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1994 Epifauna on Tire Units from the Garden State North and Garden State South Artificial Reefs off Long Beach Island, New Jersey

by

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Preface

This document reports on results of an analysis and preliminary interpretation of benthic invertebrate samples as part of a NEFSC cooperation research partnership with the State of New Jersey artificial reef program. It is intended to make the data available in a timely manner to the Reef Program This study is part of a continuing series examining aspects of the ecology, trophodynamics and energy flux of fish and other biota found on or near artificial reefs in the New York Bight. This study is not intended to be a detailed taxonomic analysis of the reef epifauna community, but rather to describe major components of the community, especially those that may substantially be involved in food webs supporting reef fishery resources. Documenting the ecological value of artificial reefs to reef-associated fishery resources has been a well known need of reef-fishery management, especially in the coastal marine areas of northeastern US.

Contents

Tables

Figures

INTRODUCTION AND METHODS

Several dozen artificial reefs have been constructed in coastal waters of the New York Bight, since the 1920s (Steimle 1982, McGurrin et al. 1988). The objectives of this construction were to provide reef-like habitat for fish and other reef-associated organisms that was limited in the predominantly flat sandy areas of the Bight, and to either distribute reef habitats for better access or to disperse them to decrease conflicts among users of reef resources (New Jersey Department of Environmental Protection 1987). Despite this relatively long history of the use of artificial reefs in this area, there are many questions about the function of these reefs that have not been adequately answered.

One area of research that requires additional work is how the ecology and "productivity" of reef communities, especially forage species, supports sustainable reef fisheries (Steimle and Figley 1990; Steimle and Meier, in press). There are little data available in the literature on the quantity and quality (as calorie or protein-rich food for fish) of benthic organisms found associated with temperate Atlantic, non-coral reef habitats. This information is necessary to understand to what degree an artificial reef habitat enhances food webs in an area to support fishery resources (Steimle and Figley 1996). The study reported here addresses these information needs by presenting the results of one of a series of studies which examines the benthic community found on two artificial reefs (Garden State North and Garden State South) off central New Jersey in relation to the fishery resources found on this habitat.

The two artificial reefs are approximately 10 to 13 km (6-7 nautical miles) off Long Beach Island NJ. The Garden State North reef is approximately 16 km SE of Barnegat Inlet NJ and the Garden State South reef is approximately 7 km south of Garden State North and 14 km NE of Little Egg Harbor Inlet NJ (Figure 1). The Garden State North reef is in about 24 m of water and the Garden State South reef is in about 18 m of water. The two artificial reefs are at the inshore edge of deeper waters that intrude inshore (Figure 1) through troughs between submerged sand ridges, called the "fingers" by local fishermen. Both reefs are at about the maximum 20 m depth of the relatively stabile summer thermocline in the area (Segar and Berberian 1976), although the deeper Garden State North reef is probably mostly below it and more consistently in cooler waters. Both reef sites were on similar, but slightly variable sediments: 80-90% sand, 0-6% gravel, and 5-15% silt/mud. Sand waves in both areas were less than 0.3 m in height and about 3 m apart, indicating moderate to light currents. There are no natural reefs within 30-40 km of either artificial reef, although there are scattered ship wrecks and a system of navigational buoys along the coast, and groins and jetties along the shore that can serve as sources of larval epifaunal recruitment.

The results reported here are based on faunal samples removed from the relatively smooth side walls and partial treads (flaps) of stacked, split rubber automobile tires units (Figure 2) placed on the two artificial reefs in 1986. The tire units at the Garden State North reef were deployed 2 months before units at the Garden State South reef. Three tire flaps were collected on each of the reef sites in late August (South reef) and early November 1994 (North reef) by divers. The divers randomly selected, partially enclosed in a 3 mm (⅛ in.) mesh nylon collection bag, carefully cut off and removed each sample flap from a stack of flaps (see Figure 2) and sealed it in the bag. The flaps in their bags were brought to the sea surface, carefully removed from the mesh bag and placed in heavy duty plastic bags, including all loose material in the collection bag, and tagged, for a short trip back to the laboratory, where they were frozen. These circular flaps had an outer rim diameter of about 1.44 m (48 in.) and the relatively smooth sidewall flaps, which included only a small amount of tire treads, were about 18-20 cm (~7 in.) wide, varying according to the size and design of the original automobile tire used.

