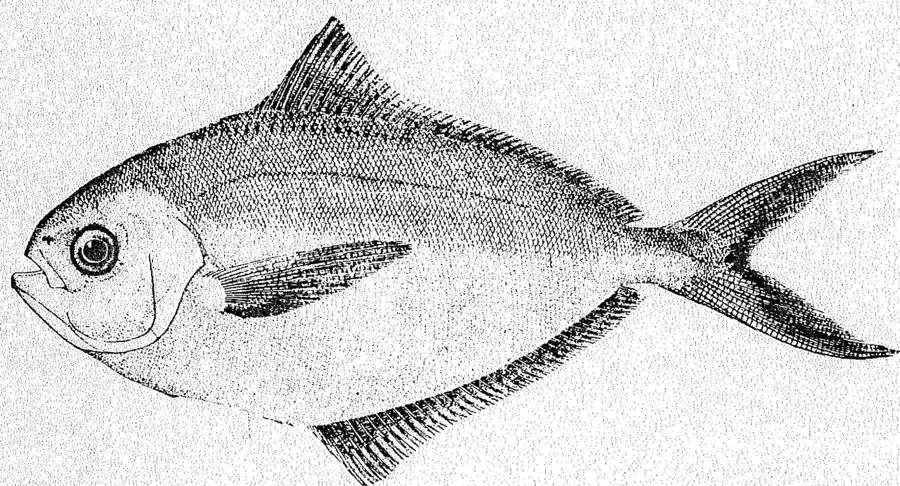

BIOLOGICAL & FISHERIES DATA ON BUTTERFISH, *Peprilus triacanthus* (Peck)

MARCH 1978

Biological and Fisheries Data

on

butterfish, *Peprilus triacanthus* (Peck).

by

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CONTENTS

FIGURES

TABLES

1. IDENTITY

1.1 Nomenclaturee

1.1.1 Valid Name

Peprilus triacanthus (Peck).

1.1.2 Objective Synonomy

Stromateus triacanthus, Peck 1804.

Stromateus cryptosus, Mitchill 1814.

Rhombus cryptosus, Cuv. and Val. 1833.

Peprilus triacanthus, Storer 1839.

Rhombus triacanthus, DeKay 1842.

Poronotus triacanthus, Gill 1861.

Rhombus triacanthus, Jordan and Evermann 1896.

1.2 Taxonomy

1.2.1 Affinities

Suprageneric - Phylum Vertebrata
- Subphylum Craniatae
- Superclass Gnathostomatae
- Series Pisces
- Classe Osteichthyes
- Ordere Perciformes
- Family Stromateidae

Generic - *Peprilus*, Storer 1839.

Haedrich (1967) reported three genera in the family Stromateidae, *Stromateus*, *Pampus*, and *Peprilus*. According to Horn (1970) "Peprilus is distinguished from the other stromateid genera by the combination of: deep body; large eye; long pectoral fin; two to four small spines ahead of the dorsal and anal fins; a ventral spine on the pelvic bone; and, no pelvic fins. Differences also exist among the three genera in meristic values; in the number of epural elements in the caudal skeleton (three in one species of *Stromateus*, and two in all other species); and, in the number of branchiostegal rays (five in *Pampus*, six in the other two genera)."

Specific - Peprilus triacanthus (Peck).

Leim and Scott (1966) offer a synoptic description of the butterfish, as follows: "Body ovate, strongly compressed, greatest depth under first part of dorsal fin, being 2 3/4 in total length; caudal peduncle is small. Head short, 4 3/4 in total length, blunt compressed, profile obtuse; mouth small, terminal, lower jaw projecting, angle of mouth in front of eye, a single series of weak teeth in each jaw. Eye large, 4 in head. Fins: dorsal (1)e III, 45, spines short and weak, the first part of fine increasing in height (to about 1/3 of body depth) ande rapidly falling off to a lower, uniform posterior position, fin originates a little behind base of pectoral and endse on caudal peduncle; caudal large, very deeply forked, itse length 5/7 of greatest depth of body; anal III, 38, spines very short, lying down, the first directed forward, fin narrows evenly from front to rear, not quite as long as dorsal but ending under its tip; pectorals large, length equals 2/3 of greatest body depth, base a little below middle of side and a short distance behind gill opening, fin directed slightly upward; pelvics, none. Scales small, loosely inserted, covering body, part of head and part of dorsal, anal, and caudal fins. Lateral line high on side. A series of well-marked pores under forward part of dorsal fin, well above lateral line." (Figure 1D).

The specific name triacanthus is from the Latin and means "three spines", in reference to the first dorsal spine, the first anal spine, and the spine on the ventral surface of the pelvic bone.

A key to the species of the genus Peprilus, as provided by Horn (1970) is as follows. Proportional measurements are expressed in thousandths of standard length; ranges are followed by the mean, or two different means when there are two species.

1a. Row of about 17 to 25 relatively large pores immediately below anterior half of dorsal fin; premaxillary teeth usually with 3 small cusps..............................2

1b. No rows of pores below anterior half of dorsal fin; premaxillary teeth pointed, simple......................3

2a. Body elongate, shallow to moderately deep 364 to 600 ($\bar{X}$ 458); eye moderately large, 061 to 133 (086); caudal vertebrae 17 to 20, usually 19, rarely 17 or 20; dorsal and upper ventral surface in adults often mottled with dark spots...P. triacanthus.

2b. Body moderately elongate, moderately deep to deep, 460 to 640 ($\bar{X}$ 551); eye large, 065 to 144 (100); caudal vertebrae 16 to 18, usually 17, dorsal or upper ventral surface rarely, if ever, mottled.............................. *P. burti*.

3a. Dorsal and anal fins except in larvae and juveniles smaller than 50 to 75 mm SL moderately to extremely falcate, the longest anal ray six or more times the length of the shortest anal ray; dorsal often slightly less falcate.................................4

3b. Dorsal and anal fins only slightly falcate, the longest dorsal and anal rays less than six times the length of the shortest of each...5

4a. Body ovate, very deep, 565 to 877 ($\bar{X}$ 710); dorsal rays 38-47, usually 41 to 45 (42.9); gill rakers 20 to 23, usually 21 or 22 (21.5); caudal vertebrae 16 to 18, usually 17..*P. paru*

4b. Body moderately elongate, moderately deep to deep, 459 to 618 ($\bar{X}$ 529); dorsal rays 42 to 51, usually 45 to 48 (46.7); gill rakers 23 to 27, usually 24 to 26 (24.7); caudal vertebrae 20 to 22, usually 21................*P. medius*

5a. Body ovate, deep, 542 to 676 ($\bar{X}$ 619); eye moderately large, 078 to 115 (093); snout length considerably less than eye diameter, 052 to 074 (063); dorsal spines 3 or 4, most frequently 4; often a series of irregularly spaced, medium-sized pores visible along dorsal surface; total vertebrae 31 to 33, usually 32 (32.0).........*P. ovatus*

5b. Body elongate, shallow to moderately deep, 371 to 517 ($\bar{X}$ 427, 461); eye small, 050 to 119 (070, 073) snout length about equal to eye diameter, 058 to 083 (068, 070); dorsal spines 2 to 4, usually 3; no series of medium-sized pores usually visible along dorsal surface; total vertebrae 30, 31, or 36.......................................6

6a. Dorsal rays 43 to 49 usually 45 to 48 ($\bar{X}$ 46.5); anal rays 40 to 44 (42.0); caudal vertebrae 21 or 22, usually 21; total vertebrae 36.......................*P. synderi*

6b. Dorsal rays 41 to 48, usually 43 to 47 ($\bar{X}$ 44.8); anal rays 35 to 44, usually 38 to 41 (39.5); caudal vertebrae 17 or 18, usually 17; total vertebrae 30 or 31...*P. simillimus*

1.2.2 Taxonomic Status

Horn (1970) and Caldwell (1961) have postulated the existence of depth isolated populations of butterfish along the Atlantic coast. Caldwell proposes one population, south of Cape Hatteras, distributed to 12 fathoms, and another group of fish, distributed north of Cape Hatteras, and in all Atlantic waters 13 fathoms or deeper. Horn examined specimens from both localities and concluded there was some genetic exchange between populations, but not enough to group them as a single stock.

