tr><td></td><td colspan="2">West</td><td>→</td><td colspan="2">East</td></tr>
<tr><td>North</td><td>Area</td><td>Name</td><td rowspan="5"></td><td>Area</td><td>Name</td></tr>
<tr><td rowspan="3">↓</td><td>10</td><td>Smith Point</td><td>11</td><td>Pocomoke</td></tr>
<tr><td>12</td><td>Rappahannock River</td><td>13</td><td>Silver Beach</td></tr>
<tr><td>14</td><td>York River</td><td>15</td><td>Cape Charles</td></tr>
<tr><td>South</td><td colspan="2">30</td><td colspan="2">Ocean View</td></tr>
<tr><td colspan="6">Ocean</td></tr>
<tr><td rowspan="2">↓</td><td colspan="2">16</td><td rowspan="2"></td><td colspan="2">NMFS Water Code 625</td></tr>
<tr><td colspan="2">17</td><td colspan="2">NMFS Water Code 631</td></tr>
</table>

Figure 6. NMFS menhaden reporting areas for the Bay and coastal water of Virginia. From: Smith, J.W. and W.B. O'Bier. 2010.



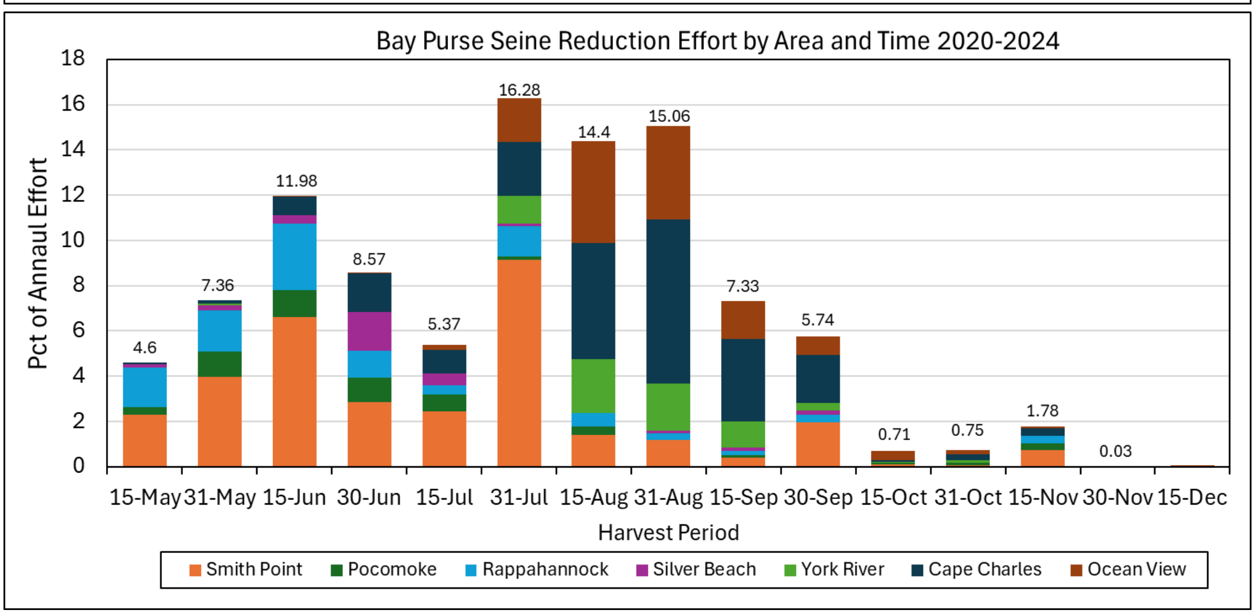


Figure 7. Menhaden purse seine reduction (top) and bait (bottom) effort by NMFS Chesapeake Bay reporting area and semi-monthly periods 2020 – 2024. Numbers above each bar present the percent of effort for that time period relative to the total effort.

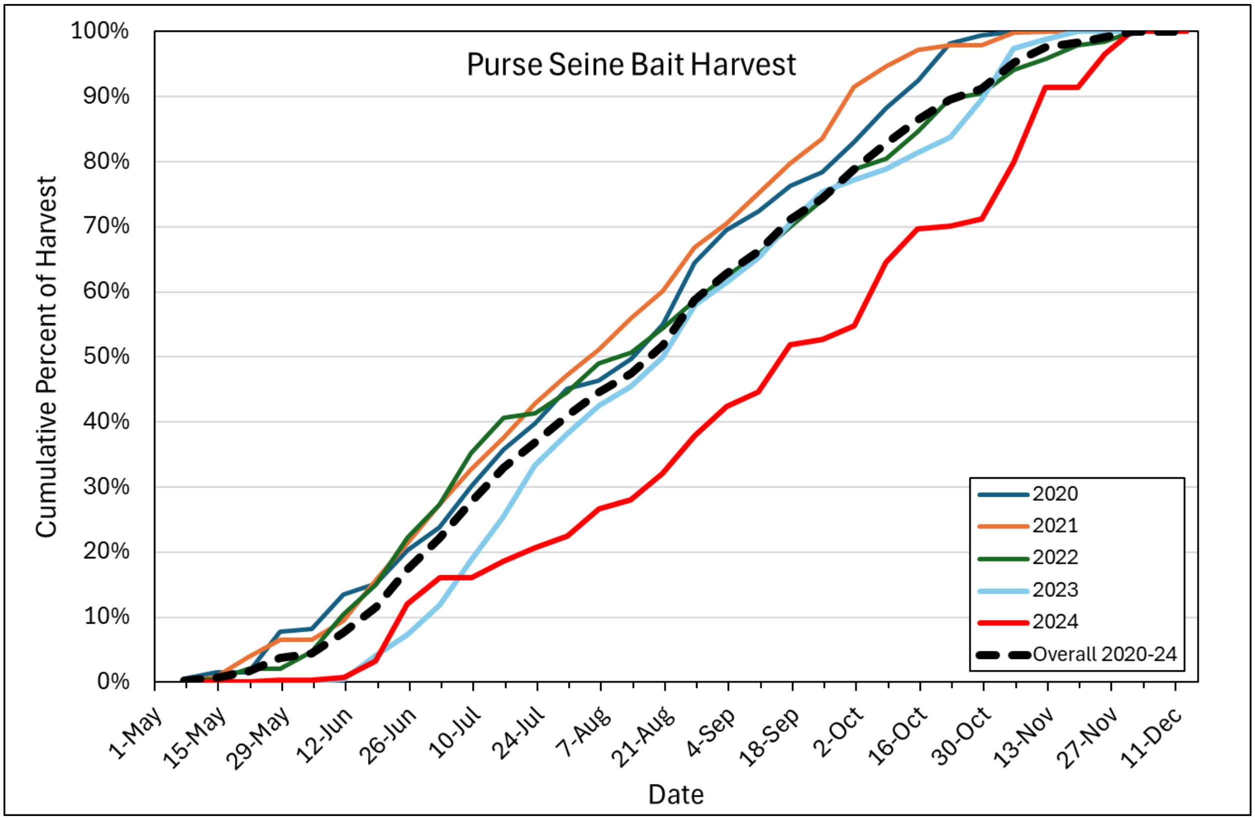


Figure 8. Cumulative purse seine bait weekly harvest reports compared to the 5-year average (2020-2024).

