1990

Stock Identification of summer Flounder (Paralichthis dentatus) in the Southern Mid-Atlantic Bight

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Final Report

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to:

Virginia Marine Resources Commission

Federal Aid for Sports Fish Restoration

F-61-R."

"WB-86-01-04."

"October 15, 1990"

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ABSTRACT

A total of 12,339 summer flounder were tagged from Virginia waters during 1987-89. A total of 874 were recaptured for an overall return rate of 7.1%. Most of the returns (48.5%) were from Virginia waters, or areas to the south. A smaller number (21.6%) were from areas north and offshore of Virginia. Another 29.9% were recaptured and returned with inadequate location data. Examining only the returns with adequate location data, yielded a separation of 69.2% and 30.8% between the groups. No differences were noted in the sizes at tagging between these groups. Tagged flounder held at VIMS exhibited no behavioral differences from untagged fish. No differences in growth and mortality were noted in these fish. The sex ratio of males to females was 1:1.16. Male summer flounder reached 50% maturity at approximately 280 mm, while females reached 50% maturity at about 330 mm. A total of 1040 flounder were successfully aged. The population was dominated by young fish (0-2 years old). The compression of age structure is indicative of a population being heavily overfished.

INTRODUCTION

The summer flounder or fluke, Paralichthys dentatus (L.), is one of our most important commercial and recreational fish species on the Atlantic coast. It ranges from Nova Scotia to Florida (Leim and Scott 1966, Gutherz 1967), while its center of abundance is from Cape Cod, Massachusetts to Cape Fear, North Carolina. Two closely related species, the southern flounder (P. lethostigma), and the gulf flounder (P. albigutta), occur south of Oregon Inlet, North Carolina and sometimes are not distinguished from summer flounder in landings there.

Summer flounder inhabit coastal and estuarine waters during the warmer months of the year and are found offshore in 20 to 100 fathoms (36 to 182 m) of water during the fall and winter (Bigelow and Schroeder 1953, Scarlett 1981). Spawning occurs during the fall and winter as the fish move offshore, or at their wintering grounds. The migratory and spawning pattern varies with latitude, the fish moving offshore and spawning earlier in the northern part of their range. Larvae and post-larvae drift and migrate inshore, entering coastal and estuarine nursery areas from October to May (Scarlett 1981).

The primary nursery grounds of summer flounder are reported to be the sounds of North Carolina, Chesapeake Bay, and the seaside bays of Virginia's Eastern Shore (Poole 1966, Festa 1974, Scarlett 1981). The importance of other coastal regions, in particular, New Jersey, may have been overlooked in the past (K. Able, pers. comm.).

Juvenile summer flounder in southern waters are reported to overwinter in bays and sounds, while in the north there is some movement offshore (Smith and Daiber 1977, Wilk et al. 1980). The offshore population returns to the coast and bays in the spring with a tendency to return to the same area as the previous year, or to move to the north and east (Hamer and Lux 1962, Poole 1962, Murawski 1970, Scarlett 1981).

Extensive commercial and recreational fisheries exist for summer flounder from Massachusetts to North Carolina, with the

majority of commercial landings in New Jersey, Virginia, and North Carolina. Historically, large fluctuations in landings have been characteristic of the commercial fisheries. Landings ranged from 4632 to 10111 Mt from 1944 to 1967. In 1969, landings reached their lowest point of 3037 Mt and then steadily increased to new all-time highs. The highest of which was 19005 Mt in 1979. More recently, commercial landings along the Atlantic coast decreased 40% from 1988 to 1989 (16272 to 9702 Mt)(MAFMC 1990).

The National Marine Fishery Service (NMFS) implemented the Marine Fishery Statistical Survey (MRFSS) in 1979 to obtain catch and statistical information from the recreational fishery. The landings ranged from 16357 Mt (1983) to 4852 Mt (1981) from 1979 to 1988. Average recreational landings for the ten-year period was 9993 Mt.

Considerably more effort has been exerted in Virginia and North Carolina state waters since the decline of the New England groundfish fishery. Prior to 1974, trawling was prohibited except in the seaside area between Cape Charles and the Maryland line, and then only during the months of June, July and August (Va. Mar. Res. Comm. 1989). In 1979, Virginia expanded its trawling areas to include the following: from Cape Charles to the Maryland line for November through August; from Sandbridge to the North Carolina line at any time; and from Cape Henry to Sandbridge between October 1 and May 1. Prior to 1979, less than 20 boats fished the Virginia territorial sea. License sales in 1979 increased to over 50 and by 1984 were 115. In 1988, 123 licenses were issued and this figure was expected to increase later. It is interesting to note that the all-time high for commercial landings was in 1979, the same year that Virginia opened most of its territorial sea to trawling.

Previous studies have indicated the possibility of more than one stock or population of summer flounder contributing to the fisheries of the Mid-Atlantic Bight (MAB) (Murawski 1970, Wilk et al. 1980, Gilliken et al. in prep.; cited in Scarlett 1981, Delaney 1986). The NMFS summer flounder stock assessment and in turn, existing management plans are based upon the supposition that only

one stock exists in the MAB (Scarlett 1981, Delaney 1986).

Various methods have been employed to identify the existence or non-existence of separate stocks of summer flounder; among these were meristic and morphometric analyses (Ginsburg 1952, Smith and Daiber 1977, Wilk et al. 1980, Delaney 1986), and tagging studies (Westman and Neville 1946, Hamer and Lux 1962, Poole 1962, Murawski 1970, Gilliken et al. in prep.; cited in Scarlett 1981).

