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By
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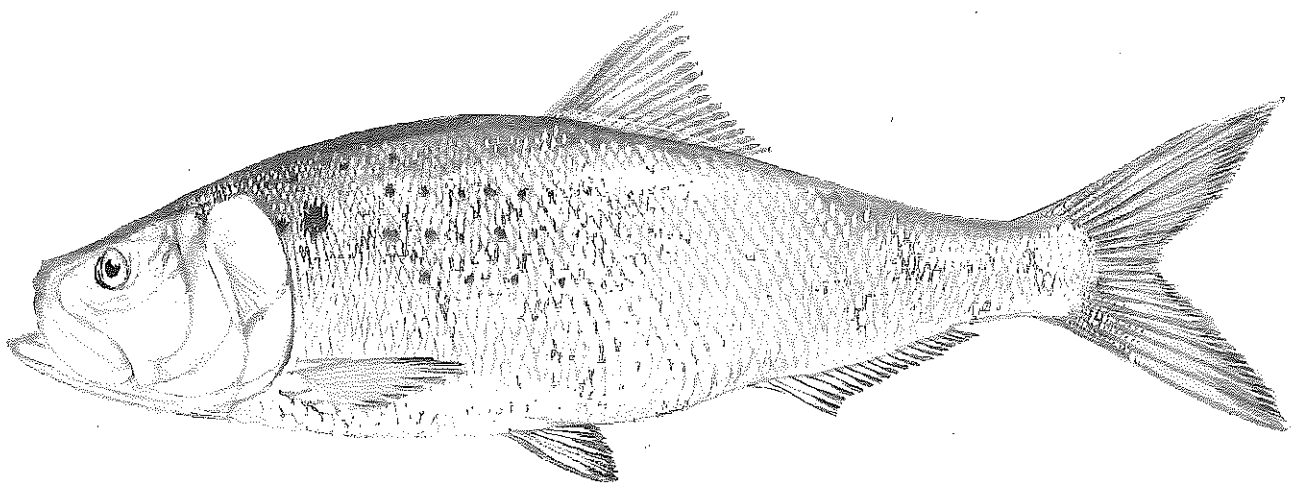

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Introduction

Bycatch or the unintentional harvesting of species other than those directly being sought by a fishing operation is becoming a problem of increasing concern throughout the world. In April 1995, a conference on bycatch attended by worldwide scholars was held in Rhode Island. Another conference on bycatch is scheduled to be held in Washington state in September of this year. The bycatch problems most familiar to the public are the incidental harvesting of porpoises in the tuna fisheries and the inadvertent capturing of sea turtles in the Gulf shrimp fishery. The incidental taking of porpoises in the tuna fishery caused such an outrage that the public refused to purchase certain brands of tuna until the tuna companies adopted procedures to eliminate the bycatch of porpoises. The National Oceanic and Atmospheric Administration has a high priority for research that attempts to mitigate bycatch in our nation's fisheries.

Why the big concern about bycatch? For porpoises, other marine mammals, and sea turtles, there are laws prohibiting the incidental harvesting of marine mammals and sea turtles. Society perceives few, if any, benefits from exploiting marine mammals. In some fisheries, the bycatch may consist of economically important species that will simply be discarded and wasted. A major concern, which has not been fully explored by researchers, is the role of bycatch species in the ecosystem. That is, what happens to the ecosystem and abundance of other species when there is bycatch?

Here in our own backyard, the Chesapeake Bay and coastal waters, recreational anglers have expressed concern about bycatch in the menhaden fishery. The menhaden fishery, one of the most economically important commercial fisheries of Virginia, occasionally harvests in varying quantities gamefish and prey species for commercial and recreational fish. For example, bluefish, spot, and croaker are inadvertently harvested along with menhaden in the Chesapeake Bay. All three species are recreational species. Alternatively, spot, croaker, and other species are also prey for larger gamefish such as bluefish and striped bass.

