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# Experimental Monitoring Of Virginia Artificial Reefs Using Fishermen Catch Data

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# EXPERIMENTAL MONITORING OF VIRGINIA ARTIFICIAL REEFS USING FISHERMEN'S CATCH DATA

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ABSTRACT

Catch and effort data were compiled in 1987-1988 from recreational fishing trips targeting artificial reefs and other structure sites in Virginia waters. Data were collected from boat-owning fishermen by a random telephone survey. Within target species groups, catch rates were compared among five fishing sites inside Chesapeake Bay and two offshore reefs. Fishermen's target species options were more diverse at estuarine (bay) sites, primarily the result of Sciaenidae species (*Leiostomus xanthurus, Micropogonias undulatus,* and *Cynoscion regalis*) and *Paralichthys dentatus.* The Gwynn's Island Test Reef, closest to mid-bay, provided significantly higher mean catch rates of *L. xanthurus* in 1988 than lower bay sites. Mean catch rates of *Tautoga onitis* at the "mid-bay" site were equivalent in both study years to those at most lower bay sites as well as two offshore reefs. Mean catch rates of *Centropristis striata* were generally higher at offshore sites compared to bay sites. Regarding indices of fishing experience quality, lower bay sites ranked relatively close for trips targeting a mixed Sciaenidae-*P. dentatus* species group. Based upon fishing trips targeting *C. striata-T. onitis,* the mid-bay reef and one lower bay structure site ranked above offshore reefs. Mean catch rates of "desirable" species at the mid-bay reef compared favorably in 1987 with results of a fishery-independent monitoring study of the same site. The telephone survey technique, while needing refinements, showed promise as a monitoring tool for evaluating relative fishing performance of reefs and other structure sites.

Habitat for structure-oriented fish in Virginia waters has undergone expansion through establishment of artificial reefs since the early 1960's. While early efforts were largely undertaken by private individuals and recreational fishing clubs, reef site development became coordinated in the early 1970's under the Commonwealth of Virginia's Marine Resources Commission (Meier et al., 1985). Two offshore sites were enhanced by the sinking of Liberty ships. A privately developed reef site adjacent to the Chesapeake Light Tower, once under jurisdiction of the Commission, became permanently buoyed and was enhanced by automobile/truck tire units, scrapped vessels, a drydock and other materials of opportunity. During 1983-1985 the Commission contracted for the construction of three artificial test reef sites, two inside Chesapeake Bay and one offshore, to evaluate modular reef building materials and potential sites for future reef development (Meier et al., 1985; Feigenbaum et al., 1985, 1986, 1989).

Virginia's artificial reef program, as with most U.S. Atlantic coastal states, must emphasize reef construction over research and monitoring as it strives to meet public demand for improved fishing locations (McGurrin et al., 1988; Reeff et al., 1990). Reef performance is typically evaluated through anecdotal information supplied by recreational fishermen and divers. Site-specific monitoring, using standardized hook-and-line fishing techniques, was conducted to evaluate the referenced test reef sites, and side scan sonar surveys have been completed on several reef sites (Meier and Eskridge, 1991). While scientific divers are occasionally requested to examine sites, no comprehensive monitoring of state reef sites has occurred.

An assessment of management needs for Atlantic coast reef programs recommended among its top priorities that states initiate systematic, multi-year monitoring studies to assess reef fisheries (Reeff et al., 1990). An additional project to assess Atlantic reef program research needs concluded that the highest priority was more research on estuarine reefs, in particular reef effectiveness in supporting fisheries (Steimle et al., 1990).

This 2-year study addresses these priorities: (1) to explore use of a random telephone survey of identified recreational fishermen to monitor relative fishing performance of artificial reefs in Virginia; and (2) to compare relative fishing performance among reefs and other popular structure fishing sites in estuarine (Chesapeake Bay) and adjacent offshore waters.

