The Bait Purse-seine Fishery for Atlantic Menhaden, *Brevoortia tyrannus,* in the Virginia Portion of Chesapeake Bay

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Introduction

Atlantic menhaden, *Brevoortia tyrannus*, are estuarine-dependent, marine migratory members of the herring family of fishes (Ahrenholz, 1991). They are of moderate size, with some specimens reaching over 300 mm in fork length and weighing up to 1.0–1.5 kg. Menhaden are ubiquitous, occurring in coastal waters of the U.S. Atlantic coast, and inhabiting most major estuarine systems. Spring through fall, menhaden form large near-surface schools, which are the targets of a large industrial fishery for fish meal, fish oil, and fish solubles (Smith, 1991).

Menhaden flesh is high in protein (Dubrow et al., 1976) and rich in marine oils and fatty acids (Joseph, 1985). Given these qualities and the ubiquitous nature of menhaden schools, it is not surprising that menhaden are a preferred bait for trap or pot fisheries for blue crab (Van Engel, 1962; Warner, 1976), American lobster (The Free Press, 2010), and crawfish (LSU AgCenter, 2008).

The purse-seine reduction fisheries for Atlantic menhaden are well-documented (Nicholson, 1975; Smith, 1991) and stock assessments are conducted regularly as prescribed in the Fishery Management Plan (FMP) for the species (ASMFC, 2001). During the early 1990's, the Atlantic Menhaden Advisory Committee (AMAC) of the Atlantic States Marine Fisheries Commission (ASMFC), which at the time was responsible for reviewing menhaden fishery-dependent data, was concerned that harvests of menhaden for bait were increasing, while landings for major segments of the bait fishery may have been undocumented. Beginning in 1994, the AMAC took steps to improve data collection of menhaden bait landings and age and size composition of the catch.

One substantial facet of the bait fishery that was suspected of under-reported landings was a directed purse-seine fishery for bait which developed during the 1970's among several vessels in the Virginia portion of Chesapeake Bay. These craft were smaller than the vessels in the industrial fishery, with commensurate reductions of gear and crew members. The vessels and their purse-seine gear are colloquially called "snapper rigs" in Tidewater Virginia. The origin of the term is ill-defined, but it probably reflects local slang. Small bluefish, *Pomatomus saltatrix*, are locally referred to as snappers, and some suggest that this scaling vernacular was likewise applied to the menhaden bait gear. One source (Castro et al., 2007) indicates that the term was coincidently adopted for bait vessels and purse-seine gear in Narragansett Bay, R.I. Regardless of the moniker's origin, by an unusual nuance in Virginia fisheries statutes, regulatory authority over the menhaden fisheries in the Old Dominion resides with the legislature in the Commonwealth's capital at Richmond, and not with the Virginia Marine Resources Commission (VMRC) in Newport News, which regulates all other marine fisheries resources. With VMRC lacking statutory authority to collect menhaden data, bait landings by snapper rigs consequently often went unreported.

In 1994 the AMAC formed a Bait Subcommittee to better substantiate menhaden bait landings along the U.S. eastern seaboard. AMAC members from the Beaufort Laboratory of the National Marine Fisheries Service, owing to decades of work with the reduction purse-seine fishery in Chesapeake Bay, were asked to document landings and age and size composition of the catch in Virginia's snapper rig bait fishery. In this report we describe our efforts to improve data collection for the menhaden purse-seine bait fishery in Chesapeake Bay. Herein, we: 1) characterize the bait purse-seine fishery for Atlantic menhaden in Virginia by describing the vessels, gear, and disposition of the catch, 2) describe catch and fishing effort, especially seasonality and areal distribution of the catch, using annual logbook data sets, and 3) describe the age and size composition of the catch through port samples, as well as the disposition of the catch.

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ABSTRACT—Through the mid 1990's, the bait purse-seine fishery for Atlantic menhaden, Brevoortia tyrannus*, in the Virginia portion of Chesapeake Bay was essentially undocumented. Beginning in 1995, captains of Virginia bait vessels maintained deck logs of their daily fishing activities; concurrently, we sampled the bait landings for size and age composition of the catch. Herein, we summarize 15 years (1995–2009) of data from the deck logbooks, including information on total bait landings by purse seine, proportion of fishing to nonfishing days, proportion of purse-seine sets assisted by spotter pilots, nominal fishing effort, median catches, and temporal and areal trends in catch. Age and size composition of the catch are described, as well as vessel and gear characteristics and disposition of the catch.*

NET No.

CAPTAIN'S DAILY FISHING REPORT

NAME OF VESSEL 1	PLANT 2	DATE OF SETS 3	4

LEFT DOCK 5 ANCHORAGE
DATE
TIME
: ❑ AM
: ❑ PM

IF DID NOT LEAVE DOCK (CHECK ONE) 6
❑ WEATHER UNFIT FOR FISHING ❑ UNLOADING
❑ LACKING SUFFICIENT CREW ❑ RADIO
❑ MECHANICAL ❑ OTHER _____
❑ NET ❑ HOLIDAY

IF NO SETS WERE MADE (CHECK ONE) 7
❑ ROUGH SEAS ❑ OTHER _____
❑ FOGGY
❑ NO FISH SHOWING
❑ NO PLANES
❑ CHANGING LOCATION

8 SET NO.	TIME 9 START	TIME 9 END	10 FISH (000)	11 PLANE NO.	12 LOCATION		13 MILES AND DIRECTION TO SHORE		14 WEATHER CONDITIONS AND REMARKS	15 SEA WATER TEMP.
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

16 REMARKS & COMMENTS 17

DATE/TIME RETURN TO DOCK: _____

CAPTAIN'S SIGNATURE 18

This form is required by State Law

Figure 1.—A blank Captain's Daily Fishing Report (CDFR) form from the mid 1990's.