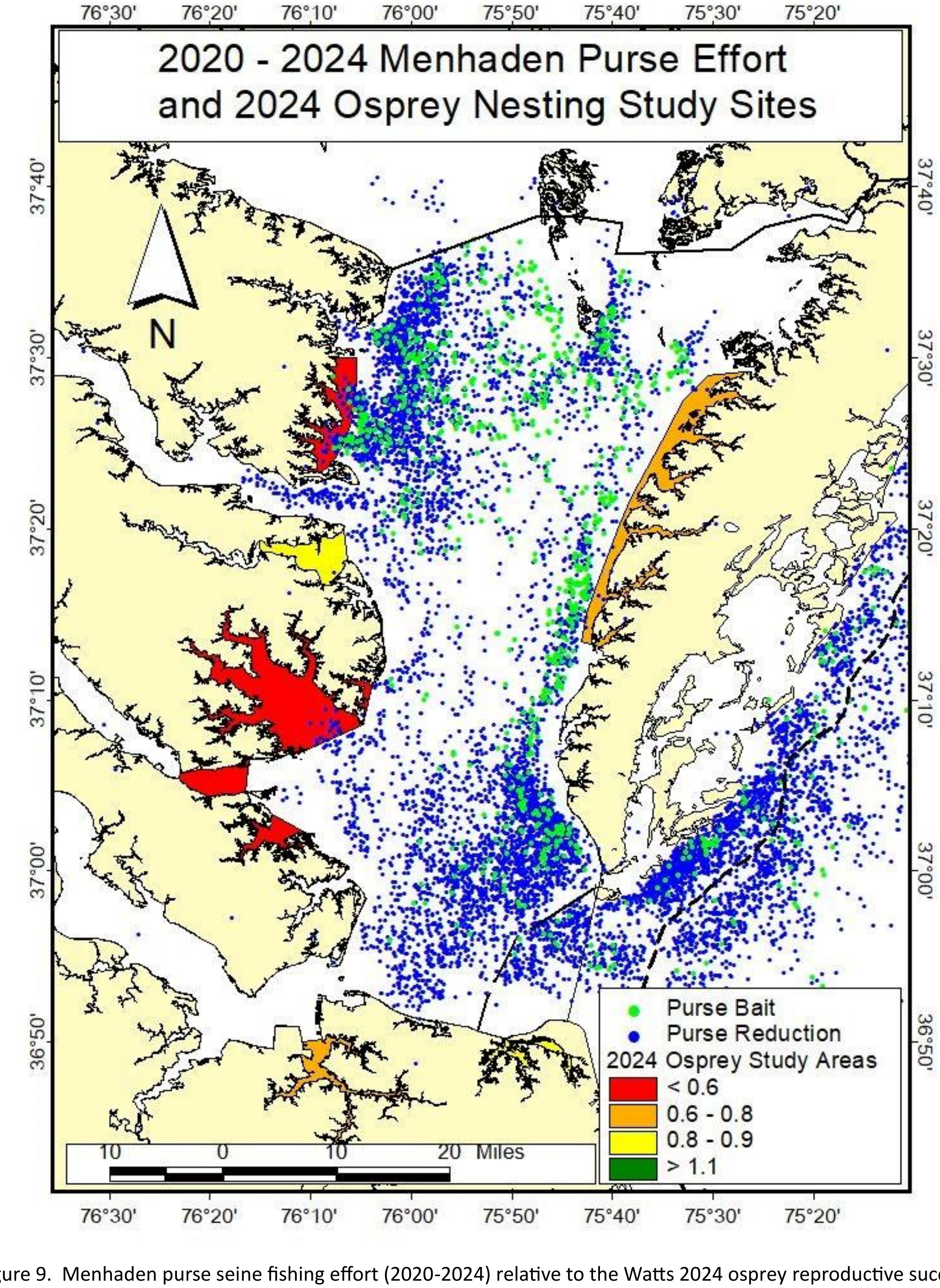


Figure 9. Menhaden purse seine fishing effort (2020-2024) relative to the Watts 2024 osprey reproductive success and nesting study areas.

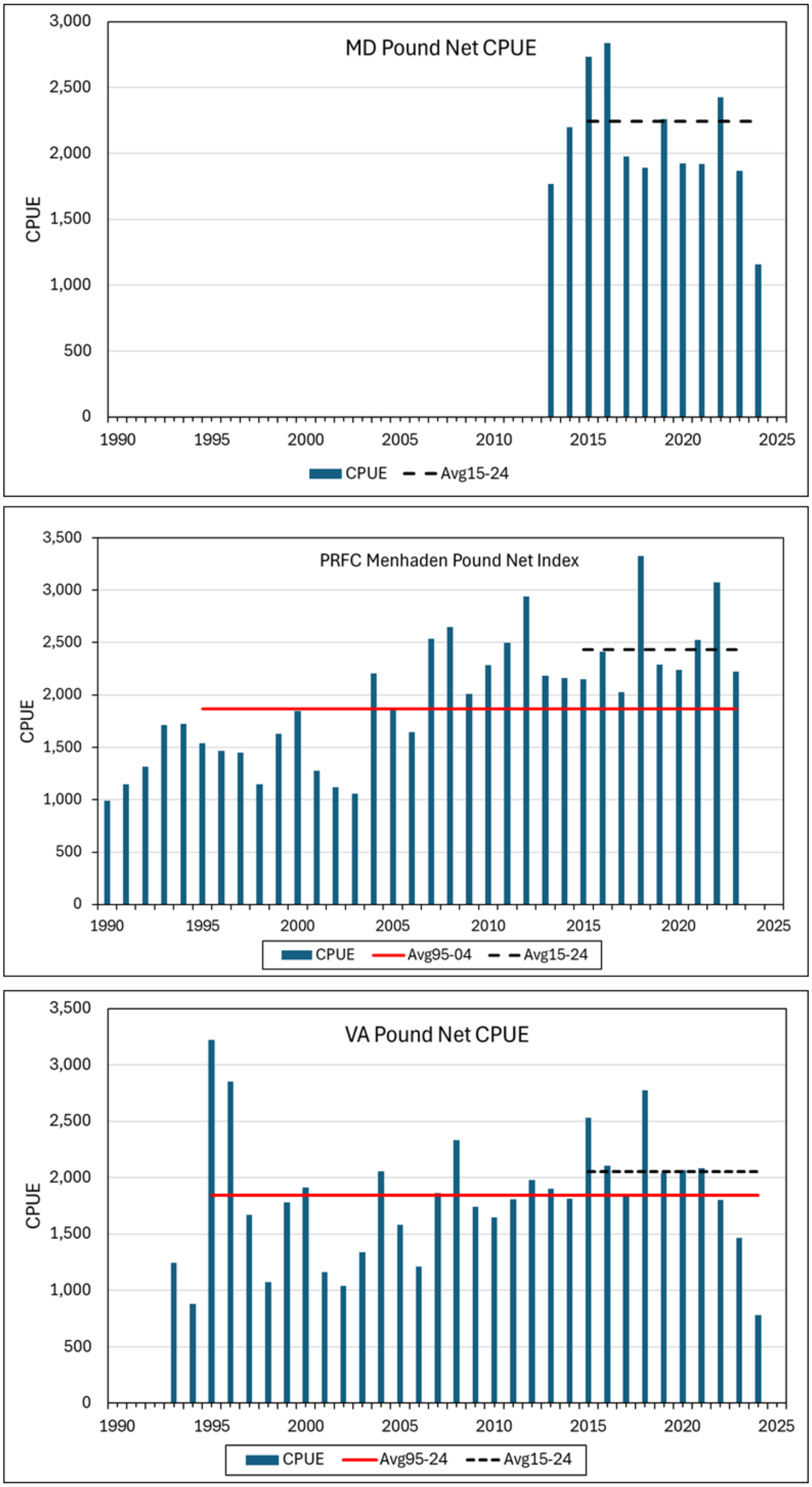
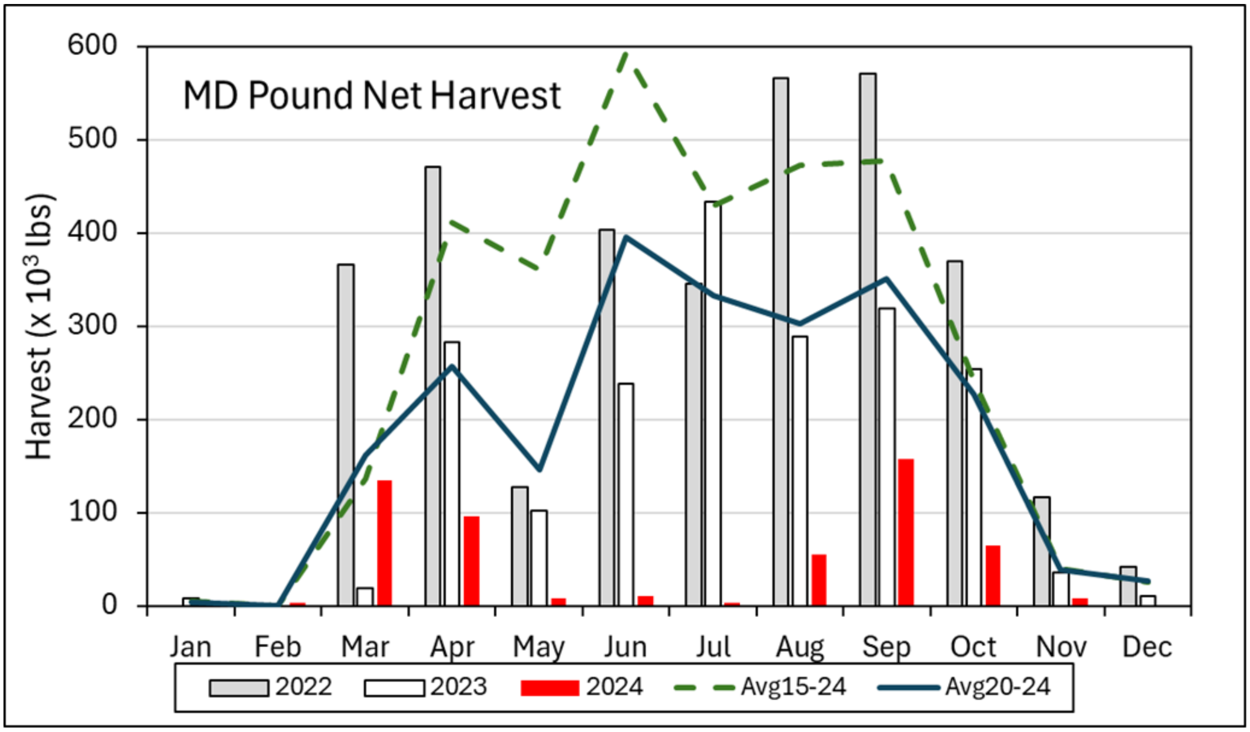


Figure 10. Annual menhaden Pound Net CPUE from Maryland, Potomac River, and Virginia. CPUE is in lbs per net day. Sources: MD DNR, PRFC, and VMRC.