Article 2, §28.2-408 of the Laws of Virginia Relating to The Marine Resources of The Commonwealth, 1992 Edition states "It is unlawful to take, catch or round up with purse net, for any purpose, food fish in an amount greater than one percent of the whole catch. If food fish represent more than one percent of the whole catch, the net shall be opened immediately and the food fish released while alive." The Article also states "It is unlawful for any vessel licensed for the purpose of menhaden fishing to catch any food fish for the purpose of marketing; for any person to have in his possession food fish in an amount greater than one percent of the bulk for the purpose of manufacturing them into fertilizer, fish meal, or oil; or for any person to use in any manner any food fish, in an amount greater than one percent of the bulk for the purpose of fertilizing or improving the soil."

The Virginia laws that regulate bycatch are primarily concerned with possession. That is, the laws focus on the vessel having possession of bycatch. The laws do state, however, that it is

unlawful to take, catch, or round up with purse net, for any purpose food fish in an amount greater than one percent of the entire catch. This particular law is difficult to enforce. Enforcement personnel must be on the master vessel or purse boats to determine the bycatch in any given set. Moreover, it is often difficult to determine if there is significant bycatch in the purse net until onboard pumping of the menhaden begins. Bycatch species that could be harvested in large quantities (e.g., bluefish and Spanish mackerel) typically are below the menhaden and only after pumping begins can the captain or onboard enforcement personnel determine the potential magnitude of the bycatch. More important, captains typically release or discard bycatch when the number of fish and marine invertebrates appear to be high relative to the catch of menhaden.

In general, the state laws that control bycatch in the menhaden fishery are difficult to enforce. First, the Laws of Virginia Relating to the Marine Resources of the Commonwealth do not define "bulk." That is, what is one percent of the bulk? Is bulk a volume or weight measure? Webster defines bulk as a spatial dimension, magnitude, mass, or volume. Second, the laws do not provide a formal listing of species that constitute food fish. That is, which species are food fish? This is very important because large fish such as cownose rays and sandbar sharks are occasionally harvested as bycatch but are not generally considered to be food fish. Because the laws do not adequately define bulk and food fish, the Chief of Enforcement for the Virginia Marine Resources Commission (VMRC) believes that the bycatch law is difficult to enforce except when a menhaden vessel has possession of a prohibited species (e.g., striped bass).

The VMRC does, however, enforce the bycatch law. They have adopted a "common sense" approach. They stop a vessel and inspect the hold contents, observe a set, or inspect the offloading of menhaden at the dock. If they observe any species of fish other than menhaden, they further examine the catch to determine the extent of bycatch. It then becomes a "judgement call" by the enforcement agent as to whether or not there is an excessive bycatch. There have been no citations issued to a menhaden vessel for having an excessive bycatch over the past several years.

In a previous study by the Virginia Institute of Marine Science (VIMS),* it was reported that the bycatch in the menhaden fishery constituted less than .02 percent of the total catch. This determination was based on number of fish and invertebrates with respect to samples pooled over dockside and at-sea observations. Some members of the recreational community expressed extreme concern about the use of number of fish and pooling of data over dockside and at-sea observations. Their reasons were that number of fish was not consistent with the concept of "bulk" and the study by VIMS stated that dockside sampling was inappropriate for assessing bycatch. A major objective of the VIMS study, in fact, was to determine procedures for assessing bycatch in the menhaden fishery.

Members of the Atlantic Coast Conservation Association, and the Virginia Anglers Association requested additional analysis of bycatch using weight of fish and restricting the analysis to at-sea observations. This is a reasonable request given the importance of the commercial and recreational fishing industries to Virginia. As concluded in the VIMS study, however, we claim that it is the number of fish and invertebrates harvested rather than the weight or biomass

*Austin, H., J. Kirkley, J. Lucy. 1994. Bycatch and the Fishery for Atlantic Menhaden, *Brevoortia tyrannus*, in the Mid-Atlantic Bight. Virginia Sea Grant Marine Resource Advisory No. 53, VSG 94-06.

that is critical for future populations of any given resource. That is, which is more important to future resource conditions, the loss of 5 one pound striped bass or the loss of one 5 pound striped bass? It must be recognized, though, that the number of fish by age or size is critical for defining future populations of any given species; juveniles do not spawn and larger animals are more fecund (i.e., have more eggs) or contribute more to the future population. It was because of this concern that the VIMS study assessed length and size of bycatch species.