Data Collection

Logbooks

At the start of the 1995 fishing season, to better quantify menhaden bait landings in Virginia, we identified and solicited captains of menhaden bait vessels to voluntarily complete daily logbooks of fishing activity called Captain's Daily Fishing Reports, or CDFR's (Fig. 1); these are identical to CDFR's completed by reduction vessels where compliance in Virginia is 100% (Smith, 1999). For each purse-seine set, CDFR's enumerate time of set, an "at-sea" estimate of catch and fishing location, whether an aircraft was used to direct the set, distance from shore, and some weather variables. CDFR's were maintained onboard by vessel crews throughout the fishing season and were collected at season's end.

Between 1995–97 most, but not all, snapper rigs participated in the CDFR program; beginning in 1998 to the present, compliance by Virginia bait vessels has been 100%. In 2001, to ensure future compliance, Amendment 1 of ASMFC's FMP for Atlantic menhaden (ASMFC, 2001) specified mandatory reporting of landings by all menhaden bait purse-seine vessels preferably using CDFR forms. At a minimum, snapper rig captains complete a CDFR form if they make at least one purse-seine set during a given fishing day. Although not required by Amendment 1, some but not all snapper rig captains complete CDFR's for days when no sets are made, noting if they did not leave the dock or, if they left the dock, that they did not make a set on the fishing grounds.

Bait CDFR's were collated, key-entered, edited, and stored as annual data sets at the NMFS Beaufort Laboratory. Summary and statistical analyses were performed using SAS (SAS, 1995) programs. CDFR forms were relatively unaltered through 2004 (Fig. 1). In 2005 data fields were added to capture GPS coordinates of fishing locations; prior

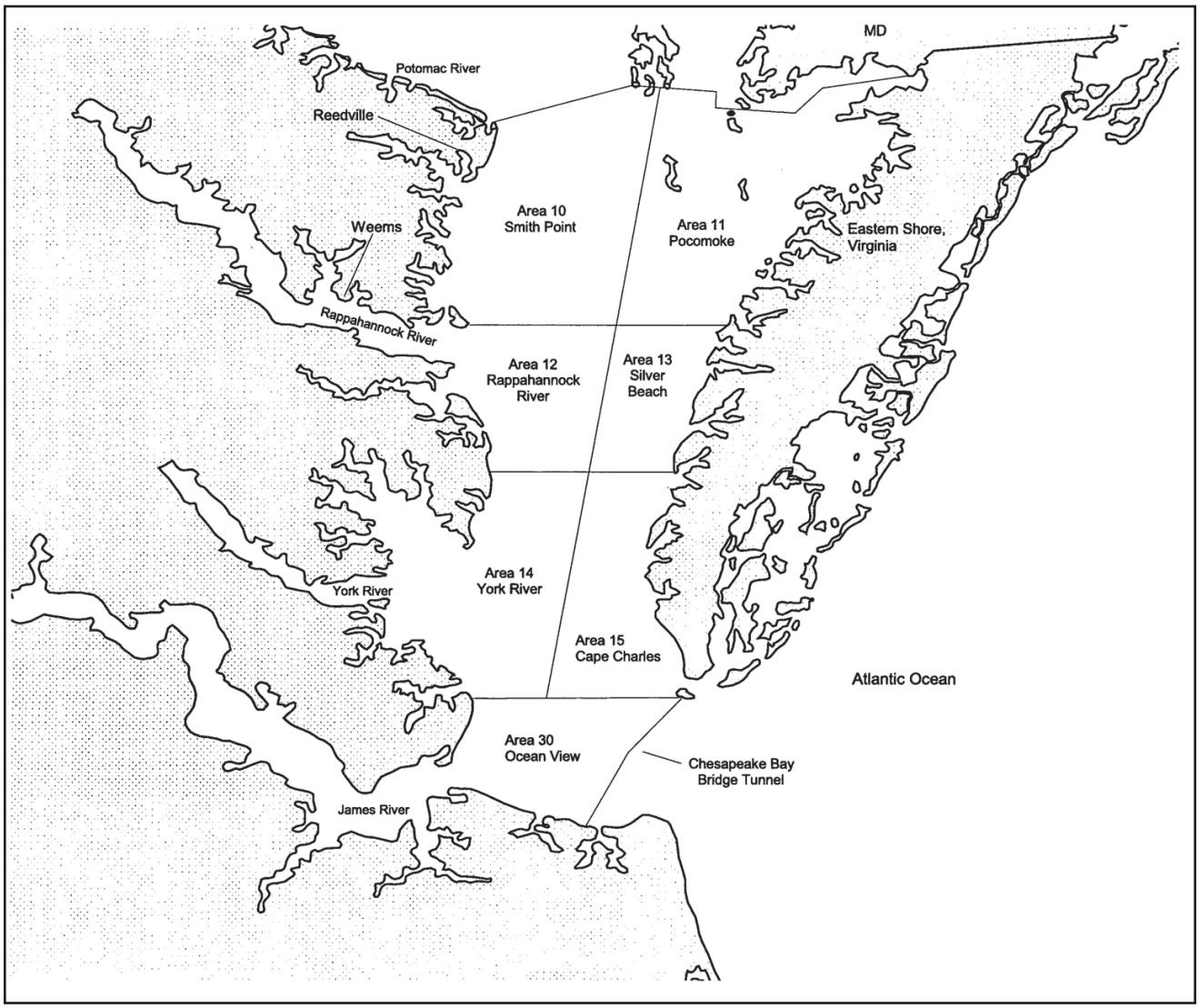

Figure 2.—The Virginia portion of Chesapeake Bay showing "large" reporting areas as defined by the CDFR program.

to this, fishing locations were identified by one of seven large fishing zones in the Virginia portion of Chesapeake Bay (Fig. 2) and by distance from nearest prominent geographic point. In 2009, the form was revamped again (Fig. 3) so that data were optically scanned directly into electronic files, vs. data-capture via the time-consuming key-entry process.