Ginsburg (1952) and Smith and Daiber (1977), found evidence of two stocks of summer flounder north and south of Cape Hatteras. Wilk et al. (1980) performed a linear discriminant analysis of morphometrics on summer flounder collected along the eastern seaboard from New York to Florida. They concluded that there was a significant difference between samples north and south of Cape Hatteras.

Tagging studies by Westman and Neville (1946) and Poole (1962) off Long Island, New York; Hamer and Lux (1962) north of Hudson Canyon; and Murawski (1970) off New Jersey; indicated that summer flounder migrate south and offshore in the fall from their coastal summering grounds, and spent the winter at the edge of the continental shelf. In spring they migrated inshore to the north and east essentially to the same inshore areas as the previous year. A total of 14596 fish were tagged north of Cape May, New Jersey. Most of the returns came from the offshore winter trawl fishery as far south as Virginia. Only a small percentage of the returns (0.3%) were recaptured in inshore waters south of Maryland (Scarlett 1981, Delaney 1986).

Since the 1960's, a trawl fishery for summer flounder has expanded inside the 20 fathom (36 m) contour along the Virginia and North Carolina coast (Scarlett 1981). This fishery progresses southward during the fall and winter, starting just south of the Chesapeake Bay mouth in October and November, to below Cape Hatteras in January and February. The North Carolina Division of Marine Resources tagged large numbers (~7300) of these flounder in the fall and winter of 1973 and 1974 (Gilliken et al. in prep. cited in Scarlett 1981). Excluding immediate returns, most fish were recaptured from North Carolina and Virginia coastal waters and

Chesapeake Bay. A small percentage (8%) of the returns were from north of Maryland. Returns from the following fall and winter came from the same general area in which the fish were tagged. None of the tagged fish were recaptured in the offshore winter trawl fishery. Recent tagging studies in North Carolina of juvenile summer flounder have indicated only local migrations from the sounds to the coastal waters with one fish recaptured in the Norfolk Canyon area (R. Monaghan, pers. comm.).

Based on egg and larval collections, Smith (1973) hypothesized that three distinct populations of summer flounder existed along the Atlantic with a seasonal progression in spawning from north to south. One segment of the population appeared to spawn north of Delaware Bay, a second from Virginia to Cape Hatteras, and a third south of Cape Hatteras. Smith's data (1973) and the tagging done in North Carolina (Gilliken et al. in prep. cited in Scarlett 1981) support one another and point to the possibility that two separate populations of summer flounder may contribute to the fisheries of the MAB.

CURRENT STUDY

This tagging study was undertaken in an attempt to identify migration patterns of summer flounder from Virginia waters; Chesapeake Bay, seaside bays of Virginia's eastern shore, and the coastal region. Stock composition of these fish was quantified through the analysis of tag returns from the recreational and commercial fisheries. Biological characteristics of the fish were quantified and compared to those reported in the literature. These results are to be disseminated to the various management agencies in order to update and improve management strategies for summer flounder.

MATERIALS AND METHODS

Overall Objectives

1. To determine the stock composition of inshore populations of summer flounder in Virginia through tagging.

2. To determine the seasonal migratory patterns of these populations.

3. If different stocks are present, to estimate the relative contribution of each stock to the total landings (in Virginia).

4. To better define age-growth and size at maturity of the inshore (southern) flounder stock.

5. To make findings available to the Middle Atlantic Fisheries Management Council, Atlantic States Marine Fisheries Commission, and the Virginia Marine Resources Commission so that they may be incorporated into future revisions of the various management plans for summer flounder.

TAGGING APPROACH

Tagging Areas

The inshore waters of Virginia where summer flounder are abundant were divided into three major areas:

1. Lower Chesapeake Bay
2. Seaside Eastern Shore inlets and bays
3. Nearshore coastal regions south of Chesapeake Bay.

Tagging Methodology

A total of 5,000 summer flounder were to be tagged each year of the study. Actual number of fish tagged was dependent upon the abundance of the population. Equal numbers of fish were to be tagged from each of the three main areas. A total of 10-15,000 fish was chosen as a goal because previous successful tagging studies of summer flounder have had marked sample sizes in this range (Scarlett 1981).

Return rates in other studies have ranged from 5-28%, but one study (Gilliken et al., in prep.) had much lower rates, probably due to the small size of fish tagged (Scarlett 1981). This problem was to be avoided by tagging fish only >250 mm TL and by using Floy

FT-4 Cinchup tags, instead of the Petersen disk tags used in previous studies.

Since it was proposed that the stocks of summer flounder spawn and spend the winter in different areas, it should be relatively simple to determine the source of fish tagged inshore by the areas where the tag returns came from:

1. Deep-water (>40m) north of Cape Hatteras ("offshore stock"),

2. Shallow-water (<40m) from Oregon Inlet south of Cape Hatteras to Cape Lookout ("inshore stock").

A target of 500 specimens per month were to be tagged from the Eastern Shore and the lower Chesapeake Bay/coastal region from May through September inclusive. Again, actual numbers tagged was dependent on the abundance of the population. A sixteen foot (4.9 m) semi-balloon otter trawl (1/4" mesh) was used to capture fish for tagging on the Eastern Shore. A one hundred foot (30.5 m) semi-balloon otter trawl (4-6" mesh) was used from a commercial trawler (F/V Anthony Anne) to capture fish for tagging in the Chesapeake Bay/coastal region. Holding tanks were used to keep fish alive while tagging was underway. Only fish greater than 250 mm were tagged. The object of spreading the tagging effort out over the entire summer when the fish were inshore was to determine whether stock composition changed during the summer.