In this advisory, we reexamine bycatch in terms of weight rather than number of fish and marine invertebrates relative to Virginia's menhaden fishery. We limit our reexamination to data obtained only from the at-sea samples. Data obtained from offloadings or dockside are not included in the present analysis. In our original study, we did not examine bycatch in terms of weight. We did, however, obtain information on size frequency for the purpose of estimating weight. Using scientifically available mathematical/statistical relationships that relate animal weight to size, we estimate the weight of most bycatch species. When more than one weight-length relationship is available, we utilize the relationship that estimates the highest weight for a given species. Weight-length relationships, however, are not available for all bycatch species. For species with no available relationship between weight and length, we assume strict proportionality between weight and length and consequently overestimate the weight of the species being considered. For species with no available information about weight and length, we assign an arbitrarily inflated weight given the size of the bycatch species (e.g., we assign one pound to a five inch harvestfish or John Dory and a 0.50 pound weight to a two inch spider crab).

Assessment of Weight

Relative to assessing the impact of bycatch on the population of a species, the more important concerns are numbers of fish caught by age or size. It also is quite difficult to obtain accurate weights of fish and shellfish while at sea. Lengths of fish, however, were recorded to obtain a size frequency distribution by species. Using appropriate measures on the size of fish and marine invertebrates, we estimate weights by using available weight-length relationships for most bycatch species.

A total of 21 species other than menhaden were harvested as bycatch (Table 1, see page 6). Spotted and gray trout were grouped together. The weight of each unit of bycatch was assessed according to the equations or relationships available in the scientific literature. We further assumed that the sample frequency or size distribution applied to the entire catch observed during sampling.

Based on the equations and other information contained in Table 1, weights were estimated for all bycatch species. The mathematical values of the coefficients have been rounded off to nearest values to reduce the complexity of the equations. References for the weight-length equations as well as other methods used to estimate weight are also listed in Table 1.

Analysis and Results

A total of 43 sets were sampled in August, October, and November 1992. Each set was sampled to determine the number of menhaden and bycatch species and the size frequency or number of fish by size of fish harvested. A total of 2,513,000 standard menhaden were harvested in