Port Samples

Beginning in 1995, the menhaden port agent at Reedville, Va., was directed to acquire dockside samples of Atlantic menhaden from bait vessels, all of which operate from the Northern Neck region, near the menhaden reduction factory at Reedville. Sampling intensity, or target number of bait port samples for a fishing season, was about 40, based on a historical proportion of samples to landings in the reduction fishery.

Biological sampling of the bait fishery is similar to that of the reduction fishery and is based on a two-stage cluster design (Chester, 1984). The port agent randomly selects the bait vessels, and at dockside retrieves a bucket of fish (first cluster) from the top of the vessel's fish hold. The sample is assumed to represent fish from the last purse-seine set of the day, not the entire boat load or trip. The agent ascertains from the crew the location and date of the last set. From the bucket the agent randomly selects ten fish (second cluster), which are measured (fork length in mm), weighed (grams), and some scales are removed for aging. June and Roithmayr (1960) performed detailed examinations (validation and verification) of Atlantic menhaden scales and determined that rings on the scales are reliable age marks.

CAPTAIN'S DAILY FISHING REPORT

Net Number:

VESSEL NAME: OSPREY
DATE: 8 / 7 / 09 (month / day / year)
OFFICE USE ONLY — VESSEL NUMBER: 23
PLANT: REEDVILLE
PLANT NUMBER: 44

IF VESSEL DID NOT LEAVE THE DOCK ON THIS FISHING DAY, CHECK HERE

IF VESSEL LEFT THE DOCK AND DID NOT MAKE ANY SETS ON THE FISHING GROUNDS THIS FISHING DAY, CHECK HERE

SET NO.	TIME (Military) START	TIME (Military) END	FISH (000)	PLANE NO.	FISHING LOCATION CDFR 5-DIGIT CODE	FISHING LOCATION GPS (dd °, mm', ss")[degrees, minutes, decimal seconds] LATITUDE	FISHING LOCATION GPS LONGITUDE	MILES TO SHORE	WEATHER CONDITIONS Cloud Cover	Air Temp.	Wind Dir.	Wind Speed
1	1050	1150	40	1	11060	37 38 32	76 01 51	5 4	3	78	2	12
2	1230	1315	30	1	11060	37 39 18	75 58 17	4 0	3	78	2	11
3	1340	1430	45	1	11060	37 37 69	76 00 82	4 7	3	79	2	10
4	1445	1525	35	1	11060	37 38 74	76 02 41	6 3	3	80	2	10
5												
6												
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10												
11												
12												
13												
14												
15												

PUMP OUT

COMMENTS:

DATE / TIME RETURN TO DOCK 1730 hrs. 8/7/09

CDFR CREATED: 02/17/2009 Rev. 010

Figure 3.—A completed CDFR from a Virginia snapper vessel from the 2009 fishing season.

Description of Virginia's Bait Purse-Seine Fishery for Atlantic Menhaden

Vessels

During 1995–2009, a total of eight vessels participated in the bait purse-seine fishery in Northern Neck. Up to five vessels fished during 1999–2000, four during 2001–05, three during 2006–08, and four in 2009; only one vessel fished continuously through the entire time period. All but one or two of the vessels fished from the port of Reedville (Cockrell's Creek) near Smith Point at the mouth of the Potomac River (Fig. 2); landings also occurred near Weems along the north shore of the lower Rappahannock River.

Of the five vessels active in the bait fishery over the past 5 years, three were built for the menhaden reduction fishery. The *Taylor's Creek* (Fig. 4) and *Hushpuppy* (Fig. 5) originally fished on menhaden for reduction at Beaufort, N.C. They were "sound boats" making day-trips to fish in central North Carolina's coastal sounds and bays. The *Hushpuppy* was sold to a bait concern in Northern Neck in about 1988; the *Taylor's Creek* moved to Virginia in 1998. The *Carter's Creek* (Fig. 6) was originally the *Absecon* and fished in the reduction fishery during the 1950's and 1960's. In about 1978 she was converted to a clam dredger for the surf clam, *Spisula solidissima*, and ocean quohog, *Artica islandica*, fishery in the mid Atlantic, and also fished as a trawler for horseshoe crabs, *Limulus polyphemus*. She was retrofitted again in 2005 to purse seine menhaden for bait.

The *Osprey* (Fig. 7) was originally built as a shrimp trawler for the southeast U.S. coast, and was converted to a menhaden vessel in about 1996. The *Indian Creek* (Fig. 8) was a former military tugboat, and it was converted to a bait purse-seiner for the 2009 fishery. Four of the five vessels in the fishery during the past 5 years are less than 100 ft long. In the parlance of the menhaden fishery, maximum hold capacities of the

Table 1.—First and last fishing days of Virginia's menhaden "snapper rig" bait fishery, 1995–2009.

Year	First fishing day	Last fishing day
1995	May 4	Nov. 13
1996	May 20	Nov. 13
1997	May 5	Nov. 11
1998	May 6	Nov. 9
1999	May 7	Nov. 10
2000	May 1	Nov. 8
2001	May 8	Nov. 14
2002	May 6	Nov. 2
2003	May 20	Nov. 17
2004	May 6	Nov. 2
2005	May 2	Nov. 15
2006	May 9	Nov. 15
2007	May 11	Nov. 12
2008	May 5	Nov. 11
2009	May 11	Nov. 10

four extant bait vessels in 2009 ranged from 250,000 to 550,000 "standard fish" (1,000 "standard fish" = 670 lb), or about 76–167 t. Snapper rig vessels have refrigerated fish holds; chilled seawater is sprayed atop the catch via baffles and recirculated through drains in the bottom of the hold.