Caldwell (1961) considers the two Atlantic populations, in conjunction with the *P. burti* form in the Gulf of Mexico, to be components of the total stock of *P. triacanthus* (a polymorphic species). He postulates that the inshore, southern Atlantic form is an intermediate between the other two populations, and acts as a genetic link. Horn (1970) believes that *P. burti* is a separate species and sites a number of morphometric and meristic characters to justify his conclusion.

1.2.3 Subspecies

See 1.2.2.

1.2.4 Standard Common Names, Vernacular Names

Butterfish is the common name recognized by the American Fisheries Society (Bailey et al., 1970). Vernacular names include harvest-fish, dollarfish, sheepshead, skipjack, pumpkinseed, starfish, lafayette, cryptous broad shiner, and short-finned harvestfish.

1.3 Morphologye

1.3.1 External Morphology

General characteristics of the external morphology of the butterfish are summarized in section 1.2.1 and Figure 1.

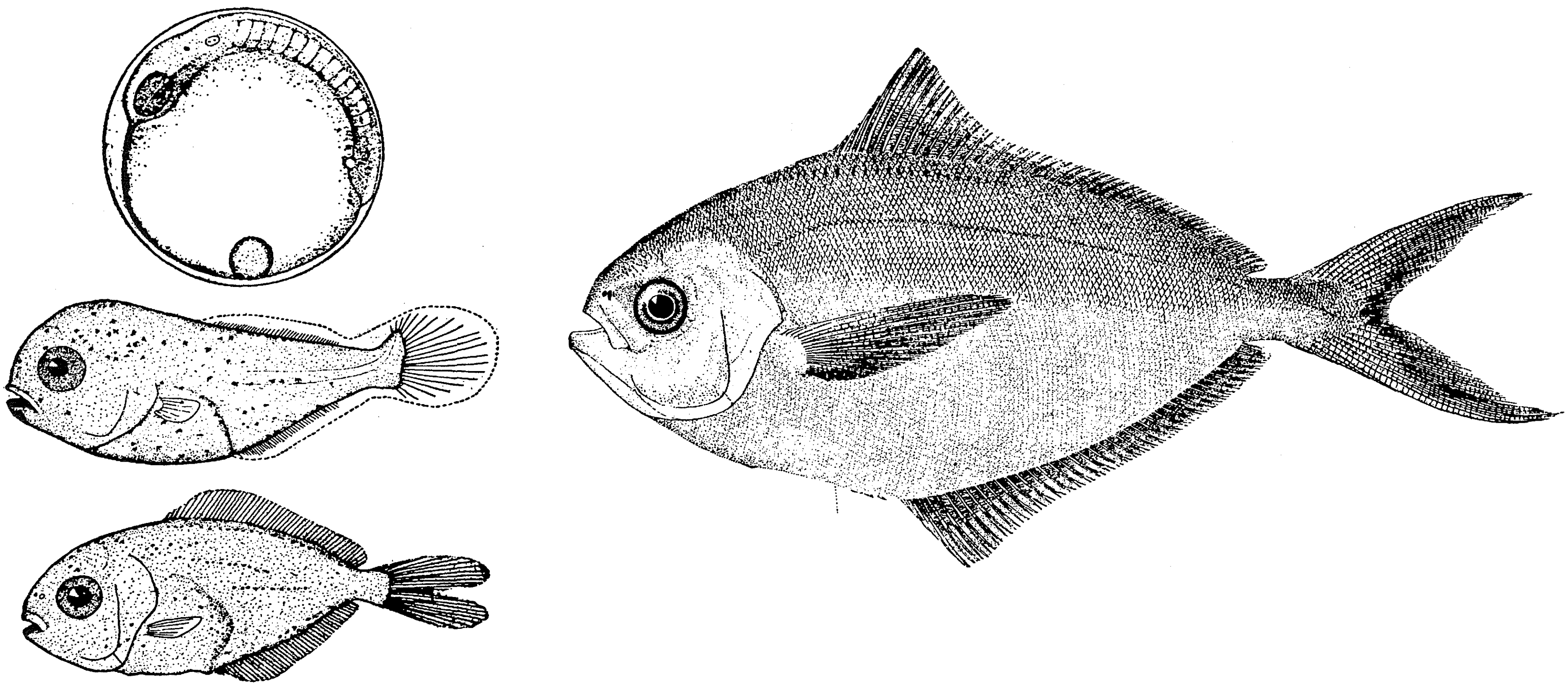

Figure 1. Life history stages of the butterfish, P. triacanthus; A - egg, B - larva 6 mm, C - fry 15 mm, D - adult, (adapted from Bigelow and Schroeder 1953).

Horn (1970) reports the following meristic values:

Character	$\bar{X}$	Range
Dorsal fin-rays*	44.3	40-48a
Anal fin-rays*	40.3	37-44a
Pectoral fin-rays	20.7	17-22a
Total gill rakers	23.8	22-25a
Total vertebrae	31.7a	30-33a
Lateral-line scales	-	96-105a

*Excluding spinesa

Morphometric data presented by Horn (1970), expressed in thousandths of SL are:

Character	$\bar{X}$	Range
Head length	289	251-358a
Snout length	071	055-090a
Eye diameter	086	061-133a
Length of upper jaw	085	064-113a
Interorbital width	092	072-111a
Length of pectoral fin	312	179-364a
Predorsal distance I	381	332-492a
Predorsal distance II	278	228-407a
Preanal distance	445	375-544a
Maximum depth of body	458	364-600a
Least depth of caudal peduncle	070	055-089a

Information on geographic variation is included in section 1.2.2.

1.3.2 Cytomorphologya

No data found.

1.3.3 Protein Specificity

No data found.

2.e DISTRIBUTIONe

2.1 Total Areae

Bigelow and Schroeder (1953) report the range on the Atlantic coast, of the butterfish, as being from South Carolina to Nova Scotia and Cape Breton. This species has been found in deeper offshore waters from Cape Hatteras and Florida (Nichols and Breder, 1927). Infrequent occurrences of butterfish have been reported as far north as Prince Edward Island (Needler, 1938).

2.2 Differential Distribution

2.2.1 Spawn, Larvae, and Juveniles

Spawning occurs a few miles out to sea, and spent individuals return to inshore waters afterwards (Bigelow and Schroeder, 1953).

After hatching, young *Peprilus* move from pelagic surface waters to bays and other protected inshore nursery areas (Horn, 197). The inshore movement of butterfish coincides with that of certain species of coelenterates with which the young fish associate (Mansueti, 1963; Horn, 1970; Leim and Scott, 1966; Bigelow and Schroeder, 1953). Advantages to the young butterfish in association with scyphomedusae and siphonophores include a source of food, protection from predation, and reduced interspecific competition (Horn, 1970). This relationship is not species specific as young *P. triacanthus* have been found with *Chrysaora, Stomolophus, Physalia,* and *Cyanea,* including *C. artica* (Horn, 1970. The association discontinues as the butterfish grow (to about 100 mm SL) and move to deeper waters in winter. Commensal relations with coelenterates are not essential to the fish as juveniles have been observed swimming freely at the surface (Bigelow and Schroeder, 1953).

2.2.2 Adults

Butterfish north of Cape Hatteras display definite migratory patterns in response to water temperatures and have developed seasonal migrations similar to Atlantic mackerel, *Scomber scombrus,* scup, *Stenotomus chrysops,* weakfish, *Cynoscion regalis,* (Horn, 1970), and the long finned squid, *Loligo pealei* (Waring, 1975). Horn (1970), Waring (1975) and Fritz (1965) concluded on the basis of distribution of survey catches that summer movements of butterfish are both inshore and northward.

The winter distribution of *P. triacanthus*, in the Middle Atlantic area, appears to be in water 100-115 fathoms deep, at the edge of the continental shelf (Horn, 1970; Bigelow and Schroeder, 1953) (Figure 2A). South of the New York Bight, from New Jersey to Chesapeake Bay, butterfish winter along the 100 fathom contour (Heald, 1968). As the season progresses, fish move northward (Figures 2B, C) and into more shoal waters. Bigelow and Schroeder (1953) describe the butterfish as a regular summer visitor to the Gulf of Maine, appearing off Rhode Island by the end of April, and at Woods Hole by the middle of May. Catches in the surf waters of Long Island (Schaefer, 1967) begin in June and end in September-October. South of Cape Hatteras there is no strong inshore/offshore migration (Caldwell, 1961; Horn, 1970).