Table 1. Weight-length relationships used to estimate weight of bycatch species

Species	Weight-length relationship[a]	Source of weight/length relationship
Blue crabs	$W = .00062420\ L^{2.55}$	Olmi, E.J. and J.M. Bishop. (1983). Variations in total width-weight relationships of blue crabs, *Callinestes sapidus*, in relation to sex, maturity, molt stage, and carapace form. J. Crust. Biol. 3(4):575-581.
Bluefish	$W = .00001120\ L^{3.04}$	Wilk,S.J., W.W. Morse, and D.E. Ralph. (1978). Length-weight relationships of fishes collected in the New York Bight. Bull. New Jersey Acad. Sci. 23:58-64.
Butterfish	$W = .00000650\ L^{3.26}$	DuPaul,W.D. and J.D. McEachran. (1973). Age and growth of the butterfish, *Peprilus triacanthus*, in the Lower York River. Ches. Sci. 18, 205-207.
Croaker	$W = .00000620\ L^{3.10}$	Parker, J.C. (1971). The biology of spot, *Leiostomus xanthurus* Lacepede, and Atlantic Croaker, *Micropogon undulatus* (Linnaeus), in two Gulf of Mexico nursery areas. Sea Grant Publ. No. TAMU-SG-71-210. Texas A&M Univ., College Station.
Cownose rays	$W = .00000450\ L^{3.20}$	Smith, J.W. (1980). The life history of the cownose ray, *Rhinoptera bonasus* (Mitchill 1815), in lower Chesapeake Bay, with notes on the management of the species. Master thesis, College of William and Mary, Virginia Institute of Marine Science.
Summer flounder	$W = .00000190\ L^{3.29}$	Morse W.W. (1981). Reproduction of the summer flounder, *Paralichthys dentatus* (L). J. Fish. Biol. 19(1):189-203.
Harvest fish	Assume one pound weight	None available.
Hog choker	$W = .01510800\ L^{3.11}$	Koski, R.J. (1978). Age, growth, and maturity of the hogchoker, *Trinectes maculatus*, in the Hudson River, New York. Trans. Am. Fish. Soc. 107(3):449-453.
Lady crab	$W = .00034670\ L^{2.89}$	Davidson, R.J. and I.D. Marsden. (1987). Size relationships and relative growth of the New Zealand swimming crab, *Ovalipes catharus* (White 1843). J. Crust. Biol. 7(2):308-317.
Oyster toad	$L = 2.0700 + .013\ W$	Wilber, C.G. and P.F. Robinson. (1960). The correlation of length, weight, and girth in the toadfish, *Opsanus tau*. Ches. Sci. 1:122-123.
Sandbar shark	$W = 50.118723\ L^{0.33}$	Lawler, E.F. (1976). The biology of the sandbar shark, *Carcharinus plumbeus* (Nardo 1827) in the lower Chesapeake Bay and adjacent waters. Master thesis, College of William and Mary, Virginia Institute of Marine Science.
Silver perch	$W = .00001000\ L^{3.10}$	Rhodes, S.F. (1971). Age and growth of the silver perch, *Bairdiella chrysura*. Master thesis, College of William and Mary, Virginia Institute of Marine Science.
Spanish mackerel	$W = .00001152\ L^{2.98}$	Powell, D. (1975). Age, growth, and reproduction in Florida stocks of spanish mackerel, *Scomberomorus maculatus*. Fla. Mar. Res. Publ. 5. 21 pp.
Spider crab	Assume 0.50 pound weight	None available.
Spot	$W = .00000030\ L^{3.76}$	Pacheco, A.L. (1957). The length and age composition of spot, *Leiostomus xanthurus*, in the pound net fishery of lower Chesapeake Bay. Master thesis, College of William and Mary, Virginia Institute of Marine Science.
Squid	$W = .00056510\ L^{2.43}$	Pierce, G.J., P.R. Boyle, L.C. Hastie, and L. Key. (1994). The life history of *Loligo forsbesi* (Cephalapoda: Loliginidae) in Scottish waters. Fish. Res. 21:17-41.
Striped bass	$W = .00578100\ L^{3.15}$	Mansueti, R.J. (1961). Age, growth, and movements of the striped bass, *Roccus saxatilis*, taken in size selectivity fishing gear in Maryland. Chesapeake Sci. 2:9-36.
Thread herring	Assume one pound weight	None available.
Spotted Sea trout	$W = .00000460\ L^{3.11}$	Moffett, A.W. (1961). Movements and growth of spotted seatrout, *Cunoscion nebulosus* (Cuvier). Fla. Board Conserv. Mar. Res. Lab. Tech. Ser. 36: 1-35.
Weakfish	$W = .00000930\ L^{2.98}$	Shepherd, G.R. and C.B. Grimes. (1983). Geographic and historic variations in growth of weakfish, *Cynoscion regalis*, in the Middle Atlantic Bight. U.S. Nat. Mar. Fish. Serv. Fish Bull. 81(4): 803-813.
Witch flounder	Proportionality assumed Maximum weight of 4.5 pounds and maximum length of 24 inches.	Page 66 of "Status of Fishery Resources off the Northeastern United States for 1991." National Marine Fisheries Service, Woods Hole, Massachusetts.

[a]Weights (W) are in terms of grams, ounces, or pounds, and lengths (L) are in millimeters, centimeters, or inches. All estimated weight-length coefficients are rounded off in value.

the 43 sets; menhaden are reported in terms of standard menhaden and 1,000 standard menhaden weigh 670 pounds. Total bycatch from the 43 sets was 5,338 fish and marine invertebrates. Relative to the number of menhaden harvested in the 43 sets, bycatch equalled 0.21%. On a monthly basis, the ratio of the number of species caught other than menhaden to the number of menhaden was 0.287%, 0.145%, and 0.075% for August, October, and November, respectively (Tables 2-4). The laws require assessment of bycatch relative to the entire catch and not solely the catch of menhaden.