## Methods

*Selection of Study Population.*—Posted announcements, various media sources, and direct contacts with recreational fishermen and fishing clubs were used to develop a population of boat-owning fishermen who targeted artificial reef and "other structure" sites in Virginia's Chesapeake Bay and adjacent offshore waters (Fig. 1). Significant "other structure" sites in the study area consist of shipwrecks, breakwaters (the Concrete Ships), light towers (Chesapeake Light Tower), and the Chesapeake Bay Bridge Tunnel complex (CBBT, 28.3 km long, including two tunnel sections anchored by four large rock islands). The identified population of recreational fishermen, expanded during the course of the study, was sampled biweekly from March/April through November of each study year (1987–1988). Private boat owners comprised the majority of the sample population with only an occasional interview obtained from a charter or party boat captain. Sampling was accomplished with a random telephone survey technique proven effective in collecting reliable catch data on Virginia's recreational marlin-tuna fishery (Bochenek and Lucy, 1990). Using a random numbers table to select letters of the alphabet and selecting last names randomly within each letter category, 20 boat-owning fishermen were contacted each sampling period.

Two sub-populations of fishermen were identified for sampling purposes: (1) those targeting lower bay sites and offshore reef/structure sites, and (2) those frequenting the Gwynn's Island Test Reef in "mid-bay." "The Cell" fishing site, though close latitudinally to the mid-bay Gwynn's Island Test Reef, was included in "lower bay" sites because its location on the eastern side of the bay made its salinity regime more similar to study sites near the bay mouth (Fig. 1). Fishermen in the first and larger study group were contacted no more frequently than once every other sampling period. This was accomplished by maintaining records of contact dates for individual fishermen and bypassing randomly drawn names called in the previous sampling period. Fishermen appreciated the effort to hold down the frequency of interviews and the procedure produced fishing trip information from a broader cross section of the sample population.

The Gwynn's Island Test Reef, or "mid-bay reef" since it was the most up-bay reef in the study, was fished primarily by fishermen who either lived in the vicinity of the site or utilized nearby campgrounds and marinas. This population of fishermen, largely distinctive from the lower bay-offshore group, was identified through fishing clubs and notices placed at fishing-related businesses in counties closest to the reef site. This smaller population was sampled biweekly, in the same manner as the lower bay/offshore population, but on alternating weeks. The smaller size of the mid-bay reef study population initially required contacting some of the study's fishermen every sampling period. As the mid-bay reef study population expanded, however, its rate of repeat contacts more closely resembled that of the lower bay/offshore group.

*Assumptions.*—Limited funding for the study prevented field checking of fishermen's catch composition and catch rates at the dock. It therefore had to be assumed that the sampling protocol, requiring a catch recall period of only 2 weeks, provided representative catch data for making relative comparisons among fishing sites. If telephone interview catch data were biased, most likely in a positive direction for desirable species and negatively for non-desirable species, the bias was assumed consistent throughout the study. The study's telephone survey data, while not comprehensively validated, were compared to 1987 data collected in an independent, hook-and-line monitoring study conducted concurrently at the Gwynn Island Test Reef (Feigenbaum, 1988).

*Survey Questions.*—When contacted by telephone, fishermen were primarily asked: (1) did they take any fishing trips in their boat to artificial reefs or other structure fishing sites during the previous 2-week period; (2) if so; what site(s) did they fish; (3) what type(s) of fish did they primarily target or expect to catch; (4) the common name and number of fish caught, and number released, by species; (5) number of anglers and rods fished, actual time fished, and method of fishing the site; and (6) how they would rate the overall quality of the trip's fishing experience given a scale of poor (1), fair (2), good (3), very good (4), or excellent (5). Interviewers clarified, among other information: identification of fish caught; numbers of fish both caught and released (catch rates were calculated based upon total catch, not only kept fish); and actual fishing time (time lines were actually in the water).