2.3 Determinants of Distribution Changes

Water temperature is probably the most significant factor affecting the distribution of the butterfish (Horn, 1970). However, this species has been found in bottom waters ranging from 4.4° to 20.6°C (Fritz, 1965; Horn, 1970), and in shoal waters as warm as 21.6°C (Schaefer, 1967).

The butterfish is euryhaline, as are other members of the genus *Peprilus* (Horn, 1970), but the effect of salinity on its distribution is not known.

Bottom type may also be a factor influencing distributional patterns. Bigelow and Schroeder (1953) indicate butterfish have a decided preference for sandy, rather than rocky or muddy bottoms, and Leim and Scott (1966) state that small schools frequent sandy bottoms in summer and fall. In the southern portion of the Atlantic, *P. triacanthus* is represented by two populations, a deep water form distributed over mud bottoms, and an inshore component which prefers sandy substrates (Caldwell, 1961).

2.4 Hybridization

No data found.

3.o BIONOMICS AND LIFE HISTORYo

3.1 Reproductiono

3.1.1 Sexuality

The butterfish is heterosexual and no reference to hermaphroditism appears in the literature. Horn (1970) states that dimorphism of mature fish is limited to the distention of the abdomen in ripe females.

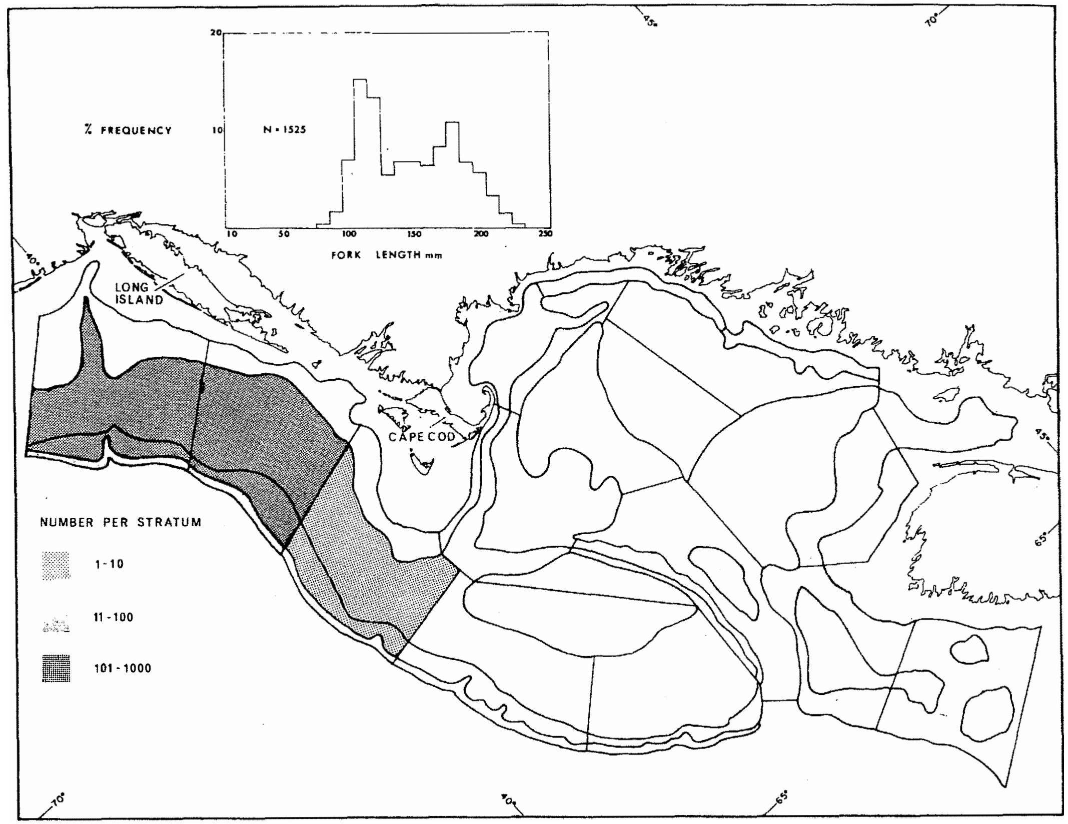

Figure 2A. Winter (January and February) distribution of butterfish off the northeast coast of the United States. Numbers of fish per stratum is the cumulative NMFS research survey catch per stratum from 1964-1966 (from Horn, 1970).

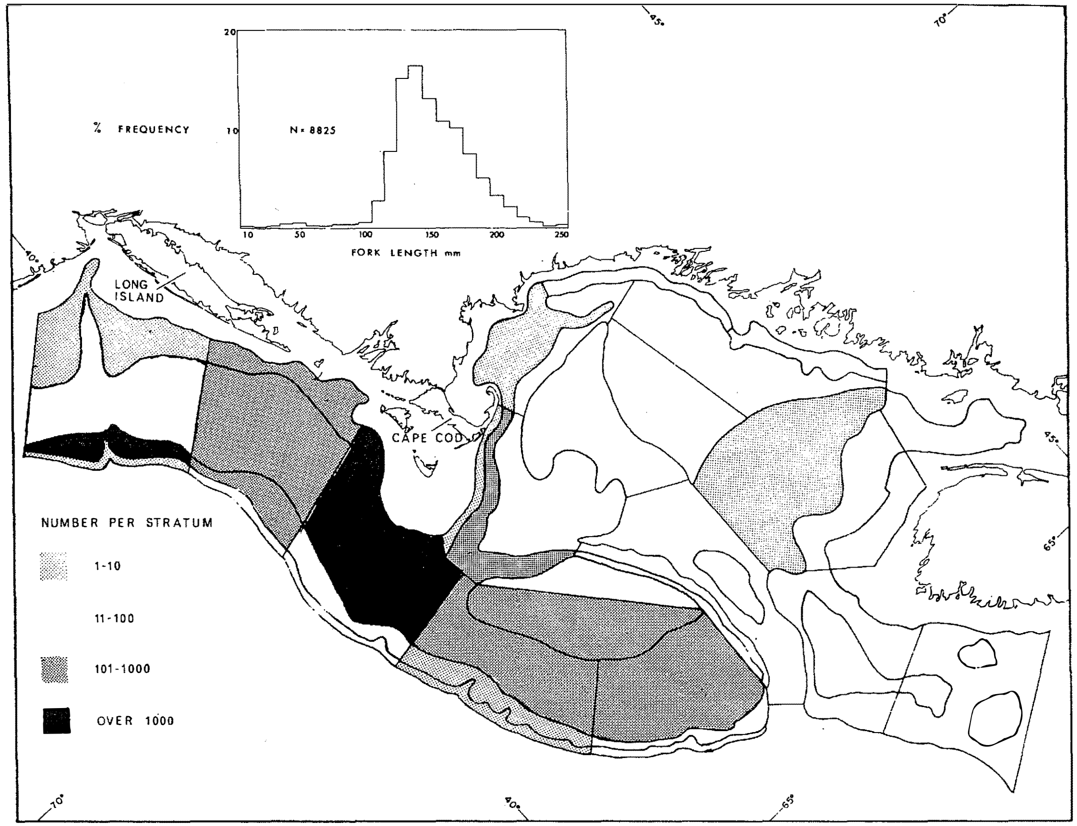

Figure 2B. Summer (July and August) distribution of butterfish off the northeast coast of the United States (1963-1965; from Horn 1970).