A critical question posed by the recreational associations was "What was the bycatch in terms of weight?" Overall, the total harvested weight of menhaden from the 43 sets was 1,683,710 pounds. The weight of all bycatch was 9,845.9 pounds which equalled 0.585 percent of the harvested weight of menhaden. Bycatch in terms of weight relative to the weight of menhaden was higher than the percent of bycatch calculated using numbers of fish but well below the one percent legal limit. In October, however, the ratio of the weight of bycatch to the weight of menhaden was below the ratio expressed in terms of numbers of fish. Bycatch in October in terms of numbers of units equalled 0.145% of the total number of menhaden harvested; in weight terms, bycatch equalled 0.083% of the harvested weight of menhaden.

What about the number of sets in which bycatch in terms of weight exceeded one percent of the weight of menhaden? For comparative purposes, we note that 24.0%, 8.3%, and 0.0% of the

Table 2. Bycatch in menhaden fishery in terms of numbers and weight, August 1992

Species	Number of Observations	Average Size (inches)	Average Weight (pounds)	Total Weight (pounds)
Blue crabs	119	3.54	0.133	15.83
Bluefish	801	13.95	1.180	945.56
Butterfish	141	5.91	0.183	25.79
Croaker	507	8.40	0.257	130.30
Cownose rays[a]	148	16.54	12.235	1,810.72
Summer flounder	71	7.48	0.132	9.37
Harvest fish	124	5.02	1.000	124.00
Hog choker[a]	472	4.72	0.144	68.19
Lady crab[a]	0			
Oyster toad[a]	0			
Sandbar shark[a]	51	30.00	6.700	341.70
Silver perch	0			
Spanish mackerel	1,144	26.33	3.167	3,622.70
Spider crab[a]	49	1.97	0.500	24.50
Spot	46	7.49	0.183	8.42
Squid	126	2.76	0.039	4.93
Striped bass	0			
Thread herring[a]	95	6.26	0.100	95.00
Sea trout	220	8.99	0.196	43.00
Witch flounder	0			
Total bycatch	**4,114**		**1.767**	**7,270.01**
Menhaden	1,433,000		0.670	960,110.00
Percent of bycatch:				
Total bycatch[b]	0.29[c]			0.76[d]
Food fish[b]	0.23[c]			0.51[d]

[a]Not traditional food fish species.
[b]Bycatch assessed relative to all species (total) and only traditional food fish species.
[c]Ratio of number of bycatch to number of menhaden expressed in terms of percent.
[d]Ratio of weight of bycatch to weight of menhaden expressed in terms of percent.

sets in August, October, and November exceeded one percent of the number of menhaden harvested. On a weight basis, the number of sets in which bycatch exceeded one percent of the harvested weight of menhaden was 32.0%, 0.0%, and 33.3% during August, October, and November, respectively. If we examine bycatch relative to food fish and discarded or released fish, however, there were no sets in August, October, or November in which the possession of bycatch exceeded one percent of the weight of the entire catch or the weight of menhaden.

If the analysis assumes that sandbar shark and cownose rays are not generally considered as food fish, only 16% of the sets in August had bycatch exceeding one percent of the weight of menhaden. If we further acknowledge that most of the Spanish mackerel were discarded or released by the captain and crew (onboard observation), there were no sets in August in which the bycatch in terms of weight and retained by the vessel exceeded one percent of the weight of the entire catch. In addition, the 4 sets in August in which bycatch, comprised mostly of Spanish mackerel, exceeded one percent of the weight of the entire catch were relatively small sets. The number of standard menhaden harvested in the four sets were 15,000, 20,000, 35,000, and 100,000. If we also acknowledge that striped bass is a prohibited species and must be released or discarded, the number of sets in November in which the total weight of bycatch exceeded one percent of the weight of menhaden drops to zero.