Gear

Standard mesh size (bar length) for purse-seine gear in Chesapeake Bay is 7/8-in, which is the minimum allowed by Virginia law. During the initial decades of the snapper rig fishery, purse seines for bait were scaled-down versions of the larger nets used in the menhaden reduction fishery (which often approach 1,200 ft long and 80–90 ft deep). Bait purse seines are usually acquired as surplus nets from the reduction fishery; the bag or bunt section is moved from the middle of the net to the end, then tapered to accommodate the single purse boat method of setting the seine. As the bait fishery has evolved, dimensions of snapper rig nets now rival reduction nets in length and depth. Snapper rigs normally utilize one purse boat to set the net and employ 6 or 7 crew members, as well as a spotter pilot to locate schools of menhaden.

Fishing Season

The menhaden purse-seine fishing season in Chesapeake Bay extends from the first Monday in May through the third Friday in November, regardless of the disposition of the catch. By choice, fishing is almost exclusively done during weekdays. Purse-seine fishing is mostly restricted to lower Chesapeake Bay proper, and is prohibited in most tributaries of the bay, except for the lower reaches of the Rappahannock and York rivers. One exception allows vessels under 70 gross tons (ostensibly bait vessels, but none in the extant snapper rig fleet qualify) to fish in a few additional tributaries of Northern Neck during the purse-seine season.

CDFR information revealed that during 1995–2009, initial purse-seine sets for bait were made in early to mid May (Table 1); average date-of-first-set was 8 May. Final purse-seine sets for bait were made in early to mid November (Table 1); average date-of-last-set

Figure 4.—*F/V Taylor's Creek*, 87-ft long, began her career in Beaufort, N.C., as a purse-seiner for the reduction fishery. She moved to Northern Neck, Va., and began fishing with the "snapper rig" fleet in 1998. Photo credit: WBO.

Figure 5.—*F/V Hushpuppy* is an 81-ft steel-hulled vessel. For comparative purposes, here she is in the foreground with the *F/V Gregory Poole* in the background, an 176-ft vessel in the reduction purse-seine fleet. *F/V Hushpuppy* began service as a menhaden purse-seiner for the reduction fishery in Beaufort, N.C. She was sold to a menhaden bait firm in Northern Neck, Va., in 1988. Of extant bait vessels in Va., *F/V Hushpuppy* has had the longest continuous service. Photo credit: JWS.

was 11 November. Assuming these mean start and finish dates, an average fishing season in the bait fishery extends about 27 weeks and consists of approximately 135 "weekday" fishing days.

Total Annual Landings

Because VMRC has no mandate to collect menhaden fishery statistics, bait landings in Virginia prior to about 1995 are somewhat suspect and may be underestimates, especially those from the snapper rig vessels. To better document landings we placed CDFR's onboard two of four bait vessels in 1995 and on two of three vessels in 1996 and 1997. From 1998 to present, all snapper rig vessels maintained CDFR's (Table 2).

Since daily trip tickets or reasonable facsimiles are not required of snapper rig vessels in Virginia, dockside measures of bait landings are unavailable. Nevertheless, summed at-sea estimates of daily purse-seine catches from CDFR's are considered reliable estimates of total daily catch because menhaden captains are particularly adept at estimating individual purse-seine catches. For example, Smith (1999) showed that for menhaden reduction vessels in Virginia, vessel-specific ratios of actual annual landings to annual CDFR estimates of catch ranged from 0.90 to 1.03 for the 20-vessel fleet in 1995. Thus, CDFR estimates of catch for the snapper rig fleet are considered reasonably accurate estimates of landings. CDFR catch estimates are couched in the vernacular of the menhaden industry, that is, in thousands of "standard fish," which were multiplied by 0.3039 to convert to metric tons (Smith, 1991).

Figure 6.—*F/V Carter's Creek* is an 135-ft vessel which unloads Atlantic menhaden at Reedville, Va., for both bait and reduction. She began her service as a menhaden reduction vessel in the late 1950's, was converted to participate in various dredge and trawl fisheries in the 1970's, then was converted back to a menhaden purse-seiner in 2005. Photo credit: JWS.

During the 1980's menhaden bait landings by snapper rigs were largely undocumented, but they were probably equivalent to Virginia's menhaden bait landings by all other fishing gears (mostly pound nets, gill nets, and haul seines) (Table 3). By the late 1990's menhaden bait landings by snapper rigs were five times greater than those of other gears combined. This contrast continues through present, and was most disparate in 2003 when landings by snapper rigs amounted to 20,879 t and bait by all other gears totaled 1,584 t.

Snapper rig landings for bait during 1989–92 were poorly documented, but averaged about 5,000 t annually (Table 3), probably from two or three active vessels. Beginning in the mid 1990's, landings increased and more than doubled to 11,190 t by 1995, then climbed to 17,640 t by 1998, most probably a reflection of more accurate data collection via the CDFR's. Landings declined to 12,763 t in 2000, then increased again over the next 3 years, peaking for the time series at 20,879 t in 2003. Landings in 2005 of 19,814 t rivaled those of 2003, however, landings in 2004 fell to 9,361 t, less than half of the previous year's total. By 2008, landings improved again to 13,213 t. Landings during 2007–09 averaged 12,799 t.

Snapper rig landings in Virginia contribute substantially to coastwide landings of Atlantic menhaden for bait

Figure 7.—*F/V Osprey*, 90-ft long, is a converted shrimp trawler. She began service as a purse-seiner for bait at Reedville, Va., in about 1996. Photo credit: JWS.

(Table 3). During the 1990's, Virginia's snapper rig landings as a proportion of total coastwide landings of menhaden for bait grew from 11% in 1991 to 45% in 1998. No doubt much of this increase was because of better documentation of snapper rig landings. By 2003 snapper rig landings represented 62% of coastwide menhaden bait landings, although in recent years this percentage has declined to roughly 30%.