All summer flounder captured were measured (total length), weighed (grams) when possible, and scales removed for age determination. The scale method for ageing summer flounder has only recently been verified as the best method for this species (Shepherd 1980). Subsamples of fish were selected each month to determine sex and stage of maturity following the schedule of Morse (1981).

The tagging program was advertised through the media and by placing posters at important commercial and recreational landing ports in Virginia, North Carolina and Maryland during the first year, and as far away as New Jersey in subsequent years. Contact with other states was maintained through the state biologists who have been members of the State/Federal Statistics and Scientific

Committee on summer flounder, the group which prepared the Summer Flounder Management Plan, and which the Principal Investigator of this project chaired for several years.

Rewards of $2 were offered for each return, with a drawing held each year to determine winners of special rewards ranging from $50 to $500.

Analysis of Returns

Data analysis of tag returns was simple and straight forward since the principal objectives were to determine where Virginia fish migrate, and from this to infer stock composition. As a secondary goal, if the returns were sufficient, maximum liklihood estimates of the instantaneous rate of fishing mortality were to be derived.

Tag Retention

Retention of the FT-4 Cinchup tags and tagging mortality were examined during this study. Tagged and untagged fish were held in tanks at VIMS. A representative size range of fish were held and tag retention and mortality examined with relation to size of fish, time duration, and placement of tags. Fish were fed prey species captured from the York River at VIMS.

Location

This species is of extreme importance to both the recreational and commercial fisheries in Virginia, and was recognized as a species of high priority for management research by representatives of both industries. The research herein is extremely important to the effective management of summer flounder, and to insure that only equitable management regulations are imposed upon the fishermen of Maryland, Virginia, and North Carolina.

If there are two or more stocks, and management regulations are based on only one, such regulations may prove to be unfair to a portion of the user group. If a 14" size limit is imposed across the range of the species then this may be unfair to fishermen where the stock may mature at a smaller size (as has been suggested for the southern or inshore stock). In addition, other evidence from tagging off New Jersey/New York (Poole 1966, Murawski 1970), suggests flounder grow larger and older as they migrate further

north each successive summer. This could mean that imposition of a 14" size limit on flounder in Virginia might severely impinge on both the recreational and commercial fisheries there, while enhancing the fisheries in states to the north. In other words, Virginia fishermen might have to sacrifice a large part of their catch, yet gain little from the increased yield (per recruit) that would accrue from a 14" size limit; this gain being realized by fishermen to the north. This proposition would be a hard one to accept for those responsible for promulgating equitable marine fishery regulations.

Expected Results

Results of this study will contribute information both for stock composition and migratory patterns of summer flounder. Because the fall and winter trawl fishery is focused on spawning summer flounder located in two geographically separate areas, (offshore continental shelf edge from Norfolk Canyon north; inshore, <40 m from Cape Henry, Virginia, south to Ocracoke Inlet, North Carolina), the contribution of tag returns from these two areas will provide an estimate of the relative contribution of these two stocks to the Virginia inshore summer fishery. In addition, subsequent returns will provide estimates of the relative proportion of summer flounder that return to Virginia, and the proportion that migrate north to be captured by fisheries of other states.

Dissemination of Results

Results of this work will be made available to the Middle Atlantic Fisheries Management Council, the Atlantic States Marine Fisheries Commission, and the Virginia Marine Resources Commission, so they may be incorporated into future revisions of the various fisheries management plans for summer flounder.

RESULTS

The results section of this report has been divided into five parts following the original format set in the previous progress reports. All results pertinent to each job category can be found in the appropriate section. All tables and figures referred to in each section can be found at the end of each.

Project Title: Stock Identification of Summer Flounder in the Southern Mid-Atlantic Bight

Job Title 1: Tagging Study

Objective: To tag and release 10-15,000 fish from Chesapeake Bay and surrounding waters.

To collect length data and scale samples from tagged fish.

Target Date: September, 1989.

Segment Objective: To tag and release 3-5,000 fish each summer.

Segment Status: All objectives have been met.

Results: A. Tagging operations.

A total of 12,339 summer flounder were tagged in Virginia waters during the course of the study (Table 1). The upper target of 5,000 fish tagged was met and exceeded during the first and second years. In 1989, only 1,664 summer flounder were tagged, a reflection of slightly lower effort (two less cruises in the bay), and a dramatic reduction in the number caught. This decline was evident from the catch and effort data taken during each cruise (Table 2, Fig. 1). Overall catch per unit effort (CPUE) declined from 1.6 fish caught per minute to 0.4, a 75% decrease from 1987 to 1989. Catch and effort data will be discussed in depth in a later section.

The majority of summer flounder were tagged from various locations within Chesapeake Bay (8,215 fish), over half of these were tagged off of Cape Charles City (4,576). Almost equal numbers of flounder were tagged from the other two major areas, 2,150 from the Wachapreague-Eastern Shore area, and 1,974 from coastal Virginia south of the bay mouth (Virginia Beach-Sandbridge area).