Table 3. Bycatch in menhaden fishery in terms of numbers and weight, October 1992

Species	Number of Observations	Average Size (inches)	Average Weight (pounds)	Total Weight (pounds)
Blue crabs	104	4.38	0.228	23.68
Bluefish	32	9.51	0.425	13.60
Butterfish	181	4.69	0.086	15.55
Croaker	84	6.58	0.115	9.70
Cownose rays[a]	0			
Summer flounder	148	8.43	0.207	30.67
Harvest fish	0			
Hog choker[a]	48	4.53	0.129	6.19
Lady crab[a]	32	2.00	0.065	2.08
Oyster toad[a]	8	6.81	0.452	3.63
Sandbar shark[a]	0			
Silver perch	80	5.04	0.751	6.01
Spanish mackerel	0			
Spider crab[a]	0			
Spot	16	6.22	0.223	3.57
Squid	0			
Striped bass	8	32.48	18.987	151.90
Thread herring[a]	0			
Sea trout	85	9.28	0.215	18.32
Witch flounder	31	7.61	1.427	44.24
Total bycatch	**857**			**329.12**
Menhaden	590,000		0.670	395,300.00
Percent bycatch:				
Total bycatch[b]	0.15[c]			0.08[d]
Food Fish[b]	0.13[c]			0.08[d]

[a]Not traditional food fish species.
[b]Bycatch assessed relative to all species (total) and only traditional food fish species.
[c]Ratio of number of bycatch to number of menhaden expressed in terms of percent.
[d]Ratio of weight of bycatch to weight of menhaden expressed in terms of percent.

Conclusions

In general, the updated analysis presented in this advisory indicated that bycatch in Virginia's menhaden fishery did not pose a problem with respect to the laws in 1992. The updated analysis found that regardless of whether or not weight or number of fish and marine invertebrates was used to assess bycatch, the percent of bycatch relative to the entire catch or only the catch of menhaden was generally below one percent in 1992. The updated analysis did reveal, however, that the number of sets in which bycatch exceeded one percent did increase when weight rather than number of fish and marine invertebrates was used to assess bycatch.

The number of sets in which bycatch exceeded one percent of the entire catch increased from 7 to 10 when weight rather than number of fish and marine invertebrates was used to assess bycatch. However, if the analysis was restricted to traditional food fish, the number of sets having bycatch in excess of one percent of the weight of the entire catch declines from 10 to 6 out of 43. If we further acknowledge that striped bass caught in the November sets and most of the Spanish mackerel caught in the August sets were released or discarded by the crew, there were no sets in any of the months in which the vessel possessed bycatch in excess of one percent of the weight of the entire catch.

Table 4. Bycatch in menhaden fishery in terms of numbers and weight, November 1992

Species	Number of Observations	Average Size (inches)	Average Weight (pounds)	Total Weight (pounds)
Blue crabs	0			
Bluefish	102	19.10	3.501	357.10
Butterfish	45	5.49	0.144	6.49
Croaker	0			
Cownose rays[a]	0			
Summer flounder	4	9.00	1.000	4.00
Harvest fish	0			
Hog choker[a]	0			
Lady crab[a]	132	2.80	0.154	20.37
Oyster toad[a]	0			
Sandbar shark[a]	0			
Silver perch	0			
Spanish mackerel	0			
Spider crab[a]	0			
Spot	0			
Squid	0			
Striped bass	84	34.06	22.13	1,858.82
Thread herring[a]	0			
Sea trout	0			
Witch flounder	0			
Total bycatch	**367**		**6.122**	**2,246.78**
Menhaden	490,000		0.670	328,300.00
Percent bycatch				
Total bycatch[b]	0.08[c]			0.68[d]
Food fish[b]	0.05[c]			0.68[d]

[a]Not traditional food fish species.
[b]Bycatch assessed relative to all species (total) and only traditional food fish species.
[c]Ratio of number of bycatch to number of menhaden expressed in terms of percent.
[d]Ratio of weight of bycatch to weight of menhaden expressed in terms of percent.

It must be recognized, however, that the VIMS study and the updated analysis in this advisory offer, at best, a limited snapshot. The VIMS study was conducted in 1992 given resource conditions prevailing at the time. The focus of the VIMS study was to determine procedures for accurately assessing bycatch, test the procedures, and provide an assessment of bycatch relative to menhaden during 1992. The VIMS study could not assess bycatch relative to a wide range of resource conditions. Obviously, changes in the abundance of striped bass, bluefish, or other species could cause a change in bycatch relative to menhaden or alter the composition of bycatch. A more thorough assessment of bycatch, regardless of using weight or numbers of fish and invertebrates, would require a study conducted over several years and with variable resource conditions. ✣ ✣

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