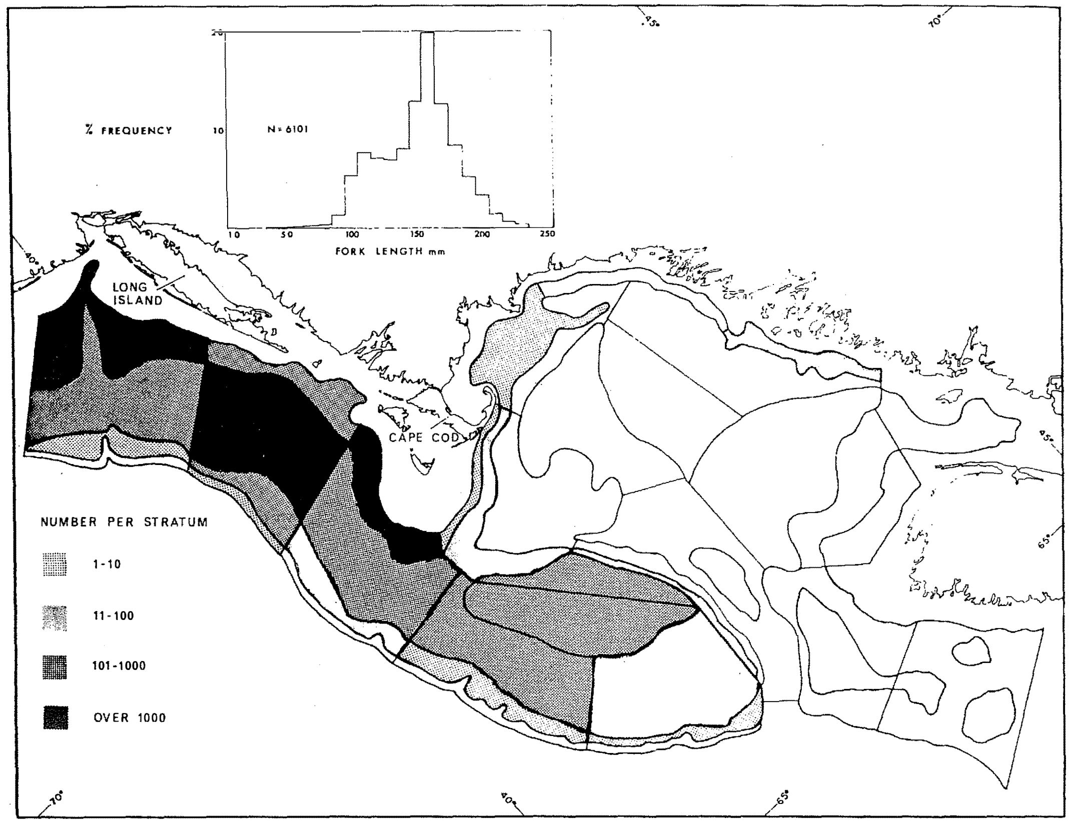

Figure 2C. Autumn (October, November, and early December) distribution of butterfish off the northeast coast of the United States (1963-1965; Horn 1970).

3.1.2 Maturity

Butterfish are probably fully recruited into the spawning population when two years old and 180 mm (SL) in length. Horn (1970) examined nearly ripe individuals as small as 120 mm (SL), but states that maturation generally occurs from 140-180 mm. DuPaul and McEachran (1973) report that butterfish are fully recruited in their second summer, as 37 of 56 age I fish examined were maturing, and all age II fish were in spent or resting condition.

3.1.3 Mating

Horn (1970) suggests that aggregations of mature fish, with little courtship activity, massively extrude reproductive products into the water, however, no direct observations of spawning have been reported.

3.d.4 Fertilizatione

Fertilization of butterfish eggs is external.

3.1.5 Gonads

No data found.

3.1.6 Spawning

Number of spawnings per year: Butterfish spawn only one time per year.

Spawning seasons: In Chesapeake Bay, ripe fish are reported as early as May 26, with major months of spawning being June and July (Hildebrand and Schroeder, 1928; Pearson, 1941). Spawning in the Gulf of Maine begins in June with reproduction peaking in July and subsiding in August (Bigelow and Schroeder, 1953). Seasonal gonadosomatic indices are unimodal, peaking in June (Wilk et al., 1975; Kawahara, 1977).

Spawning time of day: No data found.

Sequence of spawning of individuals in a population: No data found.

Factors influencing spawning time: Temperature appears to be the major factor affecting spawning time, as spawning is progressively later in more northern latitudes.

Relation of time of breeding to that of related and/or associated species: No data found.

Location and type of spawning grounds: See 2.2.1 and 3.1.6.

Variation and causes of variation of spawning grounds: No data found.

Nature of mating act: See 3.1.3.

Variation in mating behavior: No data found.

Nesting habits: Butterfish do not produce nests.

Reproductive isolation: See 1.2.2.

Induction of spawning: No data found.

3.1.7 Spawn

Fertilized eggs are buoyant, transparent, and 0.7 to 0.8 mm in diameter. A single oil globule of 0.17 to 0.2 mm is present in advanced egg stages (Bigelow and Schroeder, 1953) (Figure 1A).

3.2 Pre-Adult Phase

3.2.1 Embryonic Phase

Colton and Honey (1963) fertilized butterfish eggs and noted the development of eggs and larvae. The average temperature in their hatching jars was 14.6°C with a range from 13.3 to 16.8°C. Their description of embryonic development is as follows: "As development advances (these) separate oil globules coalesced into one, but a few eggs had several oil globules at the time of hatching. Twenty four hours after fertilization the formation of the blastodermal cap was completed. Forty eight hours after fertilization the blastopore was closed or was closing and the eye became differentiated.

Fifty six hours after fertilization the tail had formed, and light, scattered pigment appeared on the oil globule and on the dorsum of the embryo from an area just posterior to the eyes and extended in two rows to the end of the tail. Seventy two hours after fertilization approximately 50 per cent of the eggs had hatched."

Parasites and predators: No data found.

Rates of development: Incubation is complete in less than 48 hours at temperatures of 65°-72°F (Nichols and Breder, 1927).

3.2.2 Larval Phase

General patterns of development: Colton and Honey (1963) state that newly hatched larvae averaged 1.72 mm in length, ranging from 1.68 to 1.75 mm. Pigmentation was similar, but more pronounced than that of the 56 hour embryo.

Growth in the 24 hour period following hatching was considerable; the average length of the 24 hour larvae was 2.27 mm (2.14 to 2.44 mm).

One hundred forty four hours after hatching the average length of larvae was 2.57 mm. The eyes were almost completely pigmented and the pectoral fins well developed. In most larvae at this stage, the oil globule was completely absorbed.

3.2.3 Adolescent Phase

Young butterfish assume the characteristic shape of adults early in their development (Figure 1C). For further discussion of the adolescent phase see 2.2.1.

3.3 Adult Phase

3.3.1 Longevity

Average life expectancy: Average life expectancy appears to be related to fishing intensity. Since fishing pressure has increased with the advent of distant water fleet trawling, mean weight of fish in the population has decreased. DuPaul and McEachran (1973) and Waring (1975) found that most butterfish were one or two years old, from the York River, Virginia and southern New England waters. Kawahara's (1977) results indicate the population in ICNAF S.A. 5-6 is composed mostly of 0+ and 1+ individuals. However, under natural conditions (without heavy fishing pressure) the average life expectancy is probably greater.

Maximum age: The maximum reported age of butterfish is six years (Draganik and Zukowski, 1966), however, DuPaul and McEachran (1973), Waring (1975) and Kawahara (1977) reported the maximum age as 3+.

3.3.2 Hardiness

See 2.3.

3.3.3 Competitors

No data found.

3.3.4 Predators

Butterfish provide a substantial part of the diet of a number of commercially important finfish including haddock (*Melanogrammus aeglefinus*), and silver hake (*Merluccius bilinearis*) (Horn, 1970). Bigelow and Schroeder (1953) report that swordfish (*Xiphias gladius*), bluefish (*Pomatomus saltatrix*) and weakfish are also major predators.

3.3.5 Parasites and Diseases

Pathological conditions affecting butterfish include infections by the monogenetic trematode, *Microcotyle poronoti*, and the digenetic trematode, *Lepidapedon elongatum* (National Marine Fisheries Service, 1976).

3.4 Nutrition and Growth

3.4.1 Feeding

Time of day: No data found.

Place, general area: Butterfish feed throughout their area of distribution.

Manner of feeding: Butterfish are apparently pelagic feeders, as their food items tend to be nektonic or planktonic organisms (see 3.4.2).

Frequency: No data found.

Variation in feeding habits: No data found.