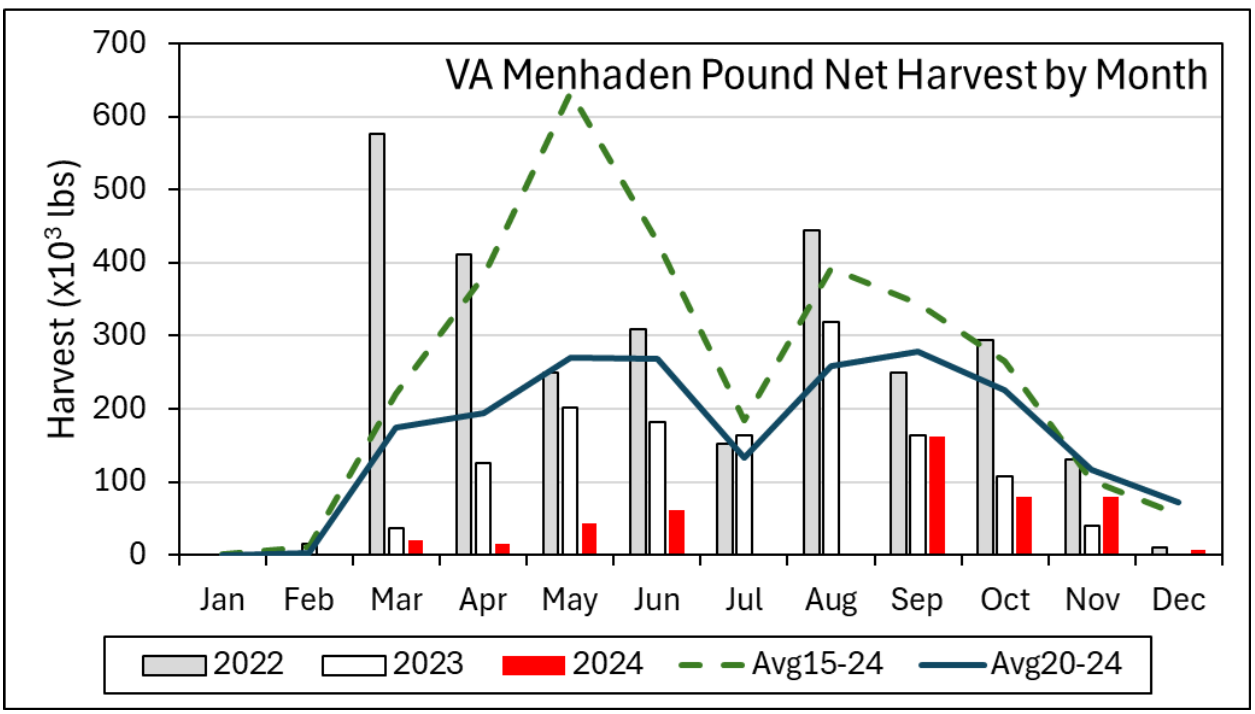


Figure 11. Menhaden monthly pound net harvest for Maryland (top) and Virginia (bottom) for the last three years relative the 10 and 5-year averages.

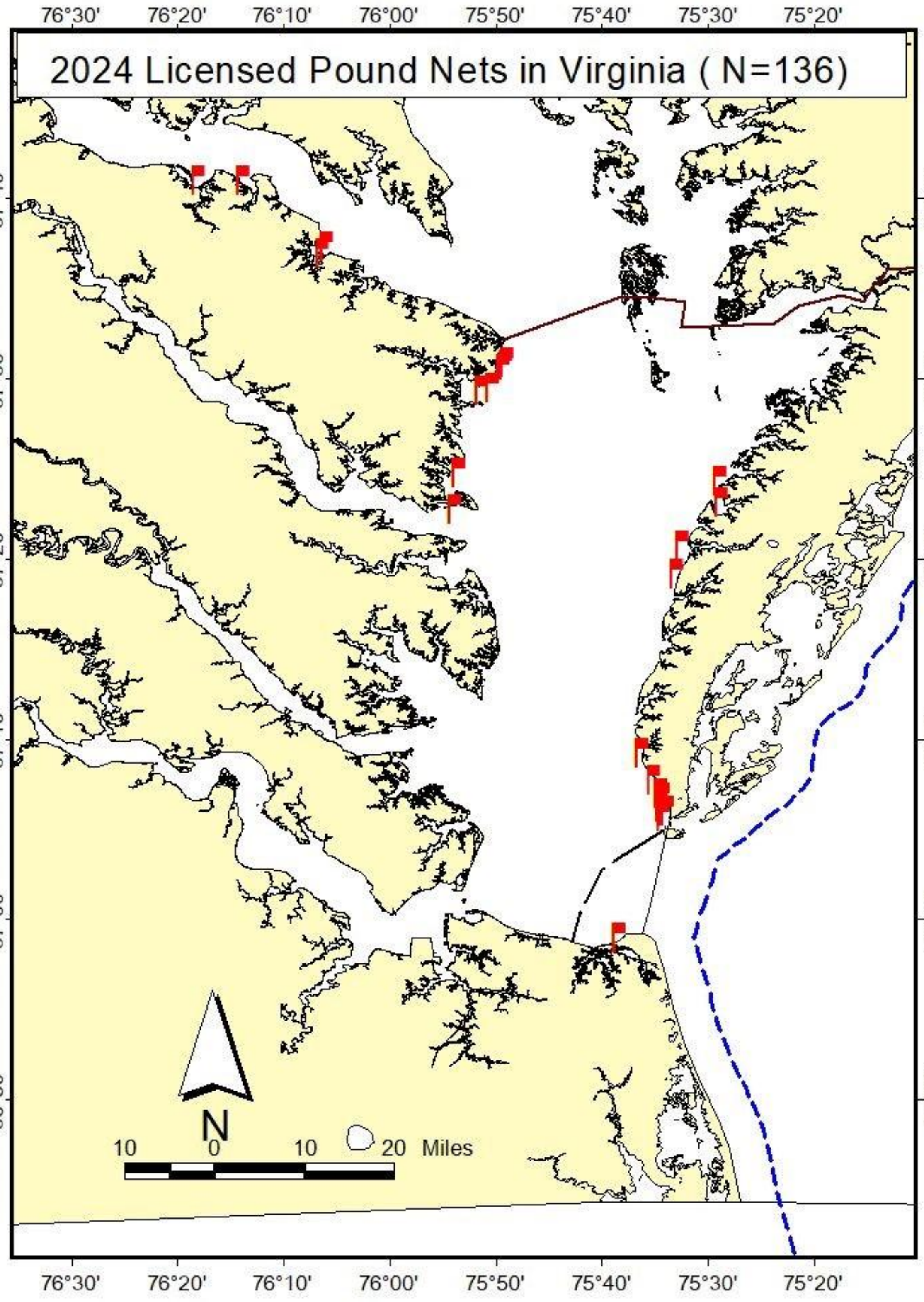
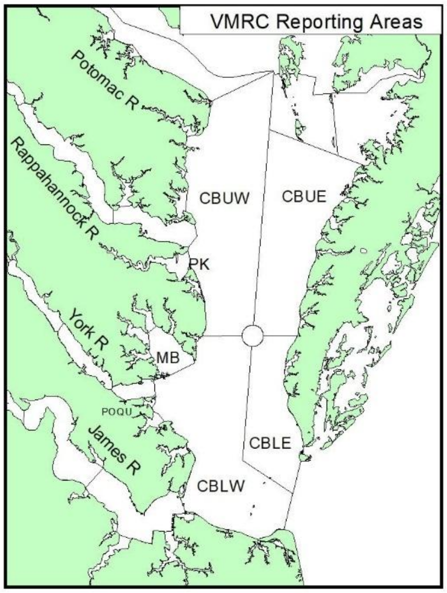


Figure 12. Location of 2024 licensed pound nets in Virginia.