The use of the tire flap as a sampling device has advantages and disadvantages. Advantages include diver convenience and the realism of the flap being part of an actual reef unit, subject to all the environmental factors acting upon the unit. Disadvantages include movements of the flaps in currents, especially during storm surges, and possible effects to epifauna by this disturbance. Preservation-storage and interpreting the residuals (the organisms that come off the flap surface after collection, transport or during storage which are found loose in the storage bag) as results, are other problems. The flap movement, although normal for this type of artificial reef unit, can affect the quantity of organisms colonizing this type of unit and the variance in epifaunal abundances; the flap movement can also reduce the buildup of silt on the units. The loose, residual material created by this sampling method, however, means these results can not be reliably used to discuss ecological differences between various exposure surfaces on the reef unit tire flaps, if such an separation is needed. The inconsistent orientation of the tire flaps on the stacks, from near vertical to near horizontal positions, also hinders obtaining reliable information on surface exposure differences.

For faunal analysis, each flap was removed from the freezer and allowed to defrost for about one hour. Two randomly selected sample sites on the flap for removing attached organisms were chosen from both the inside (concave side) and outside (convex side) of each flap for a total of four samples per flap. Random selection was done by free spinning a metal arrow pivoting on a flat level base placed in the center of the wheel hole in the tire flap. To collect the faunal sample, an adjustable, rectangular copper wire frame covering 234 cm^2 (36 $inch^2$) was centered on the place pointed to by the arrow, and the wire frame adjusted slightly to cover a section of the flap from inside to outside edge. Notes were taken regarding the overall appearance of each sample and approximate percent flap surface coverage of dominant taxa or features (e.g., bare surface or barnacle scar) was estimated. A strong metal blade was used to carefully scrape and remove all organisms within this rectangle. Only organisms with their point of attachment within this area were collected, not organisms attached outside the sample area but hanging or falling within it. All removed organisms were placed in a 0.5 mm mesh sieve and washed to remove silt. The samples then were preserved with 70% denatured ethanol. The detached and loose organisms and other material remaining in the original sample bag (residuals) were also removed, washed and preserved, as above.

Sample sorting and faunal identification, including residuals samples, were done under a dissecting microscope. Samples were sorted to species whenever possible (or necessary because of rarity and difficulty) and counted. The counts of samples containing large numbers of small blue mussels (Mytilus edulis) were estimated by weighing the whole mussel sample and dividing this weight by a factor based on an average count per unit moist weight. This factor was calculated by counting and weighing three random subsamples of the sorted mussels. If the apparent average size of the mussels in any sample differed from this standard, a new conversion factor was calculated by the same method. The weights of all taxa were obtained by blotting each sample on slightly moist paper towels for about 2 min. to remove excess water and then weighed on an electronic balance to 0.1 mg accuracy.

For each taxon in a sample, the sample site (reef, tire #, inside or outside flap), highest level of identification, count (if countable), mean size or range, weight, and percent coverage (from initial notes) were recorded, along with any other notes or observations about the sample. Empty shells or tests of benthic taxa found in the sample were not counted or weighed. Summary statistics (mean and standard deviations) were done on a ten digit scientific calculator. Tests of statistical significance of differences between data sets, e.g., inside versus outside flap, or between reefs, was not done because of small sample sizes (N = 3 flaps or 6 flap sides per reef) and the high variability in the results, and especially, because a reliable way to allocate, numerically or by weight, the residual material to a finite flap side sample could not be found to provide a truer estimate of the average qualities of organisms present on a unit area of tire surface.