3.4.2 Food

Types eaten: Horn (1970) reports that young butterfish (24-41 mm SL) feed primarily on jellyfish. Stomach contents, examined by Haedrich (1967), were primarily jellyfish, ctenophores, and salps. Hildebrand and Schroeder (1928) found fine, flocculent substances, cycloid scales, mollusk shells, and strands of algae in specimens they analyzed. The diet of adult *P. triacanthus* is known to include small fish, squid, crustacea such as amphipods, copepods and shrimp, and annelid worms (Bigelow and Schroeder, 1953; Leim and Scott, 1966; Nichols and Breder, 1927). Maurer and Bowman (1975) found stomachs to contain tunicates, crustaceans, chaetognaths, and polychaetes.

3.4.3 Growth Rate

DuPaul and McEachran (1973) back-calculated lengths, using otoliths, of butterfish from the York River, Virginia (Table 1). The mean lengths at capture they observed were; age 0-93 mm (FL), I-119 mm, II-169 mm, III-185 mm.

Kawahara's (1977) back-calculated lengths at age (sexes combined) are also listed in Table 1.

Waring (1975) reports the observed mean length at age for butterfish from southern New England waters as; age I-123 mm (FL), II-169 mm, III-188 mm, IV-186 mm.

Von Bertalanffy growth functions determined by Kawahara (1977) are:

males: $l_t = 226.5\ (1-e^{-0.5784(t+0.3963)})^a$

females: $l_t = 206.7\ (1-e^{-0.9747(t-0.0158)})^a$

sexes combined: $l_t = 210.2\ (1-e^{-0.8618(t+0.0699)})^a$

Condition factors: No data found.

Relation of growth to feeding, spawning, etc.: No data found.

Food-growth relations: No data found.

3.4.4 Metabolism

No data found.

3.5 Behavior

3.5.1 Migrations and Local Movements

See 2.2.2 and 2.3.

TABLE 1. Back-calculated fork lengths of butterfish in the lower York River in the fall of 1969 and from ICNAF S.A. 5-6 (from DuPaul and McEachran, 1973 and Kawahara, 1977).

YORK RIVER

Age Group	# Fish	Mean back-calculated lengths (mm) of age groups I	II	III
I	56	90	--	--
II	53	98	142	--
III	10	103	137	165

ICNAF S.A. 5-6

Age Group	# Fish	Mean back-calculated lengths (mm)I of age groups I	II	III
I	1,274	128	--	--
II	341	122	176	--
III	40	119	169	195

3.5.2 Schooling

Extent: Butterfish are a schooling fish, but schooling of adults by sex or age has not been demonstrated. Young fish may form aggregations in association with coelenterates.

Mixing of stocks within species: No data found.

Mixing between species: Horn (1970) presents the following table which lists the ten fish species most regularly collected with butterfish in groundfish surveys off the northeast coast of the United States between the Gulf of Maine and Hudson Canyon:

Species	Summer	Fall	Winter
Spiny dogfish	X	X	X
Little skate	X	X	
Haddock	X	X	
Silver hake	X	X	X
Squirrel hake	X	X	X
Alewife	X		
Yellowtail flounder	X	X	
Winter flounder		X	
Fourspot flounder		X	X
Longhorn sculpin		X	

Butterfish and squid are often found together and much of the distant water fleet catch of butterfish is taken as by-catch in the directed squid (*Loligo* and *Illex*) fisheries (López-Veiga and Labarta, 1975; Nagasaki, 1976).

Patterns of schools: No data found.

Vertical movements: Butterfish apparently congregate near the bottom during daylight, as daytime otter trawl catches were much greater than night catches in US and USSR surveys (Waring, 1975).

Size, density, and behavior of schools: No data found.

3.5.3 Responses to Stimuli

No data found.

4.e POPULATIONe

4.1 Structuree

4.1.1 Sex Ratio

The sex ratio of samples aged by DuPaul and McEachran (1973), taken in the fall, in the York River, Virginia was 1.05:1.00 (males:females).

4.1.2 Age Composition

Japanese first quarter length and age frequencies from 1970-1976 are presented in Figure 3. The age distribution of the catch remained stable from 1970-1972, with 1+ individuals dominating the catch. A considerable proportion of the landings in 1973 were of those fish spawned the previous summer. From 1974-1976 age 0+ and 1+ fish were essentially co-dominant in the samples. Thus, a trend of decreasing age at recruitment is notable since 1970 (Murawski and Waring, 1977). Length frequency distributions correlate well with aged samples (DuPaul and McEachran, 1973). Frequency distributions are generally bimodal (Schaefer, 1967; Horn, 1970; Waring, 1975; DuPaul and McEachran, 1973).

4.1.3 Size Composition

Length composition of the population: See 4.1.2 and size at first capture.

Length composition of the catch: See 4.1.2 and size at first capture.

Size at first capture: Generally the size at first capture varies with the type and mesh size of gear used. The smallest individuals landed in the United States food fishery are 12 cm (FL) and in the domestic industrial fishery, 8 cm. Japanese length frequencies indicate butterfish are selected as small as 5 cm. Surveys by US and USSR research vessels indicate the exploitable population is comprised of individuals from 3 to 30 cm (Waring, 1975; Murawski and Waring, 1977).e

Size at maturity: See 3.1.2.

Maximum size: The maximum length of butterfish recorded in length frequency analyses is 30 cm (FL) (Murawski and Waring, 1977) (Figure 3). The relationships between fork length and total length (mm) is:

$$TL = -6.32156 + 1.2379\ FL$$

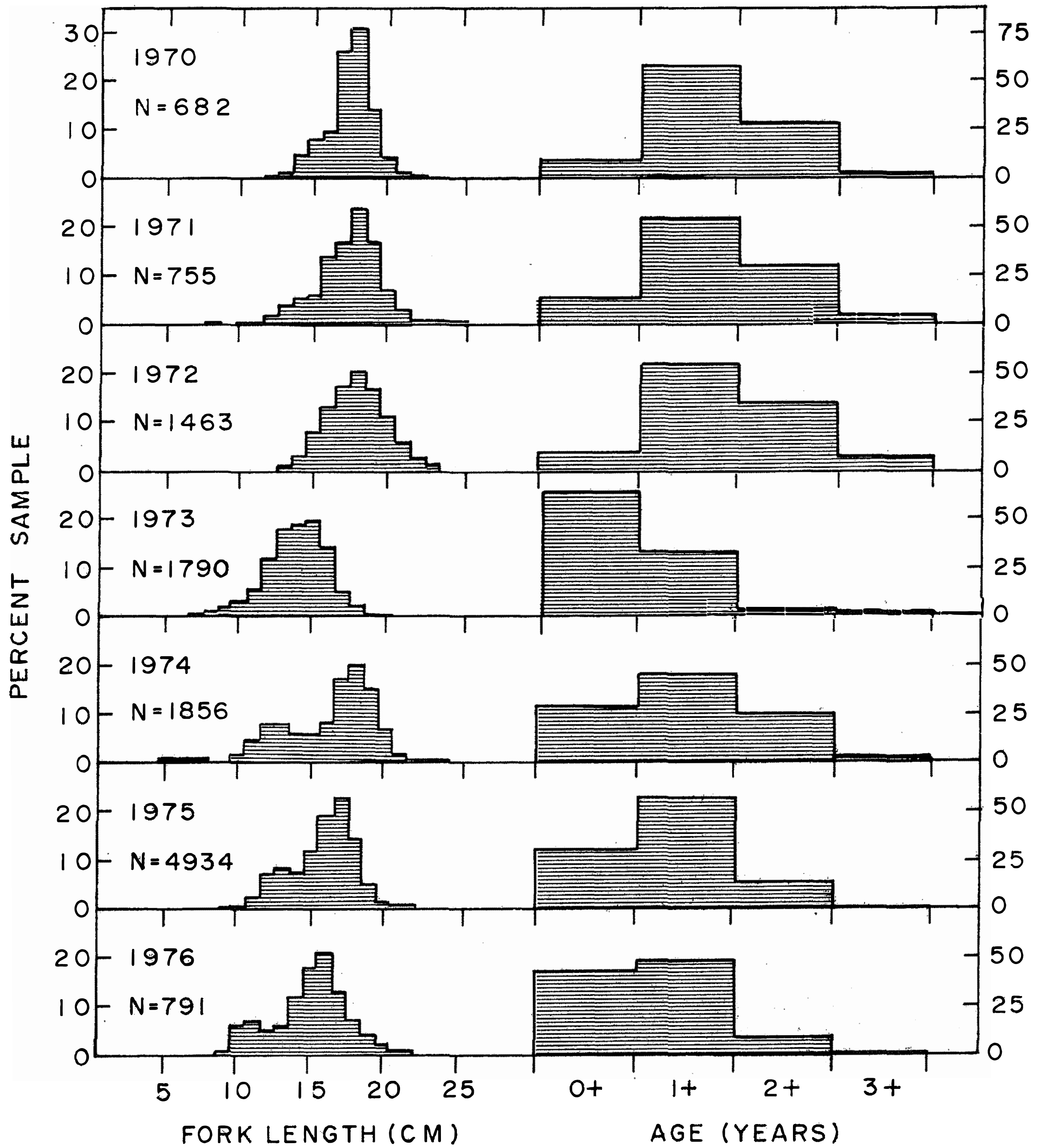

Figure 3. Length and age composition of Japanese first-quarter butterfish samples, 1970-1976 (Murawski and Waring, 1977).