VMRC Harvest Areas

Area	Description
CBLE	Ches Bay Lower East
CBLW	Ches Bay Lower West
CBUE	Ches Bay Upper East
CBUW	Ches Bay Upper West
JA	James River
POQR	Poquoson River
YK	York River
MB	Mobjack Bay
PK	Piankatank River
RA	Rappahannock River
PO	Potomac River

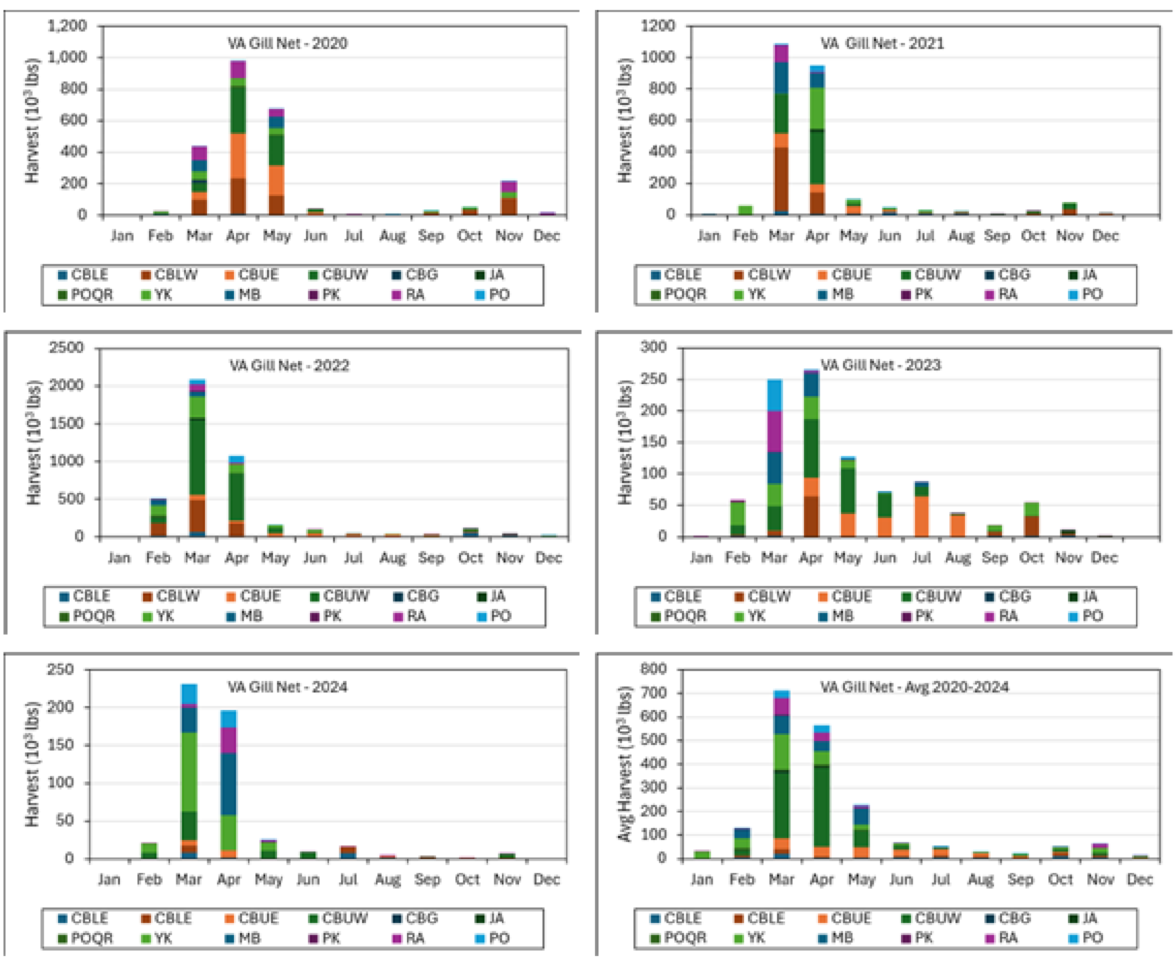
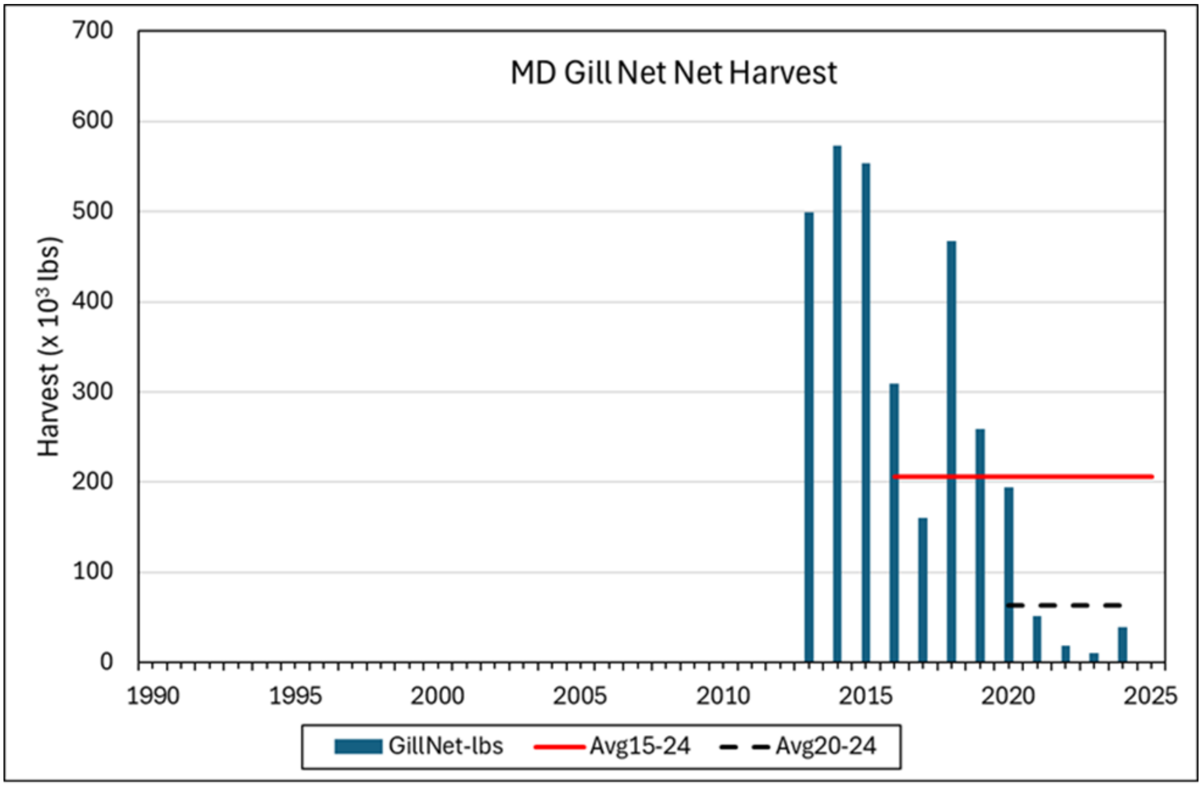


Figure 13. Virginia monthly pound net harvest by VMRC reporting area 2020-2024 Smaller water bodies were collapsed to reduce the number of reporting areas (see map).



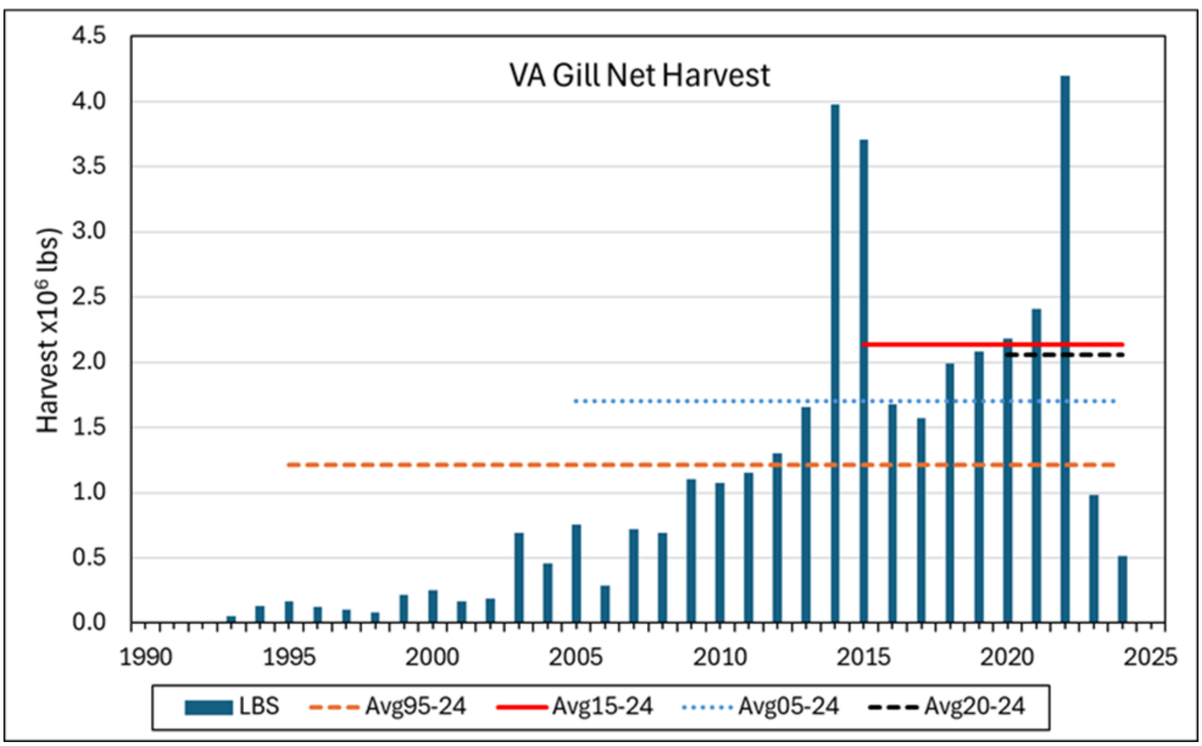
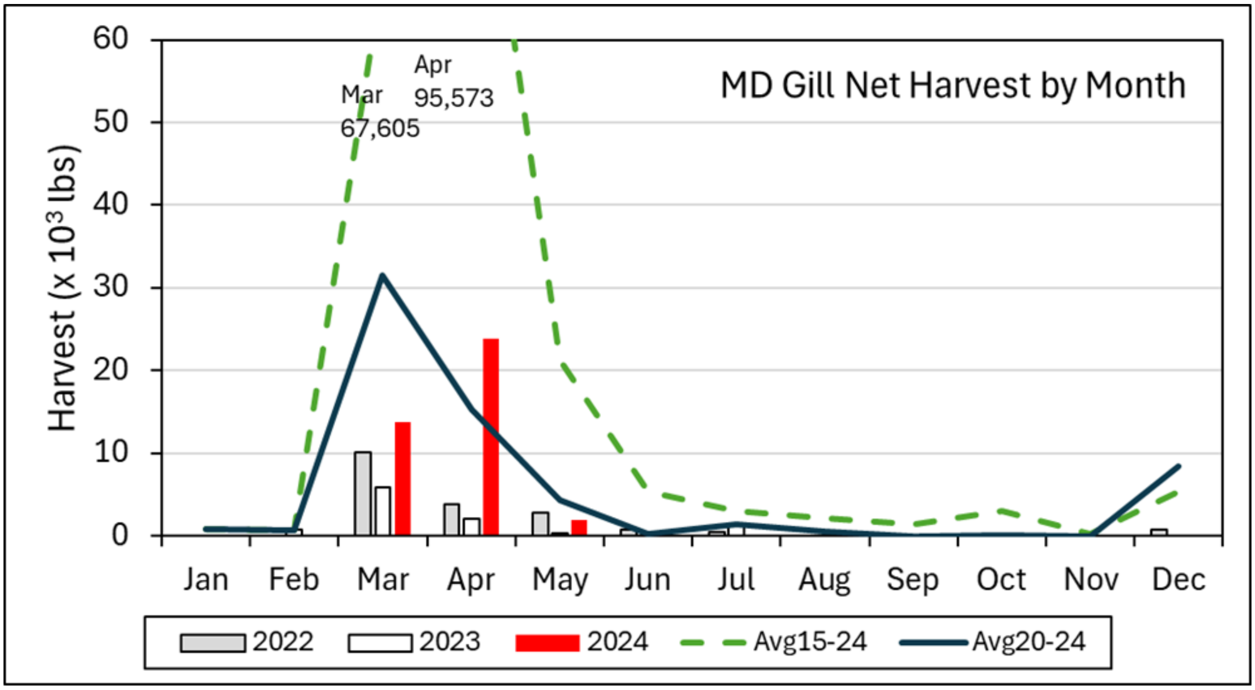