Scale samples and total lengths (mm) were taken from each tagged fish. Fish were weighed (gm) when conditions permitted. The data will be treated in a later section dealing with the biological characteristics of summer flounder in Virginia waters.

All fish were captured by trawling. A 23' VIMS Privateer was

used to capture flounder from the seaside bays and inlets of Virginia's Eastern Shore. A commercial trawler, the F/V Anthony Anne, was used in Chesapeake Bay and adjacent coastal waters. Tow times were 15-30 minutes depending on the size and content of the previous catches.

B. Catch Per Unit Effort.

In order to examine changes in the abundance of summer flounder, catch and effort statistics were kept for each cruise during the study period. Number of tows made, tow duration in minutes, and the number of flounder caught and tagged per tow were recorded.

Overall catch per unit effort decreased fifty (50) percent each year of the study (Table 2). The overall number of flounder caught per minute of tow time decreased from 1.6 in 1987, to 0.8 in 1988, and to 0.4 in 1989. Assuming that immigration was equal to emigration throughout the course of the study, summer flounder abundance in Virginia during 1989 was one-fourth of what it was at the start of the project in 1987. Data from a VIMS juvenile summer flounder index indicated little to no recruitment from 1987 to 1989, leaving the fishery dependent on only one year class, the 1986 group. Preliminary data for 1990 has indicated recruitment of summer flounder on the same order as that of 1986, the last successful year class in Virginia.

Table 1. Total number of summer flounder (*Paralichthys dentatus*) tagged and overall returns by tagging area as of 9-13-90. (Numbers in parantheses are percent returns.)

	Number Tagged				Number of Returns			
Tagging Area	1987	1988	1989	Total	1987	1988	1989	Total
Wachapreague	946	528	676	2150	132 (14.0)	83 (15.7)	42 (6.2)	257 (12.0)
Chesapeake Bay								
Cape Charles	1533	2613	430	4576	95 (6.2)	227 (8.7)	8 (1.9)	330 (7.2)
Kiptopeke	267	1131	213	1611	11 (4.1)	99 (8.8)	3 (1.4)	113 (7.0)
Middle Grounds	1303	448	73	1824	65 (5.0)	27 (6.0)	2 (2.7)	94 (5.2)
Other Ches. Bay	103	43	58	204	6 (5.8)	2 (4.7)	2 (3.5)	10 (4.9)
TOTAL CHES. BAY	3206	4235	774	8215	177 (5.5)	355 (8.4)	15 (1.9)	547 (6.7)
Virginia coast	922	838	214	1974	37 (4.0)	32 (3.8)	1 (0.5)	70 (3.6)
TOTAL	5074	5601	1664	12339	346 (6.8)	470 (8.4)	58 (3.5)	874 (7.1)

Table 2. Summer flounder catch per unit effort (CPUE) data for 1987-89. (All fish captured with 100' otter trawl unless otherwise noted.)

	Wachapreague[1]			Chesapeake Bay			Virginia Coast			CB + VA Coast			All Areas		
	1987	1988	1989	1987	1988	1989	1987	1988	1989	1987	1988	1989	1987	1988	1989
# of Tows	90	185	226	173	223	123	41	69	40	214	292	163	304	479	389
Tow Time (mins)	1125	2337	2790	3887	4932	2910	900	1514	1069	4787	6446	3979	5912	8783	6769
# Caught	1629	620	966	6782	5348	1437	1065	1058	296	7847	6406	1733	9476	7026	2699
# Tagged	942	523	674	3143	4307	760	930	861	214	4073	5168	974	5015	5691	1648
# YOY	289	0	205							3276	197	418	3565	197	623
# Caught/tow	18.10	3.32	4.27	39.20	23.98	11.68	25.98	15.33	7.40	36.67	21.94	10.63	31.17	14.67	6.94
# Tagged/tow	10.47	2.80	2.98	18.17	19.31	6.18	22.68	12.48	5.35	19.03	17.70	5.98	16.50	11.88	4.24
# YOY/tow	3.21	0	0.91							15.31	0.68	2.56	11.73	0.41	1.60
# Caught/min.	1.45	0.27	0.35	1.75	1.08	0.49	1.18	0.70	0.28	1.64	0.99	0.44	1.60	0.80	0.40
# Tagged/min.	0.84	0.22	0.24	0.81	0.87	0.26	1.03	0.57	0.20	0.85	0.80	0.25	0.85	0.65	0.24
# YOY/min.	0.26	0	0.07							0.68	0.03	0.11	0.60	0.02	0.09