Density of size groups: No data found.

Length/weight relationship: The overall length/weight equation for southern New England fish (Waring, 1975) using fork length and total weight is:

$$\log W = -5.8848 + 3.5768 \log L$$

Length/weight relationships for York River butterfish (DuPaul and McEachran, 1973), utilizing FL and TW are:

females: $\log W = -5.4177 + 3.3696 \log L$

males: $\log W = -4.9820 + 3.1773 \log L$

4.2 Abundance and Density

Murawski and Waring (1977) calculated the annual abundance of butterfish off the northwest Atlantic coast for the period 1968-1976, by virtual population analysis. Estimates of initial population size, assuming a natural mortality coefficient (M) of 0.8, ranged from 31,896 MT (1976) to 70,631 MT (1973), averaging 53,571 MT. Biomass estimates from expanded catch per tow data averaged 61,360 MT from 1969-1973 (Waring, 1975).

4.3 Natality and Recruitment

4.3.1 Reproduction Rates

No data found.

4.3.2 Factors Affecting Production

No data found.

4.3.3 Recruitment

McHugh (1972) postulates, on the basis of historical catch statistics, that butterfish may vary widely in abundance due to natural factors. Waring (1975) reviewed the relative year class strengths of young-of-year fish from Albatross IV and USSR autumn surveys, 1968-1974, and concluded the 1971 year class was the most abundant.

4.4 Mortality and Morbidity

4.4.1 Mortality Rates

Estimates of the total instantaneous mortality coefficient (Z)a for cohorts from 1968-1975 ranged from 1.1 (1968) toa 2.5 (1974) (Murawski and Waring, 1977). Fishing mortalitya rates calculated from virtual population analysis (VPA) increaseda dramatically from 0.213 (1968) to 0.872 (1974). Comparisons of population size estimates from areal expansion of survey data and results of the VPA indicate that M is probably at least 0.8 (Murawski and Waring, 1977).

4.4.2 Factors Causing or Affecting Mortality

See 3.3.4 and 4.1.2.

4.4.3 Factors Affecting Morbidity

No data found.

4.4.4 Relation of Morbidity to Mortality Rates

No data found.

4.5 Population Dynamics

Biostatistical data reviewed by Murawski and Waring (1977) indicated that during the period 1968-1976, fishing mortality rates increased (as did landings and associated by-catch), while mean weight of individuals in the exploitable population and average age at capture decreased. Exploitation rates (E) during 1972-1975 ranged from 0.35-0.42. Yield per recruit studies (M=0.8; Figure 4) resulted in F_{max} and $F_{0.1}$ values of 0.71 anda 0.47 for a 30 mm mesh net, and 1.33 and 0.69 for a 60 mm one. Catches resulting from the average annual recruitment are 14,540 MT (30 mm mesh) and 18,945 MT (60 mm mesh) assuming $F_{0.1}$.a

4.6 The Population in the Community and the Ecosystem

See 3.5.2.

5.a EXPLOITATIONa

5.1 Fishing Equipmenta

Table 2 summarizes the domestic landings of butterfish, by gear type, in 1952 and 1972. Otter trawls have accounted for a relatively constant percentage of the landings (about 44%).

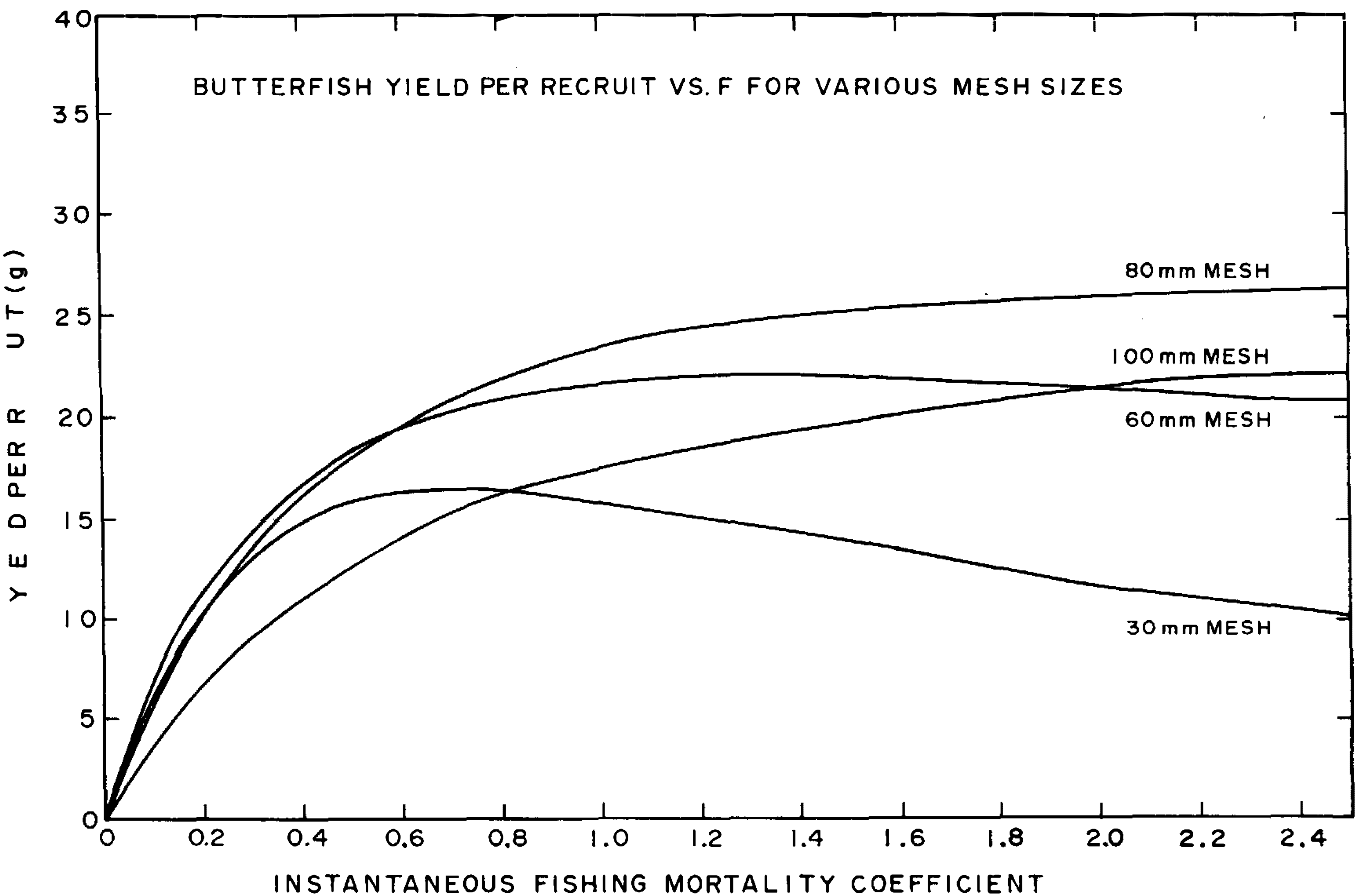

Figure. 4. Yield per recruit of butterfish with various mesh sizes (M=0.8) (Murawski and Waring, 1977).