Figure 14. Menhaden gill net harvest for Maryland (top) and Virginia (bottom). Note that the scales on the y-axis are different: MD in thousands and VA in millions. Potomac River gill net data is not yet available. Sources: MD DNR and VMRC



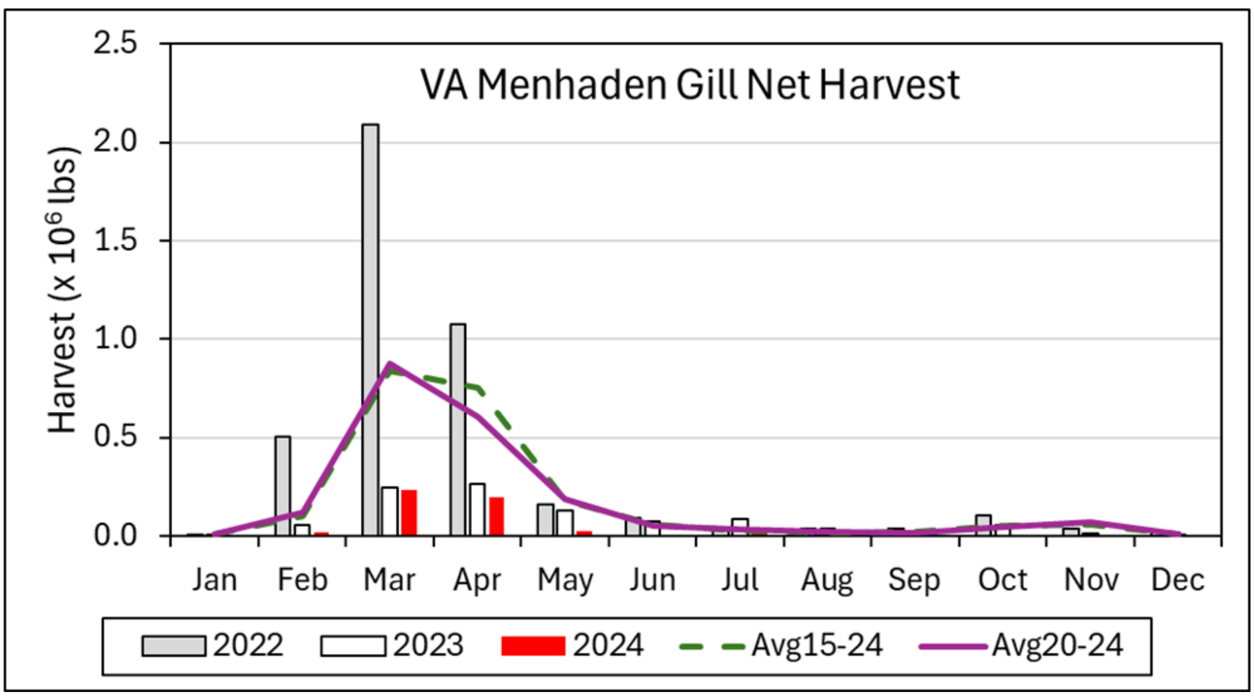
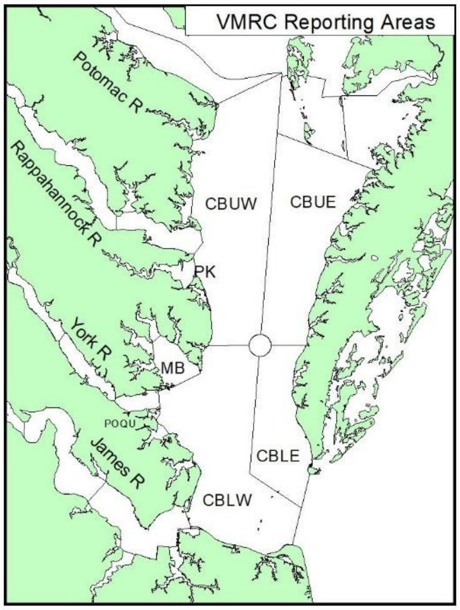
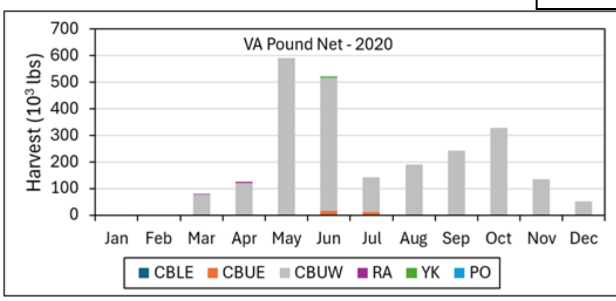


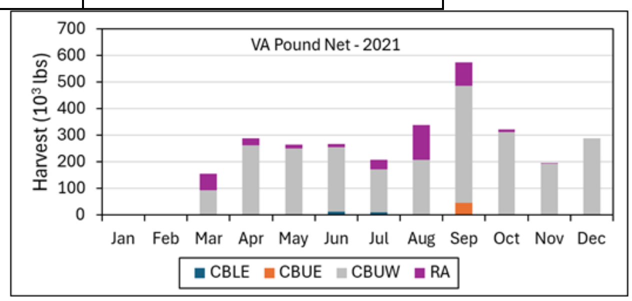
Figure 15. Menhaden monthly gill net harvest for Maryland (top) and Virginia (bottom) for the last three years relative the 10 and 5-year averages.

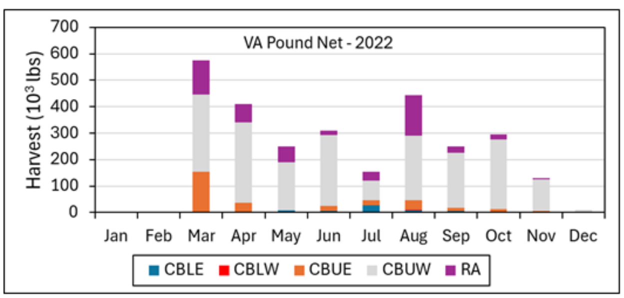


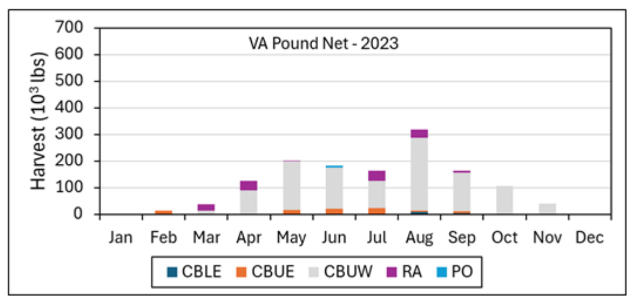
VMRC Harvest Areas

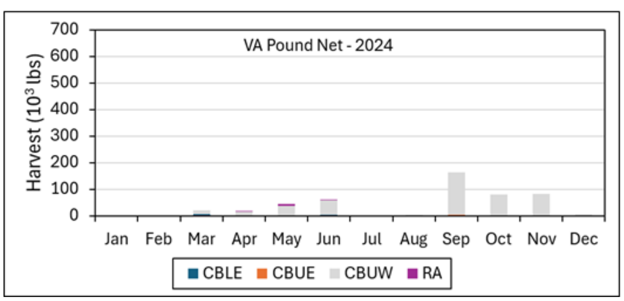
Area	Description
CBLE	Ches Bay Lower East
CBLW	Ches Bay Lower West
CBUE	Ches Bay Upper East
CBUW	Ches Bay Upper West
JA	James River
POQR	Poquoson River
YK	York River
MB	Mobjack Bay
PK	Piankatank River
RA	Rappahannock River
PO	Potomac River