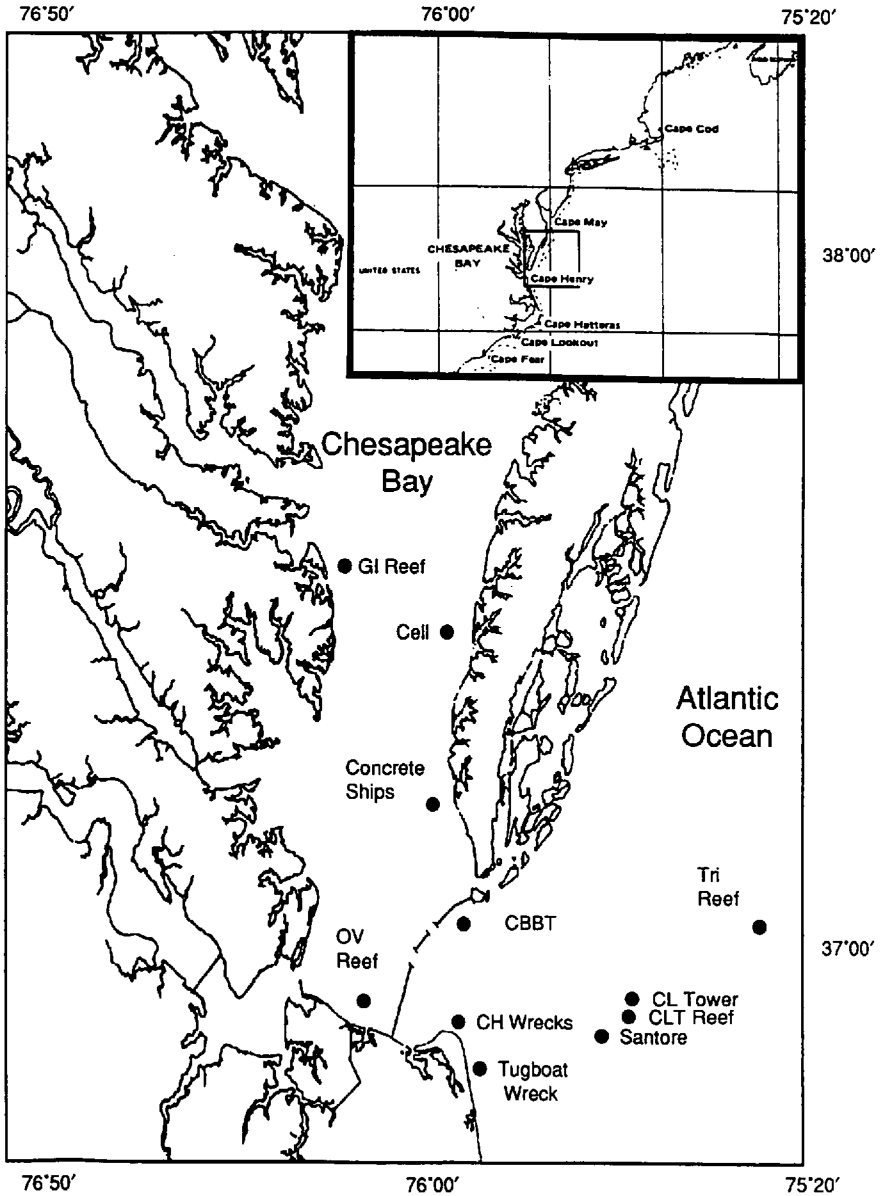



Figure 1. Locations of artificial reefs and other structure fishing sites frequented by boat-owning fishermen sampled in 1987–1988.