TABLE 2. Percent domestic landings of butterfish by gear type, in 1952 and 1972.

1952 % Catch	Gear Type	1972 % Catch
42.86	Otter trawl	44.77
52.16	Pound net	30.50
.01	Purse seine	21.43
.57	Haul seine	2.17
.08	Gill net	.98
.01	Dredge	.10
.05	Handline	.05
4.28	Floating trap	.00

The pound net fishery has shown the greatest fluctuation in percent of the catch. In 1952 pound net fisheries in Massachusetts, Connecticut, New York, New Jersey, Maryland, Virginia and North Carolina accounted for 52.16% of the fish taken; in 1972 pound net fisheries in Massachusetts, New York, New Jersey, Virginia and North Carolina accounted for only 30.5% of the total.

Fixed gear types (pound nets, traps) and seines are most effective for butterfish during the spring and summer months when this species is inshore and migrating northward. However, trawl fisheries operate throughout the year. Butterfish are particularly vulnerable to trawling in the winter and early spring when they are concentrated in deep waters at the edge of the continental shelf.

There is no significant sport fishery for butterfish, although a small amount (<1%) of the United States commercial landings are on hand line gear.

Butterfish are part of a mixed trawl fishery, with industrial and food fish components, and are taken with squid, scup, flounders, skates and red hake (Waring, 1975). A significant pound net fishery for *P. triacanthus* exists in the mid-Atlantic states, however, landings from this fishery have decreased since the early 1950's (June, 1956).

5.2 Fishing Areas

See 5.1, 5.4 and Tables 3-7.

5.3 Fishing Seasons

See 5.1.

5.4 Fishing Operations and Results

5.4.1 Effort and Intensity

Fishing effort directed at butterfish has increased as the result of foreign activities and is reflected in the catch statistics (5.4.3).

5.4.2 Selectivity

Meyer and Merriner (1976) examined the selection properties of various mesh sizes used in pound-net heads. Selectivity relationships were derived from theoretical and empirical data (Table 3).

TABLE 3. Fifty percent retention lengths and selection factors derived for butterfish from experimental data plus theoretical 50% retention lengths and selection factors computed from regressions (NDe= no data available) (from Meyer and Merriner, 1976).

Advertised Stretched Mesh Size (mm)	Conditioned Stretched Mesh Size (mm)	Experimental 50% retention Length (FL, mm)	Experimental Selection Factors	Theoretical 50% retention Length (FL, mm)	Theoretical Selection Factors
51	50.1e	ND	ND	106	2.1
57	53.4	ND	ND	115	2.2
64	61.4	107	1.7e	125	2.0
70	68.3	124	1.8	139	2.0
76	75.1	135	1.8	154	2.1

TABLE 4. Annual landings (metric tons) of butterfish by ICNAF member countries.

		4	5Y	$5Z_e$	$5Z_w$	6A	6B	6C	6NK	Total
1963	USA		74	2,464	166				1,809	4,513
	USSR	285	110	1,779	-	5NK			111	2,285
	Total	285	184	4,243	166				1,920	6,798
1964	USA		27	946					1,588	2,461
	USSR	263	-	169					316	748
	Total	263	27	1,115					1,904	3,209
1965	USA		37	1,025					2,270	3,340
	USSR		-	732					17	749
	Total		37	1,757					2,295	4,089
					5Z combined					
1966	USA		52	553					2,010	2,615
	USSR		-	3,865					-	3,865
	Total		52	4,418					2,010	6,480
1967	USA		44	751					1,657	2,452
	USSR		-	1,406					764	2,170
	Japan			1					144	145
	Total		44	2,158					2,565	4,767
1968	USA	4	37	27	611	10			1,119	1,808
	USSR	-	-	648	948	-			315	1,911
	Japan				328				3,198	3,526
	Total	4	37	675	1,887	10			4,632	7,245
1969	USA	-	33	74	637	60	-	-	1,634	2,438
	USSR	15	-	702	8,777	183	749	681	-	11,107
	Japan				1,921				2,010	3,931
	Bulgaria			36						36
	Total	15	33	812	11,335	243	749	681	3,644	17,512

TABLE 4. (continued)

		41	5Y	$5Z_e$	$5Z_{wl}$	6A	6B	6C	6NK	Total
1970	USA	–	20	17	354	25	–	–	1,453	1,869
	USSR	3	–	70	326	8	–	–	–	407
	Japan	–	–	846	877	2,142	3,680	1,076	–	8,621
	Total	3	20	933	1,557	2,175	3,680	1,076	1,453	10,897
1971	USA	–	24	8	387	103	–	–	1,048	1,570
	USSR	3	–	61	232	72	14	–	–	382
	Japan	–	–	550	423	1,215	3,075	505	–	5,771
	Bulgaria	–	–	1	–	9	16	–	–	26
	Total	3	24	620	1,042	1,399	3,105	505	1,048	7,749
1972	USA		24	2	97	102	–	–	594	819
	USSR		83	138	214	1,160	246	7	–	1,848
	Japanl		–	1,107	289	1,198	989	78	–	3,661
	Bulgaria		–	43	53	18	–	–	–	114
	GDR		–	10	–	10	14	–	–	34
	Total		107	1,300	653	2,488	1,249	85	594	6,476
1973	USA		1	5	508	171	–	–	872	1,557
	USSR		–	500	852	927	47	6	–	2,334
	Japan		–	610	1,680	7,773	1,997	112	–	12,172
	Bulgaria		–	82	124	18	15	–	–	239
	GDR		–	–	190	–	6	–	–	196
	Romania		–	30	26	16	80	–	–	152
	Poland		81	2,354	155	214	–	–	–	2,804
	Total		82	3,581	3,535	9,121	2,145	118	872	19,454
1974	USA		4	18	1,432	637	417	81	13	2,528
	USSR			439	508	320	104	1		1,372
	Japan	3	2	1,202	2,596	1,403	207	44		5,457
	Bulgaria									
	GDR									
	Romania									
	Poland		47	1,365	88	1,061	947			3,508
	Total	3	52	3,034	4,636	3,444	1,680	56	13	12,865

TABLE 5. New England historical catch statistics for butterfish, 1879-1965 (from Lyles, 1967).

Year	ME	NH	MA	RI	CT	TOTAL
			(Thousands of Pounds)			
1879	(1)	-	5	(1)	(1)	(1)
1880	(1)	-	(1)	(1)	(1)9	(1)
1887	5	-	504	2669	24	799
1888	(1)	-	513	2839	38	(1)
1889	27	-	763	2679	42	1,099
1892	(1)	0	(1)	(1)9	(1)9	(1)
1896	(1)	-	(1)	(1)	(1)	(1)
1897	(1)	-	(1)	(1)9	(1)9	(1)
1898	15	-	31	2079	60	313
1902	8	-	106	3639	67	544
1905	6	-	83	3419	21	451
1908	6	-	67	1,112	102	1,287
1919	33	-	297	758	19	1,107
1924	12	-	378	685	6	1,081
1928	25	-	580	930	14	1,549
1929	53	-	800	1,226	30	2,109
1930	112	-	855	901	37	1,905
1931	104	-	733	753	19	1,609
1932	147	-	1,452	646	17	2,262
1933	99	-	952	487	16	1,554
1935	26	-	1,479	735	54	2,294
1937	10	-	2,250	571	39	2,870
1938	18	-	1,226	446	190	1,880
1939	51	-	2,117	618	383	3,169
1940	68	-	1,823	486	99	2,476
1942	12	-	975	208	36	1,231
1943	1	-	434	148	516	1,099
1944	-	-	207	92	230	529
1945	-	-	574	223	164	961
1946	-	(1)	2799	301	228	(1)
1947	(2)	-	4639	1,535	1,001	2,999
1948	-	-	6769	1,440	792	2,908
1949	(2)	-	721	1,279	704	2,704
1950	43	-	1,649	1,021	309	3,072
1951	4	-	1,757	1,754	622	4,137
1952	13	-	2,017	1,923	683	4,636
1953	18	-	1,720	1,500	263	3,501
1954	20	-	1,362	1,396	92	2,870
1955	-	-	1,552	2,126	256	3,934
1956	135	-	1,351	3,171	106	4,763
1957	39	-	1,705	3,104	401	5,249
1958	-	-	2,269	3,437	100	5,806
1959	47	-	2,141	2,266	85	4,539
1960	14	-	1,196	4,134	126	5,470