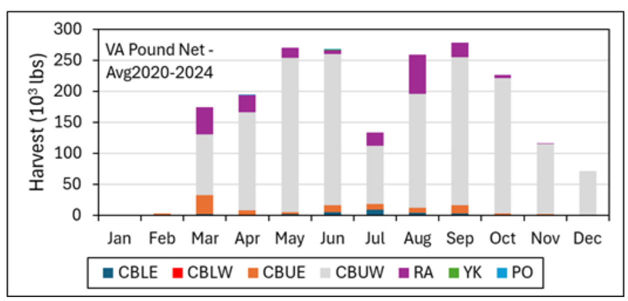


Figure 16. Virginia monthly pound net harvest by VMRC reporting area 2020-2024 Smaller water bodies were collapsed to reduce the number of reporting areas (see map).

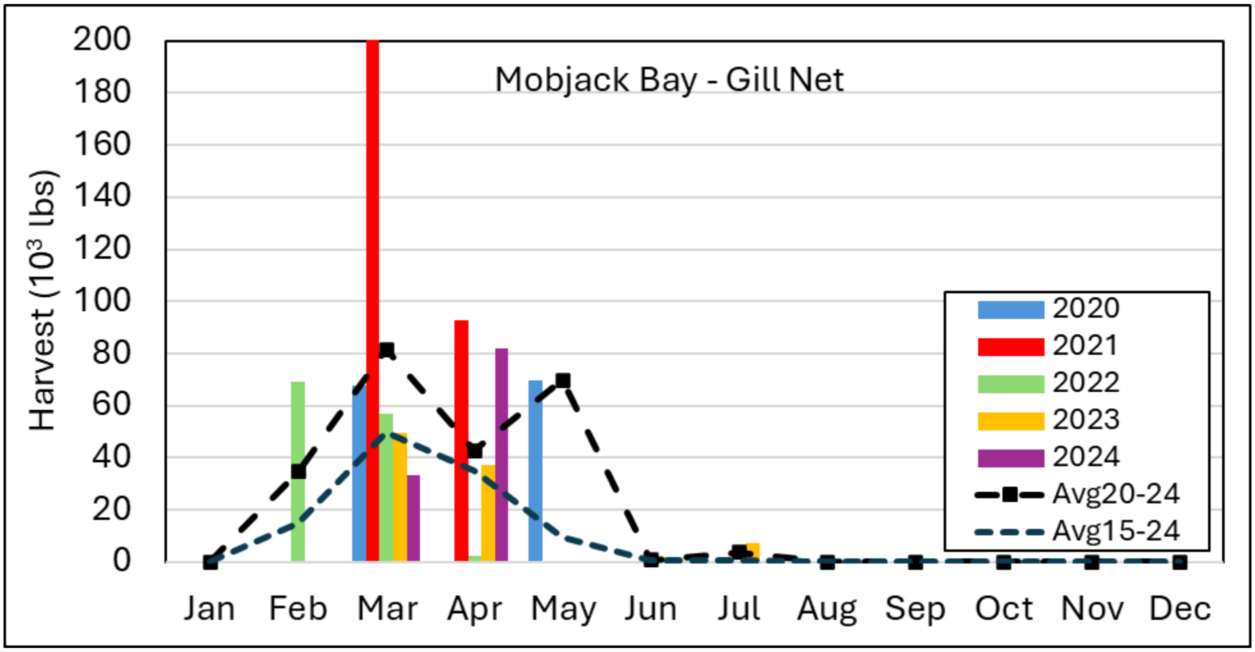


Figure 17. Mobjack Bay gill net menhaden harvest by year and month relative to the 5-year average (2020-2024) and ten-year average (2015-2024).