1. Fish captured with 16' otter trawl.

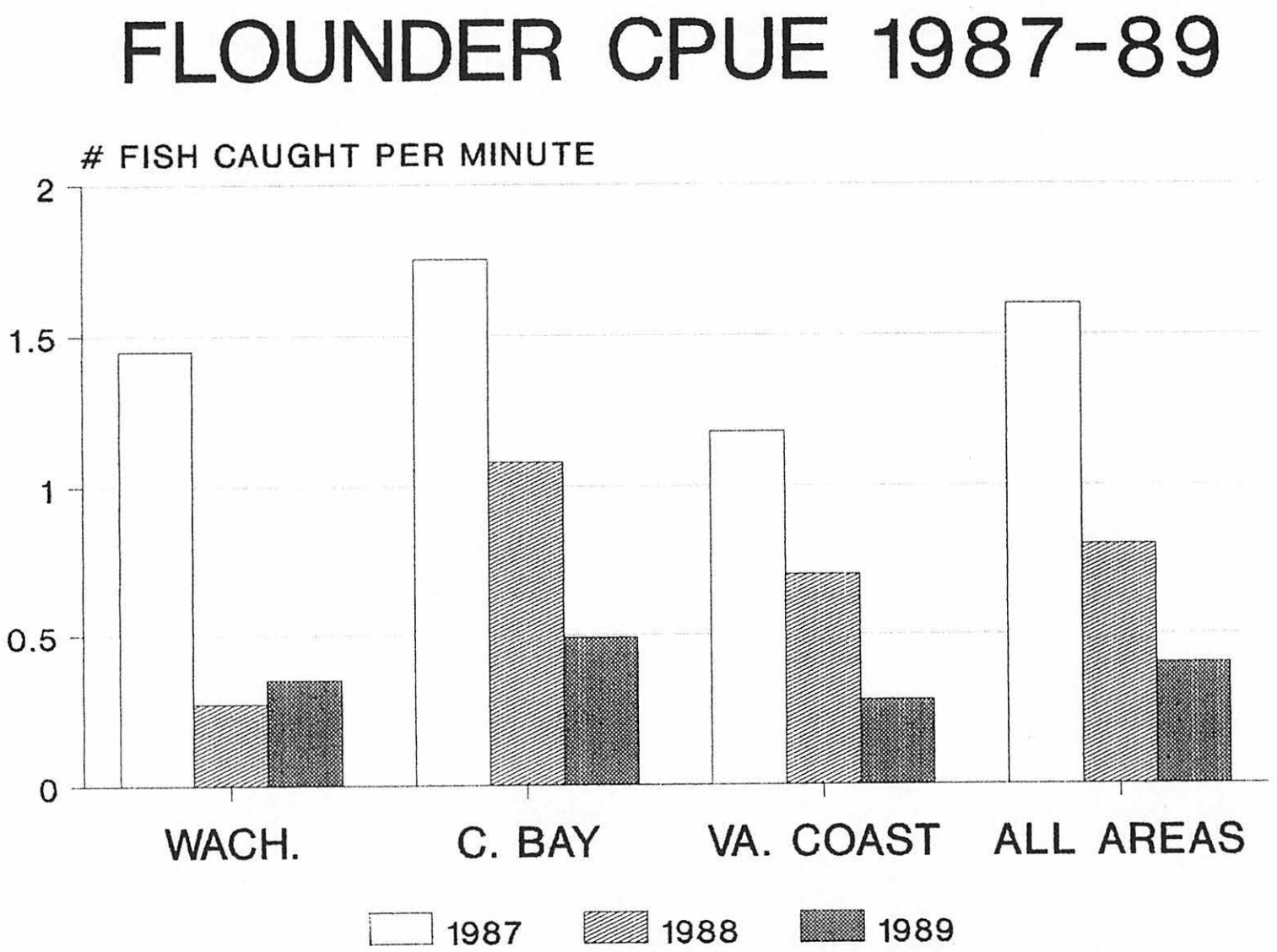

Figure 1. Catch per unit effort by area for 1987-89.

Project Title: Stock Identification of Summer Flounder in the Southern Mid-Atlantic Bight

Job Title 2: Tag Return Analysis

Objective: To determine migration and stock composition of summer flounder tagged in Virginia waters.

Target Date: September 1990

Results: A. Overview

As of September 13, 1990, a total of 874 tags were returned, an overall return rate of 7.1% (Table 1). The highest return rates came from fish tagged at Wachapreague (12.0% overall). A total of 547 returns (6.7%) came from fish tagged in Chesapeake Bay, with another 70 returns (3.6%) from fish tagged in coastal (nearshore) areas off of Virginia Beach.

Return rates decreased significantly for fish tagged in 1989, being less than one-half the rates of previous years. This pattern was discernible from all areas and may reflect a reluctance of fishermen, both recreational and commercial, to return tags due to increased restrictions on flounder fishing in Virginia and the decrease in numbers of available fish.

Most of the returns came within one year of tagging, indicating a high mortality rate. Mortality rates have been calculated and will be presented later. One fish tagged at Wachapreague on 6 July 1987 was recaptured off the New Jersey coast in February 1989, one year and eight months later. This represents the longest interval between tagging and recapture from this study.

The farthest tag return was from Rhode Island. A fish tagged at Wachapreague on 1 June 1988 was recaptured in a commercial fish trap (pound net) three miles southeast of Newport, R. I. on 22 May 1989. Another fish was purportedly caught from a fishing pier in Pompano Beach, Florida.

B. Gear Analysis

The number of returns by recapture gear was analyzed in two ways, total number of returns by gear (Table 3), and returns from fish which were at liberty for more than two weeks before being recaptured (Table 4). This eliminated immediate recaptures from the research gear and also eliminated a few of the immediate recreational recaptures.

The recreational fishery accounted for a total of 240 returns (38.5%), while the commercial fishery accounted for 384 returns (61.5%) (Table 3). These figures exclude the 253 returns from our tagging cruises. The breakdown between commercial and recreational returns was very close to the breakdown in landings between the two sectors for the previous ten years, 60% commercial and 40% recreational (MAFMC 1990).