RESULTS AND DISCUSSION

General Description of Epifauna

The tire flaps from the deeper Garden State North artificial reef were lightly covered by living epifauna. All three flaps had about 60-90% (mean 80%) of the outside and inside surfaces either bare or covered with dead barnacle (Balanus sp.) base plates or partial shells, with a few clumps of small (<2.0 cm) living blue mussels (Mytilus edulis) and a few dead, still attached and gaping, larger (3.5-5.0 cm) individuals. Most of the loose, residual material found in the sample bags was pieces of fragmented barnacle shells. The living barnacles were of mixed sized and most had several types of hydroids and bryozoans epibiotically covering their shells; some barnacles were also epibiotically covered by a yellow sheath, which may have been an early stage of sponge colonization.

The tire flaps from the shallower Garden State South artificial reef, in contrast, were largely covered with an abundant and diverse epifauna, that was dominated by dense clumps of small (generally < 2.0 cm length) blue mussels; bare tire or barnacle base scars, on average, covered less than 20% of the flap surface. Small patches of barnacles were present, but these were being overgrown by the mussels and various hydroids. On both reefs, the barnacle population appeared to be in decline (i.e., more empty shells than live individuals), and being overgrown by the more aggressive, somewhat mobile mussels.

Dominant and relative number of taxa

The dominant taxa varied between the two reefs (Table 1). The Garden State North reef was numerically dominated by crustaceans, especially by barnacles, while mussels were the dominant taxa on the Garden State South reef. Most of the mussels found in the samples from the flaps were small (< 10 mm) to medium (~45 mm) in length. Mussels, barnacles, caprellid amphipods, juvenile rock crabs (Cancer irroratus), and the scale worm (Harmothoe sp.) occurred in all samples from the Garden State South reef, while these taxa were not present in all Garden State North reef samples.

Thirty-five taxa were identified from the tire flap scrape samples. The major taxa were: coelenterates - hydroids and anemones; nematodes; Bryozoans; molluscs; annelids-polychaetes; crustaceans- pycnogonids, cirripeds, amphipods and decapods; and echinoderms- asteroidea. Since the emphasis of this study was on the taxa that were most abundant or readily available as forage for fishery resources, full identification of species found in very small quantities was not needed or done, and 35 species is a minimum estimate. The mean number of taxa per scrape sample was relatively consistent, 6.3 (±2.9 SD) to 9.0 (±3.4 SD). The greatest difference was between the inside and outside scrape results from the Garden State North reef. The Garden State South reef had lower variability, i.e., from 8.2 (±1.9 SD) to 8.8 (±3.1 SD); the mean range of taxa from the residual samples was also within this narrower range. On the average, the outside (convex) surfaces of the flaps had lower mean numbers of taxa (7.3) than did the inner (concave) surfaces (8.9). There was little difference in the mean total number of discrete, identified taxa on either tire surface (inside: 15-17; outside: 14-19).

Numerical abundance

Disregarding the colonial forms such as hydroids and bryozoans because they are not readily enumerated (Warwick 1993), the numerical abundance of the dominant species varied widely between the inside and outside flap surfaces and between reefs (Table 1).

On the North reef, the mean total number of organisms on the inside flap surfaces was more than two times the number found on the outside surfaces (56 versus 23 individuals). Barnacles (20-39% of total numbers) and blue mussels (17-29% of total numbers) contributed most to overall numerical abundance.

Blue mussels were the overwhelming (92-96% of total numbers) numerical dominant on the Garden State South reef tire surfaces. The only other species which made any notable contribution to the numerical abundance of the community were barnacles, at 2% to 7%. There were little difference in this numerical dominance and total numbers of individuals between inside and outside flap surfaces. But, considering the proportional composition, i.e., the contribution to overall numerical abundance, there is a strong suggestion on Table 1 that barnacles either prefer or survive better on the inside (concave side) of the flaps. On the inside samples they compose between 7% and 39% or the total number of individual, compared to 2% to 20% on the outside flap samples. The proportional data for the mussels suggests a possible opposite pattern, however, with greater proportion of mussel abundance being on the outside, or convex, surfaces. The abundance patterns of the other taxa are too limited, contains gaps, or involves motile species for which surface preference may not be particularly critical, to suggest similar patterns.