TABLE 5. (continued)

Year	ME	NH	MA	RI	CT	TOTAL
			(Thousands of Pounds)			
1961	7	-	1,116	2,947	89	4,159
1962	5	-	1,098	4,941	134	6,178
1963	13	-	777	5,122	97	6,009
1964	6	-	69	2,671	123	2,869
1965	1	-	220	1,181	66	1,468

(1) Not available

(2) Less than 500 pounds

TABLE 6. Middle Atlantic historical catch statistics for butterfish, 1880-1965 ([illegible] 1967)

Year	NY	NJ	PA	DE	TOTAL
		(Thousands of Pounds)			
1880	-	-	-	-	--
1887	-	-	-	-	--
1888	-	-	-	-	--
1889	365	237	(1)	(1)	(1)
1890	423	239	(1)	(1)	(1)
1891	837	231	(1)	(1)	(1)
1897	729	217	-	-	946
1901	591	3,008	-	-	3,509
1904	579	1,357	-	-	1,936
1908	1,229	2,054	-	-	3,283
1921	630	2,863	-	-	3,493
1926	998	3,078	6	7	4,089
1929	1,150	5,013	-	2	6,165
1930	1,108	2,394	-	-	3,502
1931	2,216	4,320	-	-	6,536
1932	1,239	2,623	-	-	3,862
1933	1,498	2,912	-	-	4,410
1935	2,818	3,619	-	1	6,438
1937	1,900	3,056	-	-	4,956
1938	4,495	4,104	-	-	8,599
1939	5,246	5,760	-	-	11,006
1940	4,953	3,413	-	-	8,366
1942	4,122	2,535	-	-	6,657
1943	2,525	5,553	-	-	8,078
1944	3,238	3,033	-	-	6,271
1945	1,760	3,110	-	4	4,874
1946	1,991	(1)	-	(1)	(1)
1947	998	1,569	-	8	2,575
1948	901	1,286	-	8	2,195
1949	1,520	1,500	-	68	3,088
1950	1,056	607	-	60	1,723
1951	1,878	3,780	-	21	5,679
1952	4,371	1,757	-	2	6,130
1953	903	1,802	-	30	2,735
1954	1,531	1,622	-	12	3,165
1955	1,327	1,533	-	8	2,868
1956	1,501	1,751	-	42	3,294
1957	2,481	1,777	-	25	4,283
1958	3,040	1,828	-	(2)	4,868
1959	2,563	1,798	-	2	4,363
1960	1,839	2,343	-	-	4,182
1961	1,686	2,358	-	3	4,047
1962	1,611	2,113	-	2	3,726

TABLE 6. (continued)

Year	NY	(Thousands of Pounds) NJ	PA	DE	TOTAL
1963	1,151	1,386	-	2	2,539
1964	1,067	1,187	-	4	2,258
1965	766	1,181	-	7	1,954

(1) Not available

(2) Less than 500 pounds

TABLE 7. Chesapeake Region historical catch statistics for butterfish, 1880-1965[1] (from Lyles, 1967).

Year	(Thousands of Pounds) MD	VA	TOTAL
1880	(2)	(2)	(2)
1887	(2)	(2)	(2)
1888	(2)	(2)	(2)
1890	30	139	169
1891	32	120	152
1896	(2)	(2)	(2)
1897	87	466	553
1901	472	1,072	1,544
1904	375	1,335	1,710
1908	151	725	876
1909	(2)	(2)	(2)
1915	(2)	(2)	(2)
1920	876	3,019	3,895
1921	(2)	(2)	(2)
1925	280	5,879	6,159
1929	911	5,532	6,443
1930	615	3,675	4,290
1931	1,264	4,812	6,076
1932	990	2,907	3,897
1933	589	2,286	2,875
1934	452	3,339	3,791
1935	227	2,320	2,547
1936	527	1,750	2,277
1937	92	1,956	2,048
1938	65	3,140	3,205
1939	265	2,663	2,928
1940	316	3,303	3,619
1941	297	2,384	2,681
1942	223	2,180	2,403
1944	153	2,551	2,404
1945	101	2,679	2,780
1946	321	3,370	3,691
1947	60	2,815	2,875
1948	232	1,331	1,563
1949	104	993	1,097
1950	317	1,140	1,457
1951	48	736	784
1952	48	980	1,028
1953	44	953	997
1954	33	1,437	1,470
1955	62	1,095	1,157
1956	81	1,072	1,153
1957	63	468	531
1958	27	1,045	1,072
1959	51	1,439	1,490
1960	42	1,088	1,130

TABLE 7. (continued)

Year	(Thousands of Pounds) MD	VA	TOTAL
1961	79	1,591	1,670
1962	152	1,529	1,681
1963	44	1,378	1,422

[1] Includes harvestfish from 1880 to 1929

(2) Not available

1950	43	1,649	1,021	359	1,056	607	60	317	1,140	40	6,292
1951	4	1,757	1,754	622	1,878	3,780	21	48	736	25	10,625
1952	13	2,017	1,923	683	4,371	1,757	2	48	980	124	11,918
1953	18	1,720	1,500	263	903	1,802	30	44	953	11	7,240
1954	20	1,362	1,396	92	1,531	1,622	12	33	1,437	16	7,521
1955	-	1,552	2,126	256	1,327	1,533	8	62	1,095	-	7,959
1956	135	1,351	3,171	106	1,501	1,751	42	81	1,072	109	9,319
1957	39	1,705	3,104	401	2,481	1,777	25	63	468	204	10,267
1958	-	2,269	3,437	100	3,040	1,828	2	27	1,045	237	10,718
1959	47	2,141	2,266	85	2,563	1,798	2	51	1,439	431	11,754
1960	14	1,196	4,134	126	1,839	2,343	-	42	1,088	209	9,680
1961	7	1,116	2,947	89	1,686	2,358	3	79	1,591	349	12,244
1962	5	1,098	4,941	134	1,611	2,113	2	152	1,529	-	11,416
1963	13	777	5,122	97	1,151	1,386	2	44	1,378	202	7.032
1964	6	69	2,671	123	1,067	1,187	4	33	1,211	130	6,501
1965	1	220	1,181	66	766	1,181	7	164	2,905	367	5,858
1966	-	42	1,115	28	593	1,475	5	131	2,037	503	5,929
1967	-	23	1,327	11	1,120	1,312	-	45	1,110	383	5,331
1968	1	41	959	74	974	727	-	18	698	107	3,599
1969	-	59	1,142	68	763	1,593	-	31	1,112	130	4,898
1970	-	53	640	25	521	971	-	11	1,603	132	3,956
1971	-	71	1,097	11	353	1,245	-	19	659	58	3,513
1972	12	119	267	+	411	492	+	5	252	88	1,635
1973	3	133	1,304	+	668	1,030	+	7	199	40	3,348
1974	+	1632	1,870	+	797	979	+	122	186	76	4,083
1975	+	202	1,829*	+	1,2392	856	+	222	138*	42*	4,146*

\+ Not available2
*2 Preliminary2

5.4.3 Catches

Domestic catches of butterfish are summarized by year in Tables 4-8. Catches by ICNAF member countries are listed in Table 4.e

Butterfish were landed entirely by United States fishermen during the period 1920-1963, along the Atlantic coast from Maine to North Carolina (ICNAF S.A. 5-6). The average annual landings during this period were 3,500 MT. Since 1963, with the advent of a multi-national fishery in the area, United States landings have steadily dropped to 1,561 MT in 1973 (Waring, 1975). Total landings, however, have increased from 5,350 MT (average 1963-1968) to 12,143 MT (1969-1973). The Japanese have taken the major portion (50-80%) of the catch since 1969.

6.e PROTECTION AND MANAGEMENTe

6.1 <u>Regulatory Measurese</u>

Concern for the status of butterfish in the ICNAF convention area was demonstrated by the adoption of an 18,000 MT provisional quota for 1977. With the adoption of the Fishery Conservation and Management Act, the 18,000 MT quota was promulgated in the preliminary management plan for other finfish (ICNAF, 1977; U.eS. Department of Commerce, 1976).

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