CDFR Compliance, Spotter Pilot Activity, and Fishing Days

Beginning in 1998 to the present, compliance for completing CDFR forms by snapper rig captains has been 100%, and captains provided between 318 and 482 CDFR forms annually (Table 2). Snapper rig captains utilized spotter pilots to assist them in locating fish schools and to direct setting the net for over 90% of the sets annually (Table 2). Captains of reduction vessels tend to use spotter pilots less frequently (83% of sets in the Atlantic fleet (Smith, 1999) and about 69% of sets in the Gulf fleet (Smith et al., 2002)), possibly because the larger and taller reduction vessels offer a higher vantage point to "self locate" fish schools.

Some, but not all, snapper rig captains completed CDFR's even on days when they did not fish, noting if they did not leave the dock, or that they went to sea but did not set; hence, one completed CDFR form may not equal a "trip" with sets. During 1995 to 2009 snapper rig vessels fished on average 69.2% (range: 58.1–82.7%) of the available fishing days (almost exclusively weekdays), while not leaving the dock 12.2% of available days, or not setting the net at sea on the remaining 18.6% of days. Assuming a hypothetical 135-day fishing "season" (weekdays) from early May through mid November, snapper rig vessels set on menhaden schools on about 94 (69.2%) of the available fishing days; they stayed at the dock about 16 days (12.2%) and did not set at sea on 25 days (18.6%). These estimates are comparable to the Atlantic menhaden reduction fleet which set on fish 67–83% of available fishing days (Smith, 1999), and the Gulf menhaden reduction fleet which set on fish 63–76% of the available fishing days (Smith et al., 2002).

Figure 8.—*F/V Indian Creek* is one of the newest entrants (2009) to Virginia's "snapper rig" fleet. She is a converted military tug boat. Photo credit: JWS.

Table 2.—Virginia menhaden "snapper rig" fleet: Number of vessels, CDFR's, days with at least one set, number of sets, median catch, sets/day/vessel, and percent of spotter pilot-assisted sets during 1998–2009.

Year	Vessels reporting	No. of CDFR's	Days with ≥1 set	Total no. of sets	Median catch (t) for all vessels	Sets/vessel/day		Spotter assisted sets (%)
						Median	Max	
1998	5	327	271	1,016	11	3	10	95
1999	5	438	345	1,420	9	4	10	92
2000	5	402	270	1,084	11	3	8	93
2001	4	384	341	1,242	12	3	9	93
2002	4	399	360	1,423	11	4	9	99
2003	4	399	337	1,195	15	3	10	92
2004	4	466	345	1,303	12	3	10	90
2005	4	482	369	1,399	12	3	8	96
2006	4	369	235	799	11	3	8	92
2007	3	318	258	860	12	3	8	97
2008	3	319	251	857	14	3	8	99
2009	4	340	247	860	12	3	9	99

Description of the Catch, Fishing Effort, and Disposition of the Catch

Nominal Fishing Effort, Median Catch, and Frequency Distribution of Catch

Nominal fishing effort, as reflected by number of purse-seine sets made by snapper rig vessels, ranged from 799 (2006) to 1,423 (2002) annually (Table 2). Median number of sets for bait per vessel per day was 3 or 4 sets (Table 2), which is about one less per day than vessels in the Atlantic and Gulf menhaden reduction fleets (Smith, 1999; Smith et al., 2002). Median catch size for bait ranged from 9 t (1999) to 15 t (2003) (Table 2); this is roughly half of median catch size in the Atlantic menhaden (15–30 t; Smith, 1999) and gulf menhaden (17–22 t; Smith et al., 2002) reduction fisheries. Catch-per-unit-effort for the snapper rig fleet during 1998–2009, as measured by total annual catch in metric tons divided by annual number of purse-seine sets, ranged 12–18 t/set. By comparison, CPUE's for sets by the purse-seine reduction fleet within Chesapeake Bay for the same period ranged from 22 to 31 t/set.[1]

The frequencies of catches per set by 10 t bins were calculated annually, then each bin was averaged over the 12-yr time series (1998–2009) (Table 4). Results indicated that on average 46% of sets were represented in the 0–10 t bin, while 88% of catches were represented in the first three catch intervals, that is, the 0–10, 11–20, and 21–30 t bins. By

[1] Unpublished data on file at NMFS Beaufort Laboratory.

comparison, for the Atlantic menhaden reduction fishery in Chesapeake Bay about 30% of the sets accumulated in the 0–10 t interval, and about 80% of the catch occurred in the 0–10, 11–20, and 21–30 t bins (Smith, 1999).

Set Duration and Hour of Peak Catch

Average set duration, as measured by the time when the purse boat began setting the net until the time when the entire catch was pumped into the fish hold, varied narrowly over the period. Mean set time ranged from 36 to 47 min, and averaged 39 min over the entire time series; these values are equivalent to set times in the Atlantic menhaden reduction fishery (34–43 min; Smith, 1999), and slightly less than set times in the Gulf menhaden reduction fishery (41–48 min; Smith et al., 2002). On average, sets just after sunrise produced the best catches. Hourly mean catches were highest between 0600–0759 hr for 10 of the 12 analysis years (1998–2009).

Temporal and Areal Trends in Bait Catches

To discern seasonality of the bait catch, annual catches were summed by month, then averaged across fishing years 1998–2009 (Table 5). Peak removals occurred in August (3,401 t) and accounted for 22% of the annual harvest. Catches in July (3,089 t) closely followed those of August and represented 20% of the annual removals. Catches in June (2,469 t; 16%), September (2,321 t; 15%), and October (2,275 t; 15%) were similar and combined comprised 46% of the annual harvest. Catches in May (1,462 t) represented 9% of the total removals; however, on given years when presumably spring weather was fair and fish were abundant, removals in May (2005 when 2,539 t were caught) rivaled mean catches for June and July. Catches in November (418 t) amounted to only 3% of the total removals for the fishing season.

The CDFR Program for the reduction fishery was originally designed in the late 1970's as a joint state, Federal, and menhaden industry effort to provide better information on menhaden catch locations and fishing effort (Smith, 1999). The program obviously predates GPS navigation systems, as well as later versions of LORAN; nevertheless, GPS coordinates for purse-seine sets have been available since 2005.