The next step in the analysis was to eliminate the immediate recaptures (less than two weeks at liberty), which came mainly from our tagging cruises and a few returns from the recreational fishery operating out of Wachapreague. When these returns were eliminated, the recreational fishery accounted for 35.8% of the returns, and the commercial fishery 64.2% (Table 4).

At Wachapreague, where the recreational fishery was most concentrated (one of the primary species sought is summer flounder), the recreational fishery accounted for 66.5% of the returns (Table 4). The commercial fishery accounted for only 23.4% of the returns from fish tagged there. The recreational fishery accounted for only 16% of the returns from fish tagged in Chesapeake Bay and the coastal nearshore waters. The commercial fishery accounted for 72.2% and 83.7% of the returns from fish tagged in these areas.

C. Migration Patterns

Tag returns were examined by season to analyze patterns of migration (Table 5). Tagging occurred from April to September of each year, therefore, all returns from these months were designated as summer returns. These were fish which had moved to their summer feeding grounds in nearshore or estuarine waters. The recreational fishery accounted for most of the landings (mortality) at this time. The remaining six months were divided into two three month-long periods, October thru December, and January thru March. The separation not only reflects the migration pattern of the fish, but also a change of effort in the commercial trawl fishery. Most boats fish the nearshore waters during October-December and then switch to offshore areas in January-March, searching for species such as black seabass, scup, and squid, in addition to summer flounder.

During the first summer (0-6 months after tagging), most of the returns, 89.1%, were from the respective release areas indicating little, if any, movement (Table 5). Six fish tagged at Wachapreague were recaptured from the ocean, moving northeast from the release area. Two fish tagged at Sandbridge, VA were recaptured south along the VA/NC coast. Five tags were returned with no location data.

During October-December (6-9 months after tagging), fish tagged at Wachapreague were recaptured from two areas (Fig. 2). Eleven fish (45.8%) were recaptured north and offshore of Wachapreague, while four fish (16.7%) were recaptured south along the VA/NC coast. Another eight (33.3%) were returned with no location data. Ninety-four returns (61.8%) from fish tagged in Chesapeake Bay came from the VA/NC coast (nearshore), while seventeen returns (11.2%) came from northern offshore waters (Table 5). Twelve returns (7.9%) were from areas close to the release areas in Chesapeake Bay, and twenty-nine (19.1%) had no location data (Fig. 3). Eleven returns (64.7%) from fish tagged in the

coastal waters south of the Chesapeake Bay mouth came from the VA/NC coastal waters south of the release area (Table 5). Only one return (5.9%) came from the northern offshore waters. Two returns (11.8%) came from the general release area and three (17.6%) were returned with no location data (Fig. 3).

Combining the returns from this time period, 109 (56.5%) were recaptured along the VA/NC coast south of their release areas. Twenty-nine returns (15.0%) came from areas north and offshore of the release areas. Fifteen (7.8%) were taken from the respective release areas and forty (20.7%), were returned with no location data.

During the next season (Jan-Mar), seven returns (31.8%) from fish tagged at Wachapreague were from the north and offshore areas, six returns (27.3%) were from the VA/NC coastal waters, and nine (40.9%) were returned without location data (Fig. 4). The tag returns from the other two areas were very similar (Table 5). Twenty percent were from northern offshore areas, while 36 and 33.3% were from the VA/NC coastal waters. The remaining returns were sent with no location data (Fig. 5).

The tag returns from the following summer (approx. one year at liberty), offer a better picture of the movements of summer flounder tagged in Virginia nearshore waters. Seven returns (29.1%) of fish tagged at Wachapreague were recaptured in waters of New Jersey and north (Table 5). Ten returns (41.7%) came from Wachapreague, and another four (16.7%) were recaptured from other Eastern Shore areas. Two fish (8.3%) were taken in coastal VA/NC waters and one was returned with no location data (Fig. 6). One-half (20) of the returns during this period for fish tagged in Chesapeake Bay came from the Bay (Table 5). Ten (25%) were recaptured from the waters of NJ and one was taken near Ocean City, MD. Four fish (10.0%) were recaptured on Virginia's Eastern Shore, and three (7.5%) were taken along the VA/NC coast (Fig. 7). Two tags (5.0%) were returned with no location data. Only three fish

tagged in the coastal waters of Virginia were recaptured during this time, two from coastal New Jersey and one in Chesapeake Bay.

Decreasing numbers of returns marked the next two seasons, the second fall and second winter after tagging (Table 5). This was due to the high mortality rates that the flounder population was experiencing at the time, there just were not many fish which survived more than one to two years. During the second fall after tagging, five fish (29.4%) were recaptured north and offshore of Virginia, while six (35.3%) were taken along the VA/NC coast (Fig. 8). Another six tags were returned with no location data. A total of seventeen tags were returned during the second winter after tagging. Four (23.5%) were from the northern offshore areas, one (5.9%) from coastal VA/NC, and twelve (70.6%) were returned with no location data.

Figure 10 depicts the general movements of summer flounder from the reported tag returns. A majority of fish tagged in Virginia waters moved out into the ocean and then followed the coast south, to areas east of Cape Hatteras, NC. A smaller number of fish moved east of Virginia to the offshore areas near Norfolk Canyon, and the shelf edge north of there. The two most northern arrows in figure 10 represent a general movement of flounder from Delaware Bay and New Jersey, south and east, reported from previous tagging studies (cited in Scarlett 1981).