The use of the data from the "residual" sample is obviously problematic. This residual sample usually represents epibenthic taxa that are mobile, such as polychaetes, crustacea (except barnacles), sea stars (Asterias sp.), and two juvenile rock gunnel fish (Pholis gunnellus), that are not listed in Table 1. It also contains clumps of mussels and barnacles that were dislodged from the tire surface, and organisms attached to their shells. One way to include these data is to consider that each tire flap had about ten, 234 cm^2 (36 $in.^2$) scrape sections per side, or a total of about twenty non-overlapping, scrape sections per flap. Since the "residual" sample comes from both sides of the entire tire flap, one-twentieth (5%) of the residual numbers could be added to the discrete scrape results to crudely estimate and include the possible contribution of the residuals to the results. This is probably most useful for discussing totals, but the residual sample contains taxa not found in the scrape sample, such as sea stars, or additional quantities of species which were found in relatively low numbers in the scrape samples, e.g., juvenile rock crabs (Cancer). These contributions can not be overlooked in considering the results, but are difficult to include in the data base.

It must be noted that some smaller organisms may have escaped through the 3 mm mesh collection bags while the tire flaps were brought to the sea surface. This means that the numerical estimates are probably low.

Biomass composition

Sample biomass, like numerical abundance, was dominated by blue mussels and barnacles on both flap surfaces and reef sites

(Table 2). The only other taxa that made any significant contribution (> 5% of a total) to the biomass were Metridium anemones and the sea star, Asterias. Other taxa were consistent, but minimal, contributors to the biomass, however. Some taxa, which were abundant enough to be listed on Table 1, were very small (e.g., nematodes) and do not appear on Table 2. However, other taxa, including colonial forms such as hydroids, or rarer but larger taxa (e.g., Metridium) are now important.

The proportional contribution to biomass by most dominant taxa was similar to their proportional contribution to abundance. Mussels had a greater proportion of the total biomass on outside surfaces of the flaps, 68% to 94%, then they did on the inside surfaces, 50% to 77% (Table 2). As with their abundance patterns, the biomass pattern for barnacles was opposite that of mussels. Barnacles dominated 22% to 35% of the total biomass on inside surfaces, compared to 4% to 25% on outside surfaces. The biomass patterns between flap surfaces of other less abundant taxa was generally similar to their numerical abundance patterns.

The residual biomass data generally reflected the proportional contributions of the scrape sample analysis results, but there were differences in the relative contribution of some taxa. The large residual mussel (and hydroid biomass, to a lesser degree) for the Garden State South reef (Table 2) can not be ignored in considering the overall results. The small organisms lost through the 3 mm mesh collection bag probably had little effect on these biomass estimates.

All taxa that were present in the flap or residual samples, including rare or taxa that did not make a substantial contribution to the total biomass of the samples, are listed in Table 3.

Inter-reef comparison

There was an obvious difference in the numerical and biomass dominance characteristics between the Garden State North and Garden State South reefs' tire flap fauna, considering any surface or the residual results (Tables 1 and 2). Mean abundance was two orders of magnitude higher (<100 versus >1000 individuals) on the Garden State South reef tire flap samples, compared to the Garden State North reef samples. The difference between reefs in mean flap biomass was less, but still at least an order of magnitude higher on the Garden State South reef: 174-196 g (South reef) compared to 13-33 g (North reef) per scrape sample. The Garden State North reef also generally had four times more bare or dead barnacle scar-covered surface than the Garden State South reef: 80% versus 19% (Table 4). The major contributor to these differences was the colonization and abundance density of blue mussels.

Many of the smaller and rarer organisms noted in Table 3 are probably dependent on the micro-habitats provided by the larger taxa. These included some endobenthic taxa (e.g., Nucula sp., Astarte sp., Amphitrite ornata, Potamilla sp., Corophium sp.) which found enough accumulated sediment for their needs. Most of the occurrence of small amphipods in the collections are closely associated with the hydroids, which they hold to (caprellids) or hide within the branched polyps (gammarids). The decapod crustacea and larger polychaetes, such as Harmothoe and Nereis, are probably using the inter-shell spaces and niches created by the mussel clumps for shelter and to find smaller prey or other food.