For pre 2005 catch locations, program designers found it convenient to use a combination line-of-sight locales (tied to nearest geographic points) and distance-from-shore estimates. A catalog of fishing locations was adapted from a menhaden processor at Reedville (Standard Products of Virginia[2]). Individual

[2] Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 3.—Virginia landings in metric tons of Atlantic menhaden for bait by "snapper rigs," all other gears, and state totals, as well as coastwide Atlantic menhaden for bait landings, 1981–2009.

Year	Virginia menhaden catch by "snapper rigs" (% of coastwide landings for bait)	Virginia menhaden catch for bait, all other gears	Total Virginia menhaden catch for bait	Total[1] Atlantic coast menhaden catch for bait
1981	4,405	9,734	14,139	
1982		9,988	9,988	
1983		11,105	11,105	
1984		6,589	6,589	
1985		7,856	7,856	26,659
1986		4,484	4,484	27,961
1987		6,495	6,495	30,616
1988		5,433	5,433	36,237
1989	5,778 (19)	5,249	11,027	30,948
1990	5,495 (18)	2,772	8,266	30,685
1991	3,906 (11)	2,665	6,571	36,224
1992	5,065 (13)	2,299	7,364	38,721
1993	8,019 (19)	3,257	11,276	41,889
1994	10,978 (29)	2,570	13,547	37,369
1995	11,190 (26)	2,792	13,982	42,525
1996	11,994 (33)	2,449	14,443	36,735
1997	10,590 (26)	2,396	12,985	41,451
1998	17,640 (45)	1,809	19,449	39,194
1999	15,521 (43)	2,276	17,797	36,094
2000	12,763 (36)	2,861	15,624	35,050
2001	17,464 (48)	1,960	19,424	36,312
2002	18,957 (51)	1,762	20,719	36,834
2003	20,879 (62)	1,584	22,463	33,880
2004	17,740 (50)	2,802	20,542	35,515
2005	19,814 (51)	2,320	22,134	38,832
2006	9,361 (36)	1,693	11,054	26,311
2007	12,445 (29)	3,759	16,204	42,668
2008	13,213 (28)	3,254	16,467	46,674
2009[2]	12,740 (33)	2,507	15,247	38,976

[1] Source: ASMFC (2010) for data through 2008.
[2] Data are preliminary.

Table 4.—Frequency distribution of sets for Atlantic menhaden by Virginia "snapper rig" vessels by 10 t bins (bins are defined by their midpoints) averaged over 12 years, 1998–2009.

Bin midpoint (t/set)	Mean no. of sets	Cumulative no. of sets	Cumulative %
5	521	521	46
15	343	864	77
25	123	987	88
35	85	1,072	96
45	24	1,096	98
55	13	1,109	99
65	9	1,118	99
75	2	1,120	99
≥85	1	1,121	100

Table 5.—Virginia "snapper rig" vessels: Mean catch by month averaged over 12 years, 1998–2009, with percent and minimum and maximum values.

Month	Mean catch (t)	Percent of annual mean catch	Minimum catch (t)	Maximum catch (t)
May	1,462	9	803	2,539
June	2,469	16	1,311	3,660
July	3,089	20	1,916	4,025
Aug.	3,401	22	1,580	5,499
Sept.	2,321	15	1,186	3,553
Oct.	2,275	15	1,181	3,870
Nov.	418	3	17	849

fishing locations were subsumed into a larger grid of seven areas in the Virginia portion of Chesapeake Bay (Fig. 2). These areas have proven useful for describing trends of reduction catches in the bay (Smith, 1999) and are also used here.

For summary purposes lower Chesapeake Bay is divided into seven areas; a line running roughly from north to south at the center of the bay separates three paired east-west areas, and one area encompasses the southernmost portion of Virginia's Tidewater region (Fig. 2). Smith Point and Rappahannock River areas on the bay's western shore are nearest to the ports where snapper rig vessels are located, while the Pocomoke area is nearest along the eastern shore of the bay.

Annual catches in Chesapeake Bay were summed by fishing area, and then averaged across fishing years 1998–2009 (Table 6). A majority of catches over the time series occurred in the Smith Point area, the area closest to Reedville and the home port for most of the snapper rig fleet. Annual removals from this area averaged 9,564 t, and represented 62% of the annual catch.

The Rappahannock River area ranked second in terms of annual removals with an annual catch of 2,719 t, representing 18% of the harvest. The Pocomoke area ranked a close third where annual catch averaged 2,575 t, or 17% of the total catch. The Smith Point, Pocomoke, and Rappahannock River areas combined accounted for 97% of the bait removals by snapper rigs from the bay.

By comparison, these three areas accounted for 59% of the removals in Chesapeake Bay by the reduction fleet (Smith, 1999), which is composed of larger vessels that range farther and for longer periods of time in Chesapeake Bay and ocean waters than the snapper rig fleet. Snapper vessels rarely set beyond Chesapeake Bay because ocean waters are often too rough for the smaller bait boats, and because of the distance to the bay mouth (3–4 hr one way). A few sets along the ocean beaches of Virginia's Eastern Shore barrier islands in 2006 were an exception.

Table 6.—Virginia "snapper rig" vessels: Mean catch by fishing area averaged over 12 years, 1998–2009, with percent, minimum, and maximum values.

Area	Mean catch (t)	% of annual mean catch	Minimum catch (t)	Maximum catch (t)
Smith Point	9,564	62	6,593	13,518
Pocomoke	2,575	17	593	4.630
Rappahannock River	2,719	18	359	4.566
Silver Beach	331	2	0	1,655
York River	50	<1	0	258
Cape Charles	170	1	0	579
Ocean View	26	<1	0	202

Table 7.—Percent age composition of Atlantic menhaden in the Virginia bait purse-seine catch by year, 1995–2009.