D. Stock Composition

In an attempt to delineate stock composition, we tentatively assigned all fish recaptured from areas north of their release area, and those captured in the offshore trawl fishery, to a "northern" or offshore stock. All fish which returned to areas where they were tagged, and those taken in the inshore trawl fishery (along the VA/NC coast), were assigned to a "southern" or coastal stock.

All tag returns were pooled from the information in table 5 (except for immediate recaptures), to form a summary of return locations (Table 6.). Almost 40% of the returns came from the nearshore coastal waters of VA/NC, while 15.8% came from the offshore trawl fishery. Another 5.1% came from coastal waters of Maryland north. Excluding immediate recaptures, 10.9% of the returns came from Virginia waters. Almost 30% of the tags were returned with inadequate location data.

The recapture areas of fish tagged at Wachapreague were divided almost equally between fish moving north (34.1%), and fish recaptured in Virginia, or south along the coast (35.5%) (Table 6). Only 17.6% of the fish tagged in Chesapeake Bay were recaptured north or offshore of Virginia, while 52.1% were taken in Virginia, or south along the coast. A similar pattern was seen for fish tagged along the coast of Virginia. Only 19.1% moved north or offshore, while 54.7% were recaptured in Virginia or along the coast.

Summarizing this data into a preliminary estimate of stock composition for Virginia fish, yields a 21.6% "northern" or offshore component, and a 48.5% "southern" or coastal component (Table 7). A large portion of the returns (29.9%), could not be classified due to inadequate return data. Eliminating the unknown portion for the sake of observation, gives a 30.8% "northern" component, and a 69.2% "southern" component. It must be noted again, that the apparent stock structure was different between fish tagged at Wachapreague, and the other two areas.

E. Length Analysis of Returns

The lengths at tagging of recaptured fish were analyzed to see if there were differences between fish that moved north and offshore of Virginia, and those that returned or were recaptured south along the coast. No apparent differences were noted in relation to the stock composition estimates (Table 8). Fish

affiliated with a "northern stock" were slightly smaller at tagging (340.6 mm) than those of the "southern stock" (354.0 mm). The average size at tagging of fish which were returned with inadequate location data was 354.9 mm. The overall average size at tagging of recaptured fish was 351.7 mm.

Scale samples from recaptured fish will continue to be analyzed as tags are sent in, to determine if there are differences in growth patterns or age-classes between groups. Scale samples from other fish are being analyzed to determine growth patterns in general (male-female), and other age-related parameters. This work will be incorporated in a doctoral dissertation and publication.

Table 3. Total number of tag returns by recapture gear.

	RECAPTURE GEAR			
Tagging Area	Recreational	Commercial	Other	Total
Wachapreague	170	50	43	263
(%)	(64.6)	(19.0)	(16.4)	
Chesapeake Bay				
Cape Charles	22	178	125	325
	(6.8)	(54.8)	(38.4)	
Kiptopeke	22	57	36	115
	(19.1)	(49.6)	(31.3)	
Middle Grounds	17	56	23	96
	(17.7)	(58.3)	(24.0)	
Other Ches. Bay	2	7	-	9
	(22.2)	(77.8)		
TOTAL CHES. BAY	63	298	184	545
	(11.6)	(54.7)	(33.8)	
Virginia Coast	7	36	26	69
	(10.1)	(52.2)	(37.7)	
TOTAL	240	384	253	877
	(27.4)	(43.8)	(28.8)	
w/o research recaptures	240	384	-	624
	(38.5)	(61.5)		

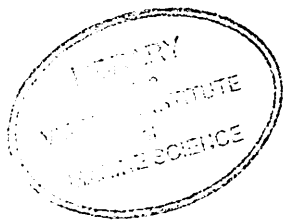

Table 4. Total number of summer flounder tag returns by recapture gear, excluding immediate (less than two weeks) recaptures.

	RECAPTURE GEAR			
Tagging Area	Recreational	Commercial	Other	Total
Wachapreague	139	49	21	209
(%)	(66.5)	(23.4)	(10.1)	
Chesapeake Bay				
Cape Charles	23	177	40	240
	(9.6)	(73.8)	(16.7)	
Kiptopeke	24	56	8	88
	(27.3)	(63.6)	(9.1)	
Middle Grounds	17	56	-	73
	(23.3)	(76.7)		
Other Ches. Bay	2	7	-	9
	(22.2)	(77.8)		
TOTAL CHES. BAY	66	296	48	410
	(16.1)	(72.2)	(11.7)	
Virginia Coast	7	36	-	43
	(16.3)	(83.7)		
TOTAL	212	381	69	662
	(32.0)	(57.6)	(10.4)	
w/o research recaptures	212	381	-	593
	(35.8)	(64.2)		

Table 5. Return locations of fish tagged during 1987-89 as of 9/13/90; does not include immediate recaptures. (Numbers in parantheses are percent totals for each area).