Inter-study comparison

This study follows an previous examination of these two reefs, using similar collection methods, conducted in 1988 (Coastal Environmental Services, Inc. 1990). A comparison of some of the results of these two brief, temporally separated studies show some differences. Some variables were not examined in both studies, e.g., numerical abundance, or were reported differently, e.g., percent coverage included overlapping organisms in the earlier study. We combined inside and outside flap biomass results from the current study to make a comparison with mean undifferentiated flap surface values reported in the earlier study (Table 5).

This comparison shows that in complete contrast to the 1994 results reported above, the high mean total biomass of 105.4 g/scrape was found on the Garden State North reef, compared to only 20.3 g/scrape for the Garden State South reef in 1988. Also, the taxa that dominated this higher 1988 Garden State South reef biomass were the barnacle, not the blue mussel we found dominant in the current study. These contrasting results suggest longer-term monitoring is needed before we can suggest testable hypotheses about the sustained forage value of epibenthic organisms on artificial reefs and that will provide information that is reliable for reef management.

CONCLUSIONS

The results of this study suggest a number of patterns or observations:

1. the Garden State South reef had a more abundant epifaunal community (by numbers or biomass) than the slightly deeper Garden State North reef;
2. blue mussels were primarily responsible for this difference, however, the mussel colonization, which was recent as indicated by the small average size of individuals in the population, could be replacing an earlier colonization dominated by barnacles; and
3. there is a relatively high degree of variability among inter-flap and inter-reef samples.

Without other information (e.g., abundance of predators, temporal dynamics of the community, etc.) the interpretation of these results are preliminary. Although there is a great need for information on the ecology and fishery-forage productivity of artificial reefs, the data reported here are too limited in quantity or temporal/spatial coverage to reliably answer any questions about the ecological function of the reef epifauna. Some of the results and putative patterns mentioned above, however, in concert with data and information from other studies (e.g., Coastal Environmental Services, Inc. 1990), can be explored to postulate hypothesis about difference in reef sites and artificial reef unit designs, and perhaps support the planning of better studies.

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Table 1. The mean numerical abundance (#) and percent total # (%T), per 234 cm^2 (36 in^2) sample, of major taxa and species from the Garden State North and South artificial reefs' tire surfaces; N=6 for "inside/outside" columns and N=3 for "residuals".

	Garden State North			Garden State South		
Flap side:	inside	outside	(residuals)	inside	outside	(residuals)
Taxa/species	# (%T)	# (%T)	# (%T)	# (%T)	# (%T)	# (%T)
Nematodes	5.67 (10)	2.67 (12)	0	0	6.67 (+)	0
Molluscs						
Mytilus edulis	9.67 (17)	6.50 (29)	7.00 (11)	2598 (92)	3284 (96)	14429 (99)
Polychaetes						
Phyllodoce sp.	0	1.67 (7)	0	0.50 (+)	0.83 (+)	0
Harmothoe sp.	0.83 (2)	1.50 (7)	3.67 (6)	16.5 (+)	10.7 (+)	38.3 (+)
Nereis spp.	2.00 (4)	2.50 (11)	1.00 (2)	0.16 (+)	1.16 (+)	0
Crustaceans						
Balanus spp.	21.7 (39)	4.50 (20)	2.00 (3)	195.3 (7)	68.7 (2)	63.3 (+)
gam. amphipods[1]	5.17 (9)	0.50 (2)	0	7.83 (+)	16.8 (+)	20.0 (+)
cap. amphipods[1]	5.00 (9)	1.33 (6)	1.00 (2)	8.83 (+)	30.5 (1)	37.7 (+)
Cancer sp.[2]	2.00 (4)	0.50 (2)	16.3 (25)	2.33 (+)	1.83 (+)	18.0 (+)
Eualus sp.[3]	0.67 (1)	0.33 (2)	18.0 (27)	3.50 (+)	0.33 (+)	11.3 (+)
Echinoiderms						
Asterias sp.	0	0	1.67 (3)	0	0	0
Tot. no.s(±1SD)	56.0(45.8)	22.5(21.7)	65.7(1.2)	2835(1798)	3423(1124)	14,617(11,287)