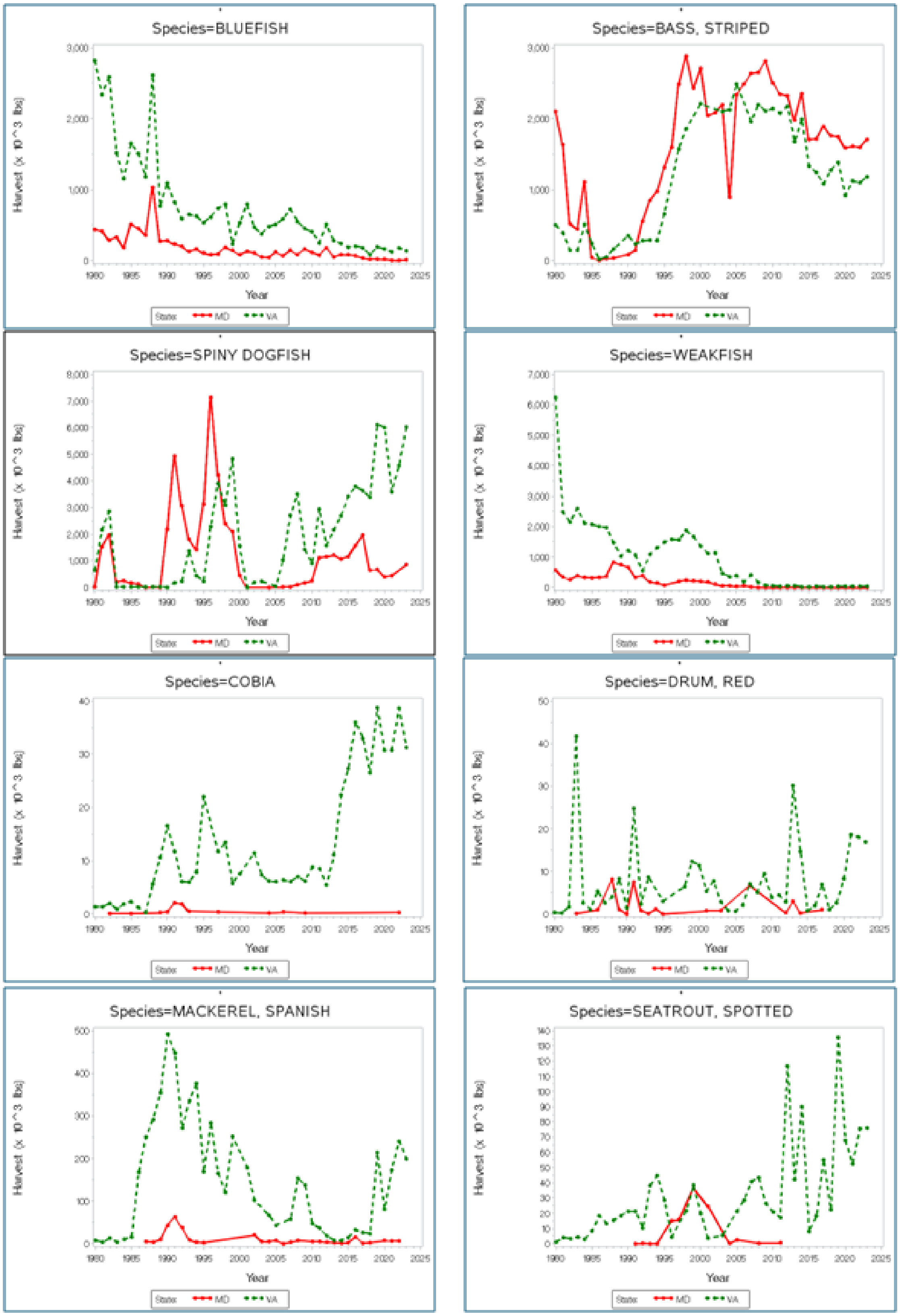


Figure 18. Commercial Harvest for Key Bay Predators. Source: ACCSP

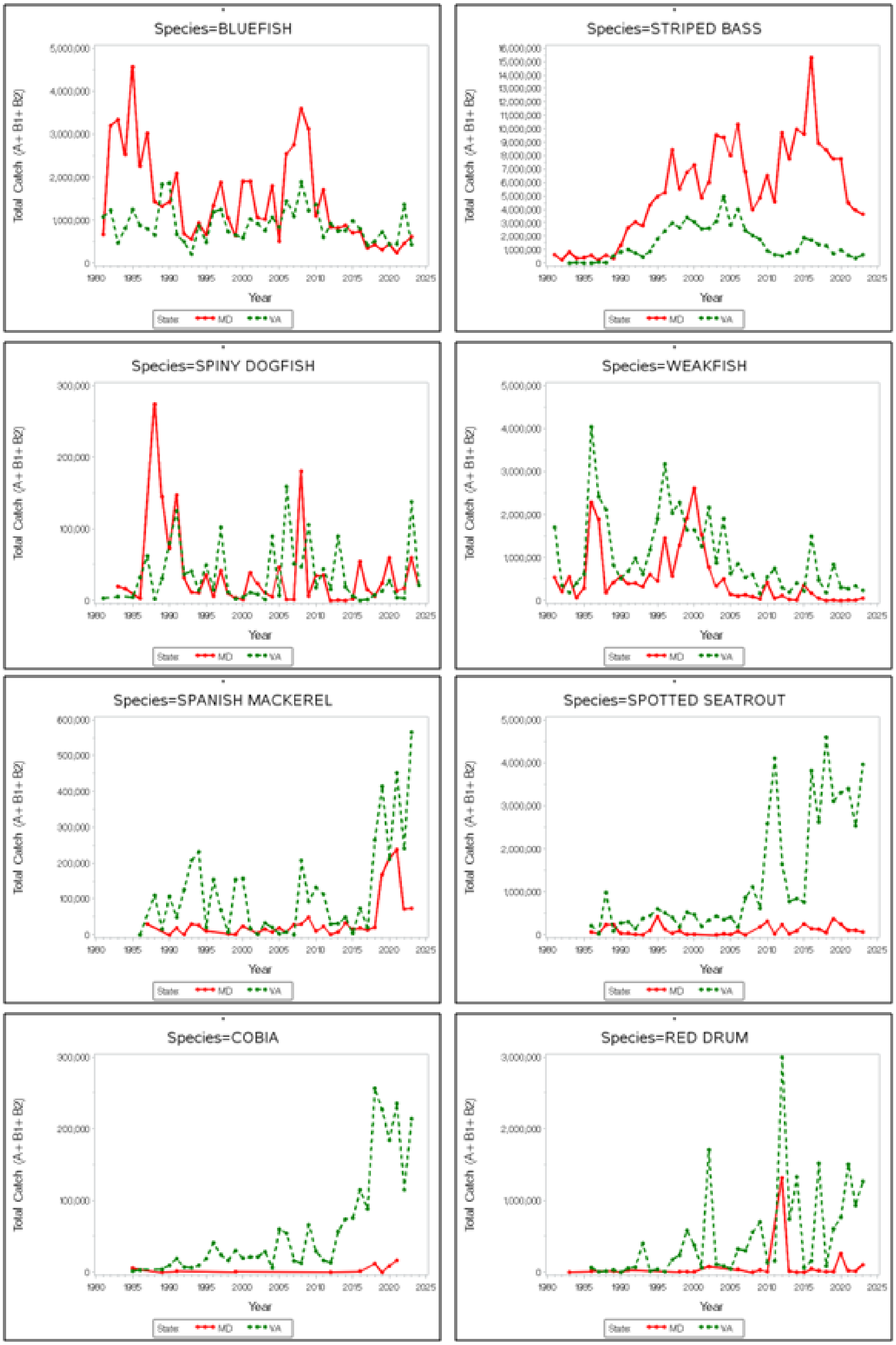


Figure 19. Recreational Catch of Key Bay Predators. Source: MRIP

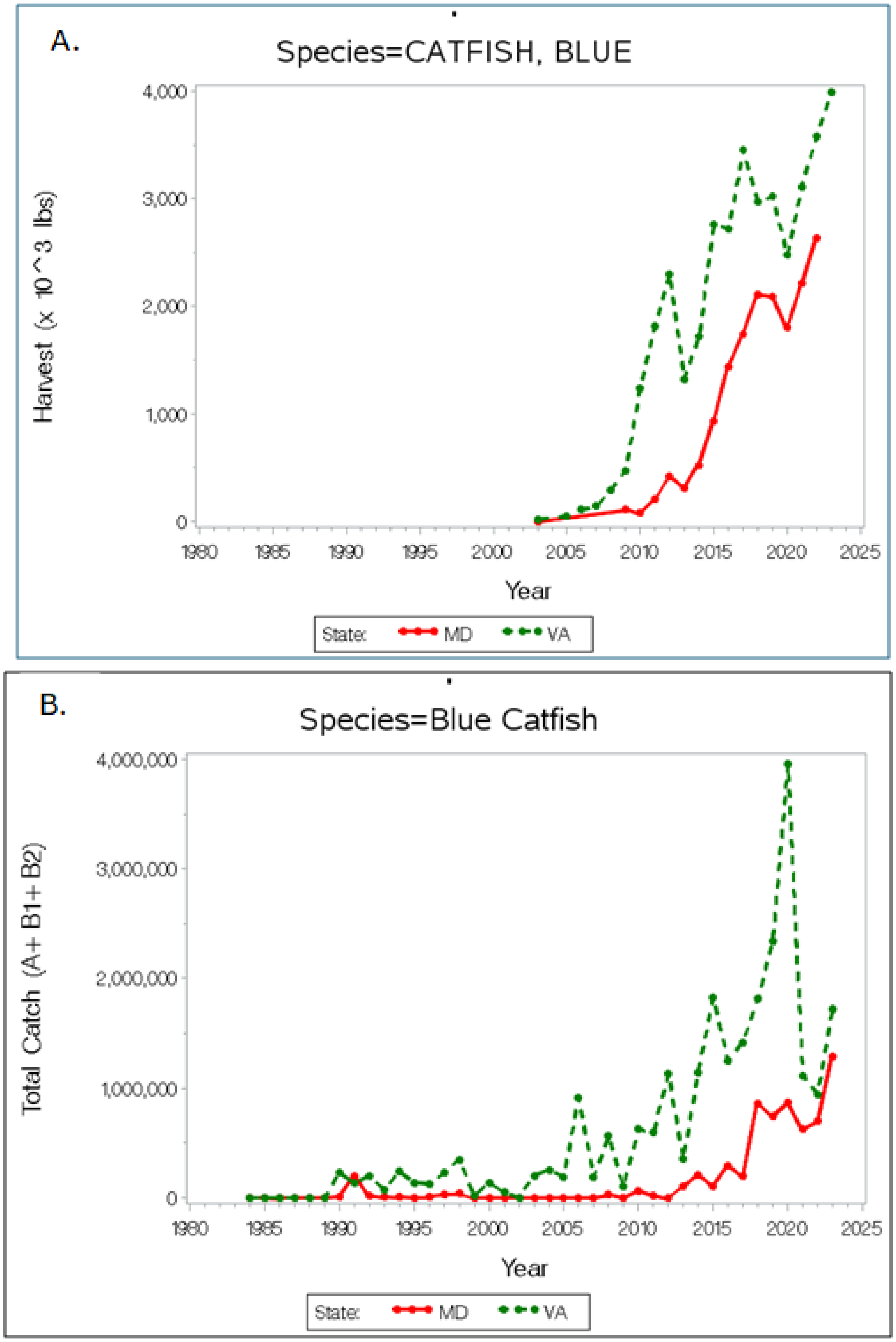


Figure 20. Blue Catfish Commercial (A) harvest and recreational catch (B) for Maryland and Virginia. Sources: ACCSP and MRIP