Season:	April-Sept. (0-6 mos)				Oct.-Dec. (6-9 mos)				Jan.-Mar. (9-12 mos)		
Tagging Area	North/ Offshore *	Release Area * *	VA/NC Coast *	Unknown * *	North/ Offshore *	Release Area * *	VA/NC Coast *	Unknown * *	North/ Offshore *	VA/NC Coast *	Unknown *
Wachapreague, VA	6 (7.0)	77 (89.5)	-	3 (3.5)	11 (45.8)	1 (4.2)	4 (16.7)	8 (33.3)	7 (31.8)	6 (27.3)	9 (40.9)
Chesapeake Bay											
Cape Charles	-	9 (81.8)	-	2 (18.2)	11 (11.1)	9 (9.1)	59 (59.6)	20 (20.2)	12 (18.2)	20 (30.3)	34 (51.5)
Kiptopeke	-	11 (100)	-	-	6 (33.3)	2 (11.1)	8 (44.4)	2 (11.1)	10 (30.3)	8 (24.2)	15 (45.5)
Middle Grounds	-	8 (100)	-	-	-	1 (3.3)	22 (73.3)	7 (23.3)	2 (10.5)	8 (42.1)	9 (47.4)
Other Ches. Bay	-	-	-	-	-	-	5 (100)	-	-	-	1 (100)
Total Ches. Bay	-	28 (93.3)	-	2 (6.7)	17 (11.2)	12 (7.9)	94 (61.8)	29 (19.1)	24 (20.2)	36 (30.3)	59 (49.6)
Virginia Coast	-	1 (33.3)	2 (66.7)	-	1 (5.9)	2 (11.8)	11 (64.7)	3 (17.7)	3 (20.0)	5 (33.3)	7 (46.7)
Total	6 (5.0)	106 (89.1)	2 (1.7)	5 (4.2)	29 (15.0)	15 (7.8)	109 (56.5)	40 (20.7)	34 (21.8)	47 (30.1)	75 (48.1)

Table 5 (cont.).

Season:	April-Sept. (10–15 mos)								Oct.-Dec. (16–19 mos)			Jan.-Mar. (20–22 mos)		
	Coastal Areas of:			\				/			/			
Tagging Area	RI/NY *	NJ *	MD *		Wach. *	Other E.Shore *	Ches. Bay *	VA/NC Coast *	Unknown *		North/ Offshore *	VA/NC Coast *	Unknown *	North/ Offshore *	VA/NC Coast *	Unknown *
Wachapreague, VA	2 (8.3)	5 (20.8)	-		10 (41.7)	4 (16.7)	-	2 (8.3)	1 (4.2)		1 (20.0)	1 (20.0)	3 (60.0)	1 (25.0)	-	3 (75.0)
Chesapeake Bay																
Cape Charles	-	2 (11.8)	-		1 (5.9)	-	12 (70.6)	2 (11.8)	-		4 (44.4)	3 (33.3)	2 (22.2)	1 (12.5)	1 (12.5)	6 (75.0)
Kiptopeke	-	5 (55.6)	-		-	-	3 (33.3)	1 (11.1)	-		-	1 (100.0)	-	-	-	1 (100.0)
Middle Grounds	-	3 (27.3)	1 (9.1)		1 (9.1)	2 (18.2)	3 (27.3)	-	1 (9.1)		-	1 (50.0)	1 (50.0)	-	-	2 (100.0)
Other Ches. Bay	-	-	-		-	-	2 (66.7)	-	1 (33.3)		-	-	-	-	-	-
Total Ches. Bay	-	10 (25.0)	1 (2.5)		2 (5.0)	2 (5.0)	20 (50.0)	3 (7.5)	2 (5.0)		4 (33.3)	5 (41.7)	3 (25.0)	1 (9.1)	1 (9.1)	9 (81.8)
Virginia Coast	-	2 (66.7)	-		-	-	1 (33.3)	-	-		-	-	-	2 (100.0)	-	-
Total	3[a] (4.4)	17 (25.0)	1 (1.5)		12 (17.7)	6 (8.8)	21 (30.9)	5 (7.4)	3 (4.4)		5 (29.4)	6 (35.3)	6 (35.3)	4 (23.5)	1 (5.9)	12 (70.6)

a. One return from Fire Island Inlet, NY; tag lost in mail

Table 6. Summary of return locations from October 1987 to September 1990, excluding all immediate recaptures.

	Return Locations									
Tagging Area	RI/NY	NJ	MD	NORTH OFFSH	WACH	OTHER E. SHORE	CB	VA/NC COAST	?	TOTAL
Wachapreague	2	5	-	20	11	4	-	13	24	79
(%)	2.5	6.3		25.3	13.9	5.1		16.5	30.4	
Chesapeake Bay										
Cape Charles	-	2	1	28	1	-	21	85	62	200
		1.0	0.5	14.0	0.5		10.5	42.5	31.0	
Kiptopeke	-	5	1	16	-	-	5	18	18	63
		7.9	1.6	25.4			7.9	28.6	28.6	
Middle Grds	-	3	1	2	1	2	4	31	20	64
		4.7	1.6	3.1	1.6	3.1	6.3	48.4	31.3	
Other C.B.	-	-	-	-	-	-	2	5	2	9
							22.2	55.6	22.2	
TOTAL C.B.	-	10	3	46	2	2	32	139	102	336
		3.0	0.9	13.7	0.6	0.6	9.5	41.4	30.4	
VA. Coast	-	2	-	6	-	-	3	20	11	42
		4.8		14.3			7.1	47.6	26.2	
TOTAL	3[a]	17	3	72	13	6	35	172	136	457
	0.7	3.7	0.7	15.8	2.9	1.3	7.7	37.6	29.8	

a. One tag returned from Fire Island Inlet, NY; tag lost in mail.