[1] Gam. = gammarid; cap. = caprellid amphipods

[2] *Cancer* sp. = *C. irroratus*

[3] *Eualus* sp. = *E. pusiolus*

Table 2. The mean moist weight biomass-grams, (WT) and percent total biomass (%B), per 234 cm^2 ($36in.^2$) sample, of taxa and species from the Garden State north and South artificial reefs' tire surfaces; N=6 for "inside/outside" columns and N=3 for "residuals".

	Garden State North			Garden State South		
Flap side:	inside	outside	(residuals)	inside	outside	(residuals)
Taxa/species	WT (%B)	WT (%B)	WT (%B)	WT (%T)	WT (%B)	WT (%B)
Coelenterates						
Metridium sp.	1.83 (6)	0	0.88 (1)	0.07 (+)	0	0
Hydroids	0.59 (2)	0.21 (2)	0	0.08 (+)	2.77 (1)	10.57 (1)
Molluscs						
Mytilus edulis	16.2 (50)	9.01 (68)	41.6 (43)	133.7 (77)	183.7 (94)	712.2 (96)
Polychaetes						
Harmothoe sp.	0.07 (+)	0.07 (+)	0.38 (+)	0.36 (+)	0.26 (+)	0.83 (+)
Nereis sp.	0.18 (+)	0.39 (3)	0.91 (1)	0.13 (+)	0.13 (+)	0
Crustaceans						
Balanus sp.	11.3 (35)	3.35 (25)	7.88 (8)	37.7 (22)	8.65 (4)	17.2 (2)
gam. amphipods[1]	+ (+)	+ (+)	0	+ (+)	0.18 (+)	0.01 (+)
cap. amphipods[1]	+ (+)	+ (+)	+ (+)	0.01 (+)	0.51 (+)	0.06 (+)
Cancer sp.[2]	0.17 (+)	0.02 (+)	2.55 (3)	0.25 (+)	0.02 (+)	0.95 (+)
Eualus sp.[3]	0.01 (+)	+ (+)	0.59 (+)	0.04 (+)	+ (+)	0.15 (+)
Echinoderms						
Asterias sp.	0	0	41.4 (43)	1.72 (1)	0	0
Tot.biomass(±1SD)	32.5(53.1)	13.3(15.6)	95.9(81.0)	174(102)	196(57.7)	742(532)

[1] Gam. = gammarid amphipods; cap. = caprellid amphipod.

[2] Cancer sp. = C. irroratus

[3] Eualus sp. = E. pusiolus

Table 3. List of taxa collected from the Garden State (GS) North and South artificial reefs off central New Jersey; "*" indicates mostly or only juveniles collected.

Taxa/species	GS-North	GS-South
Porifera	?[3]	
Coelenterata		
Metridium senile	+	+
Hydroids		
Tubularia sp.		+
Sertularia sp.	+	
Thuiaria sp.	+	
others	+	+
Aschelminthes		
Nematodes	+	+
Bryozoa		
Membranipora sp.	+	+
Mollusca		
Gastropod		
Anachis sp.	+	
Bivalves		
Nucula sp.*	+	
*Mytilus edulis**	+	+
Anomia sp.	+	+
Astarte sp.*	+	+
Hiatella sp.		+
Annelida		
Polychaetes		
Phyllodoce sp.	+	+
Harmothoe sp.	+	+
Nereis spp.[1]	+	+
Lumbrineris sp.		+
Amphitrite ornata	+	
Potamilla sp.	+	
Arthropoda		
Pycnogonids		+
Acarids (mites)	+	
Crustaceans		
Cirriped		
Balanus spp.[2]	+	+
Amphipods		
Lembos sp.		+
Corophium sp.	+	
Photis sp.		+
Stenothoe sp.		+
Caprella sp.	+	+
Decapods		
Penaeus sp.*	+	
Eualus pusiolus	+	+
Dichelopandalus sp.	+	

Libinia sp.*	+	
*Cancer irroratus**	+	+
Ovalipes sp.*	+	
Echinodermata		
Asterias sp.	+	+
Vertebrata		
Teleostomid		
*Pholis gunnellus**	+	
Total no. species	28+	22+

1. The *Nereis* spp. were mostly *N. succinea* and *N. zonata*.
2. The barnacles were mostly *B. crenatus*.
3. A yellow covering was found on some barnacle shells that could be sponge colonization.