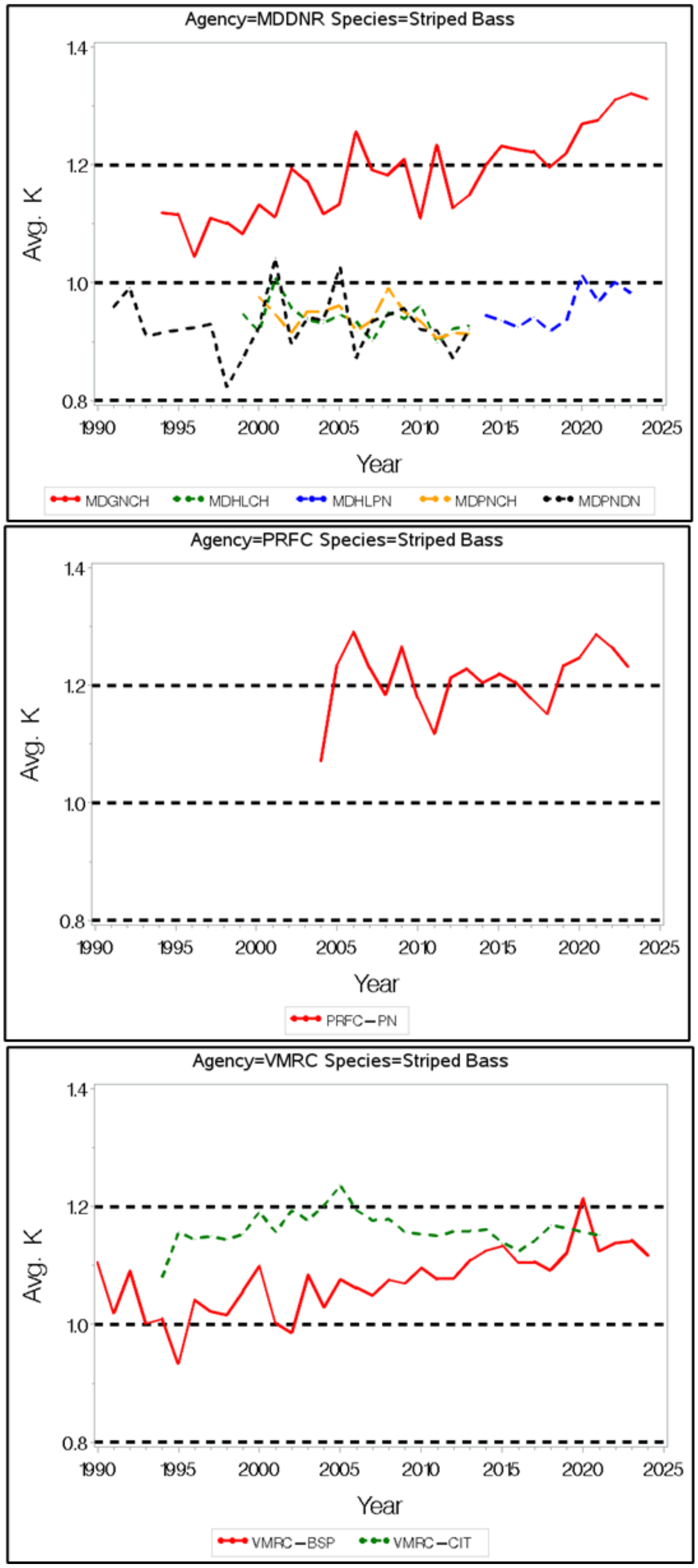


Figure 21. Striped Bass annual Fulton's Condition Factor by agency and project: 1 = normal, > 1.2 = very healthy, < 0.8 = stressed.

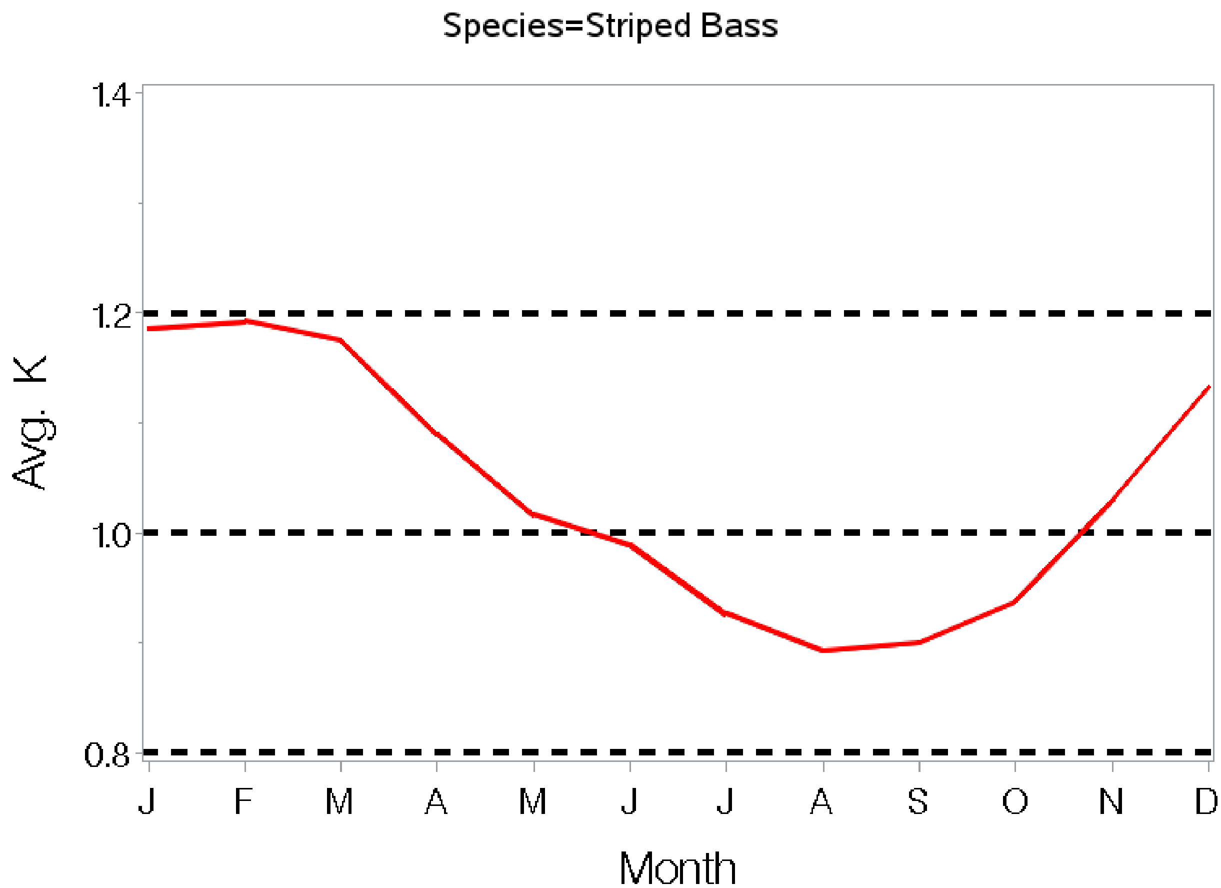


Figure 22. Striped Bass Fulton's Condition Factor by month for all agencies and projects combined.

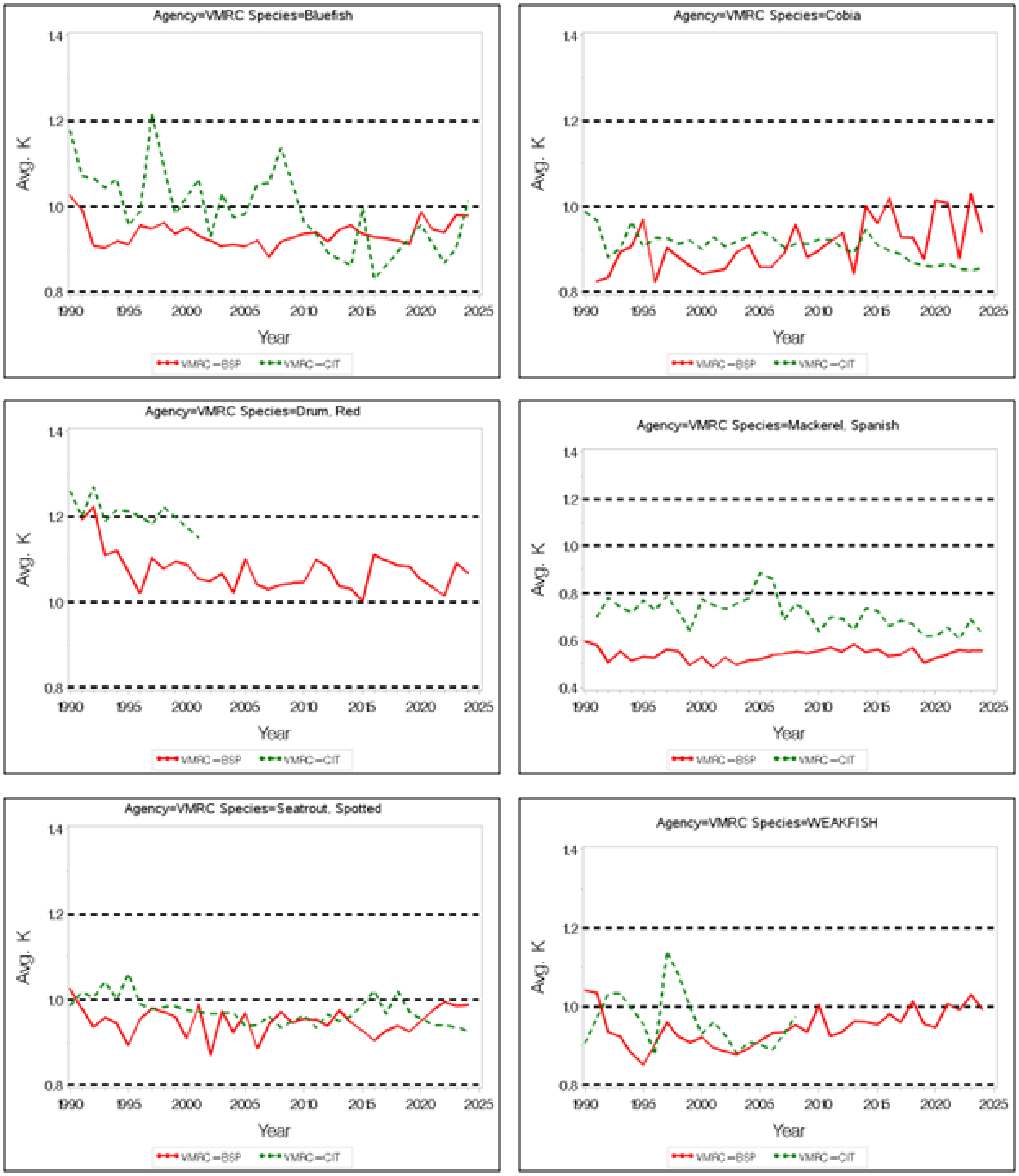


Figure 23. Fulton's Condition Factor for other bay predators for Virginia based projects only. Information for blue catfish and spiny dogfish is not available currently.