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Total no. sampled
1995	0	35.4	35.4	27.1	2.1	0	0	96
1996	0	0.0	76.6	19.7	3.7	0	0	137
1997	0	9.6	44.8	34.6	8.8	1.5	0.7	136
1998	0	5.3	52.5	27.7	12.8	1.4	0.3	282
1999	0	4.0	72.2	17.7	5.4	0.7	0	299
2000	0.9	23.8	63.2	12.1	0	0	0	231
2001	0.4	4.4	68.0	25.5	1.4	0.3	0	275
2002	0	1.3	20.4	55.5	20.4	2.4	0	470
2003	0.6	9.4	75.4	13.3	1.3	0	0	309
2004	0	6.4	73.6	16.6	3.1	0.3	0	326
2005	0	0.6	51.9	44.7	2.5	0.3	0	318
2006	0	29.5	47.3	20.7	2.5	0	0	203
2007	0	27.5	68.7	2.7	1.1	0	0	374
2008	0	3.5	86.9	7.9	1.3	0.3	0	314
2009	0.2	27	39.3	30.4	3.1	0	0	481
Mean	0.1	12.5	58.4	23.7	4.6	0.5	0.1	

CDFR's also document menhaden for bait catches by distance from the shoreline. Annual catches by snapper rig vessels were summed by distance intervals from shore, then averaged across all fishing years. Catches in the fishing stratum >3.0 mi from shore dominated (43%) annual catches of Atlantic menhaden for bait, followed by the stratum 2.1–3 mi from shore (22%). The near-shore strata, ≤1 mi (17%) and 1.1–2 mi (18%) from shore were nearly equivalent and combined represent 35% of the catch by distance from shore. A similar trend was observed in the reduction fishery for menhaden as 47% of the catch occurred beyond three miles from shore in Chesapeake Bay (Smith, 1999).

Since 2005, captains of snapper rig vessels have provided GPS coordinates of their purse-seine set location on CDFR forms. Locations of individual purse-seine sets for bait and the corresponding catch magnitudes for 2005, which are typical of 2006–09 also, are shown in Figure 9. Obviously, catches and effort are concentrated in the upper half of the Virginia portion of Chesapeake Bay.

Age and Size Composition of the Catch

Port samples acquired from menhaden bait purse-seine vessels in Chesapeake Bay over the 15-yr time series (1995–2009) revealed up to seven age classes in the catch, although only three of these were of major importance to the fishery (Table 7). Age-2 fish predominated in the catch, and on average accounted for 58.4% of the catch. Age-3 menhaden (23.7%) ranked a distant second in terms of numbers in the bait catch, although on one rare occasion (2002) they comprised a majority (55.5%) of the catch. Age-1 fish (12.5%) ranked third in importance, yet during given years they comprised up to 30–35% of the catch. Overall, age-1, -2, and -3 Atlantic menhaden accounted for almost 95% of the snapper rig catch. Mean fork lengths (mm) and weights (g) of Atlantic menhaden in the bait landings by year and age are shown in Tables 8 and 9, respectively.