Table 4. The mean percent coverage (± 1SD) of tire flap surfaces by major taxa or predominant artifacts found on 234 cm^2 (36 $in.^2$) samples on the Garden State (GS) North and South reefs.

Taxa/artifact	GS-North (N=12)	GS-South (N=12)
Barnacles-*Balanus* sp.	8.6 (21.5)	13.3 (14.4)
Hydroids	1.7 (6.3)	1.1 (2.5)
Mussels-*M. edulis*	5.7 (11.8)	65.9 (20.3)
Bryozoans	1.7 (5.8)	0.3 (0.6)
Total % live coverage[1]	20.1	80.7
Barnacle scars	26.3 (21.0)	1.4 (2.2)
Bare tire flap surface	52.7 (26.3)	17.9 (19.8)
Total % "dead" surface	80.0	19.3

1. Includes coverage by minor taxa.

Table 5. Comparison of total mean biomass (g/234 cm^2; g/36 in^2) and major taxa components from the 1988 and 1994 study of the scraped epifauna of the Garden State (GS) North and South artificial reefs off central New Jersey.

	GS-North		GS-South	
Taxa	1988 (N=48)	1994 (N=12)	1988 (N=68)	1994 (N=12)
Blue mussels	24.7	12.6	9.5	158.7
Barnacles	80.4	7.3	1.3	23.2
Hydroids	0.02	0.40	9.3	1.4
Total biomass	105.4	22.9	20.3	185.0

Figure 1. Location of the Garden State North and South artificial reefs off central New Jersey, in the New York Bight.