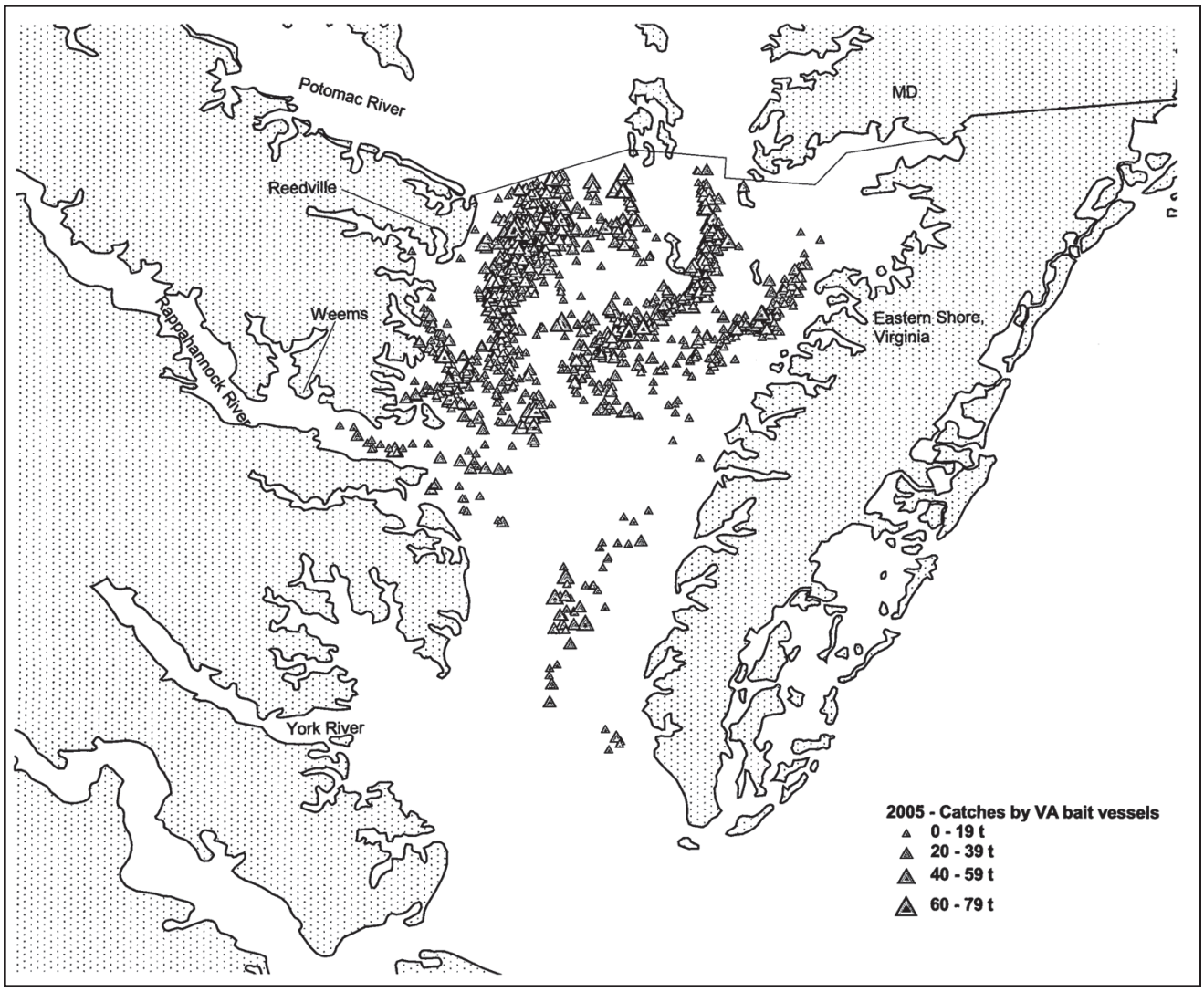

Figure 9.—Locations and magnitude of catches by the Virginia snapper rig fleet during 2005.

Similarly, the age composition of the catch of the reduction fishery (1995–2009)[3] is also comprised of age-0 through age-6 Atlantic menhaden, with mean catch over the period dominated by age-1 (20.4%) and age-2 (61.1%) categories. However, the bait fishery in Chesapeake Bay tends to harvest a slightly greater proportion of older, and presumably larger, menhaden; for example, the proportion of age-3 and age-4 fish in the bait fishery averaged 23.7% and 4.6%, respectively, whereas the same age classes in the reduction fishery averaged 15.1% and 2.5%, respectively.

[3] Unpublished data on file at NMFS Beaufort Laboratory.

Markets for Menhaden as Bait

We interviewed several wholesalers of menhaden for bait in Tidewater Virginia concerning outlets for their product. A consensus of responses indicated that a majority of menhaden landed for bait in Virginia is sold to blue crab pot fishermen in Virginia, Maryland, and the Carolinas. Smaller amounts are shipped to the U.S. Gulf coast for blue crab bait and seasonally for crawfish, *Procambarus clarkia*, bait. Minor amounts of menhaden bait from Virginia are sold in New England for lobster bait; lobster fishermen in New England prefer larger individual menhaden for their bait wells or bags; larger and older Atlantic menhaden are more readily available to bait fishing operations in New Jersey.

Limited amounts of menhaden landed for bait in Virginia are sold to sport fishermen for cut bait or chum; small quantities are also ground into a frozen chum product and marketed to anglers. When bait markets are "soft," that is,

the markets are glutted with landings, or when menhaden in the catch are too small for the bait markets, snapper rig vessels will unload their catch at the menhaden factory in Reedville where it is reduced to fish meal and fish oil.

Bait dealers in Virginia blast freeze menhaden, then pack frozen fish in 50-lb cardboard flats. Fresh menhaden for bait is also sold in 65-lb bushel baskets. The practice of packing menhaden for bait in 100-lb wooden crates, or "fish boxes," has fallen from favor and is a rarity among contemporary bait wholesalers in Virginia.

Summary and Epilogue

Over the past 4 decades, the menhaden snapper rig fishery in the Virginia portion of Chesapeake Bay has become a major contributor to the bait landings on the U.S. East coast, and on given years represented over 50% of coastwide menhaden landings for bait. Menhaden landings by snapper rigs in Virginia are widely distributed to bait markets for blue crab fisheries in Chesapeake Bay, the Carolinas, and the U.S. Gulf coast. New vessels entering into the fishery in recent years attest to its vitality.

Recent bait-related management decisions in New England and New Jersey could have significant near-term implications for Virginia's snapper-rig fishery. Atlantic herring, *Clupea harengus harengus,* is one of the preferred baits for lobster pots in New England. For fishing years 2010–12, the New England Fishery Management Council (NEFMC) proposed reducing annual Atlantic herring catch quotas to about 106,000 t, down from about 194,000 t in 2009 (Federal Register, 2010). By some estimates (The Free Press, 2010) in 2010 the state of Maine alone would need to import 20,000 t of menhaden for lobster bait to offset the shortfall in herring bait.

In a related event in 2010, New Jersey moved to limit entry into its purse-seine fishery for bait (Cape May County Herald, 2010), fearing an influx of bait vessels from New England into Garden State waters. While heretofore only minor amounts of bait from Virginia reportedly enter New England bait markets, recent actions by the NEFMC and New Jersey suggest that landings of menhaden for bait in Virginia could become an even more important facet of bait landings for the U.S. East coast in the near future.

Table 8.—Mean fork length (mm) of Atlantic menhaden in the Virginia bait purse-seine catch by age and year, 1995–2009.

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
1995		178	244	271	290		
1996			259	291	300		
1997		179	247	276	296	302	313
1998		158	233	285	308	317	317
1999		201	225	270	291	310	
2000	144	193	257	276			
2001	150	173	260	291	323	312	
2002		189	247	278	288	271	
2003	148	220	243	286	311		
2004		191	233	261	295	297	
2005		210	253	278	291	299	
2006		202	242	274	300		
2007		189	225	274	289		
2008		205	240	259	290	300	
2009	152	193	238	268	279		
Mean	149	192	243	276	297	301	315

Table 9.—Mean weight (g) of Atlantic menhaden in the Virginia bait purse-seine catch by age and year, 1995–2009.

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
1995		92	252	335	417		
1996			317	445	464		
1997		108	270	370	463	472	531
1998		70	237	431	553	558	579
1999		142	199	343	430	519	
2000	49	136	300	362			
2001	59	93	309	429	573	564	
2002		129	274	380	429	333	
2003	56	223	281	469	593		
2004		128	221	317	434	410	
2005		154	279	360	402	453	
2006		142	245	341	468		
2007		115	191	319	358		
2008		152	233	290	399	421	
2009	60	122	227	311	339		
Mean	56	129	256	367	452	466	555

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