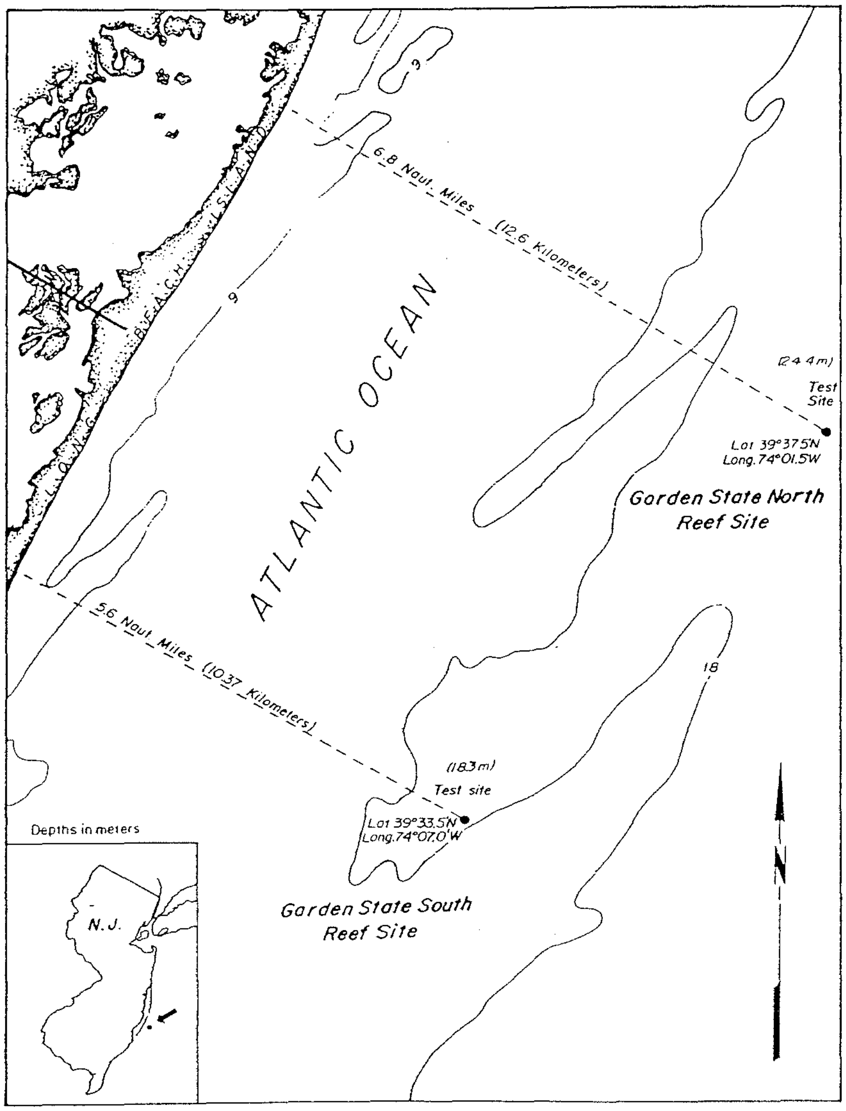

Figure 2. Upper- split rubber tire showing the attached flaps; Lower- stacked tire flaps units as used on the Garden State North and Garden State South artificial reefs.

Figure 2.3.1 Landed weight of goosefish by major market category, excluding tails from 1964-1994 for Combined Assessment Areas, NEFSC weighout database.

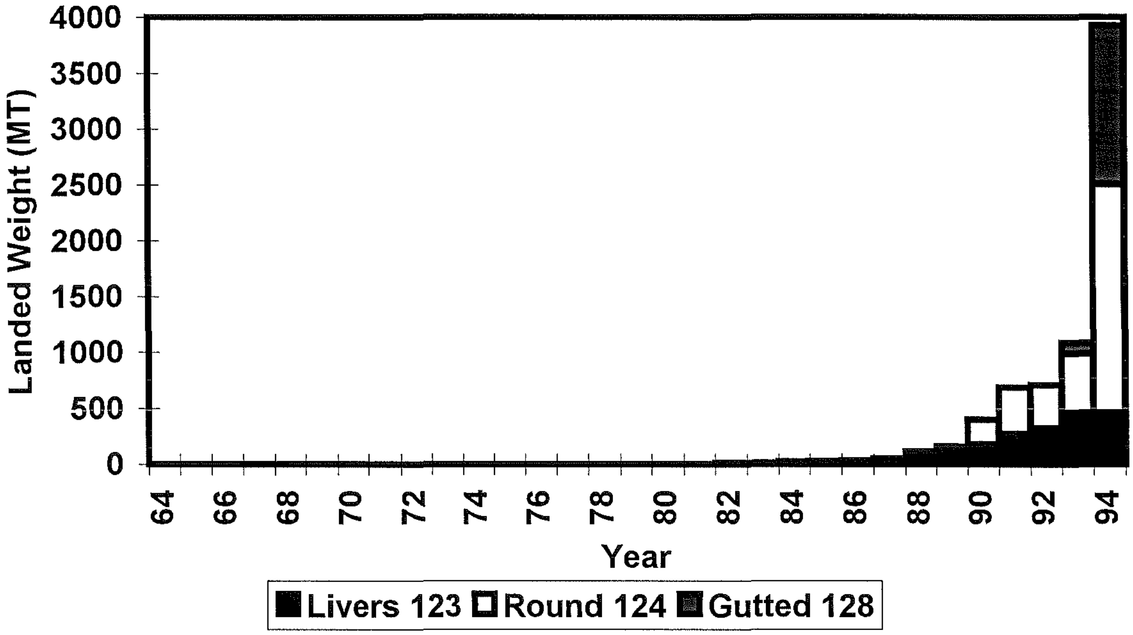

Figure 2.3.2 Landed weight (mt) of goosefish by market category of tails from 1964 - 1994 for Combined Assessment Areas, NEFSC weighout database.