*Analysis.*—Mean catch rates (total fish caught per rod hour) were compared among reef and other structure fishing sites for which six or more trips, targeting certain species or species groups, were sampled each year (Table 1). Sites were compared for fishing trips targeting either *Centropristis striata* and *Tautoga onitis* (either or both species) or any of a group of mixed species (*Leiostomus xanthurus, Micropogonias undulatus, Cynoscion regalis, Paralichthys dentatus*). The latter group represents species targeted at Bay sites which may be taken on the same trip by fishermen when fishing on the bottom with fresh bait. Insufficient sample sizes were obtained for making catch rate comparisons among Bay sites for trips targeting individual species in the Sciaenidae-*P. dentatus* group. Small sample sizes and the lack of normally distributed catch rate data warranted use of the non-parametric

Table 1. Reef and wreck fishing sites and associated sample sizes for two target species groups; catch rate comparisons within each target group were made between sites with six or more trips targeting either black sea bass-tautog (BSB-T) or spot-croaker-weakfish-flounder (S-C-W-F), respectively; see Figures 6–8

| Site name | Reef codes | Location | Water depth (m) | Number of trips sampled* | |
|---|---|---|---|---|---|
| | | | | 1987 | 1988 |
| Gwynn's Island Test Reef (Mid-Bay Reef) | GI Ref | Mid Ches. Bay | 7 | 6/54 | 6/73 |
| Chesapeake Bay Bridge Tunnel | CBBT | Lower Ches. Bay | 8–30 | 15/7 | 14/23 |
| The Cell | Cell | Lower Ches. Bay | 13 | 0/2 | 10/11 |
| Ocean View Reef | OV Reef | Lower Ches. Bay | 8 | 0/3 | 3/11 |
| Cape Henry Wrecks | CH Wrecks | Lower Ches. Bay | 15 | 7/0 | 6/0 |
| Santore Wreck | Santore | Offshore Waters | 14 | 0/0 | 6/0 |
| Chesapeake Light Tower Reef | CLT Reef | Offshore Waters | 18–24 | 9/0 | 12/0 |
| Triangle Wrecks Reef | Tri Reef | Offshore Waters | 30 | 14/0 | 13/0 |

* Number of trips targeting BSB-T/S-C-W-F.

Mann-Whitney $U$-test ($P \leq 0.05$), corrected for ties, to compare mean catch rates between sites (SPSS-X, 1986; Zar, 1984).

Weighted quality index values were calculated for each fishing site based upon trips focusing on the referenced target species groups. Relative frequencies of the five quality rating responses were determined from trips targeting a selected species group at a particular site. Products of rating frequencies and their respective point values were calculated. The resulting products (weighted quality values) were expanded by a factor of ten and summed to obtain a cumulative fishing quality index value. Relative fishing quality indices of sites were compared graphically within target species groups.

## RESULTS

Efforts to identify fishermen who owned boats and targeted artificial reefs or other structures in Virginia's Chesapeake Bay and offshore waters produced sample populations of 316 and 519 fishermen in 1987 and 1988, respectively (Table 2). Of these populations, 66 (1987) and 92 (1988) fishermen targeted the mid-bay reef accounting for catch information on 60 (1987) and 83 (1988) fishing trips. More fishermen, 250 (1987) and 427 (1988), targeted lower Chesapeake Bay and offshore areas, making 124 (1987) and 188 (1988) fishing trips to such sites (Table 2).

Lower bay and offshore fishermen targeted approximately 40 different structure or reef sites during each study year. The 10 most frequently fished sites accounted for 63% (1987) and 75% (1988) of all sampled trips (Fig. 1). Because of its fishing popularity and access to boating facilities, the Chesapeake Bay Bridge

Table 2. Boat-owning fishermen surveyed and number of fishing trips reported in survey

| Areas fished | Fishermen surveyed | | Trips captured | |
|---|---|---|---|---|
| | 1987 | 1988 | 1987 | 1988 |
| Lower Ches. Bay/Offshore | 250 (56)* | 427 (110) | 124 | 188 |
| Gwynn's Island Test Reef | 66 (40) | 92 (45) | 60 | 83 |
| Total | 316 (96) | 519 (155) | 184 | 271 |

* Number of individual boat owners who provided trip data is contained in parentheses.

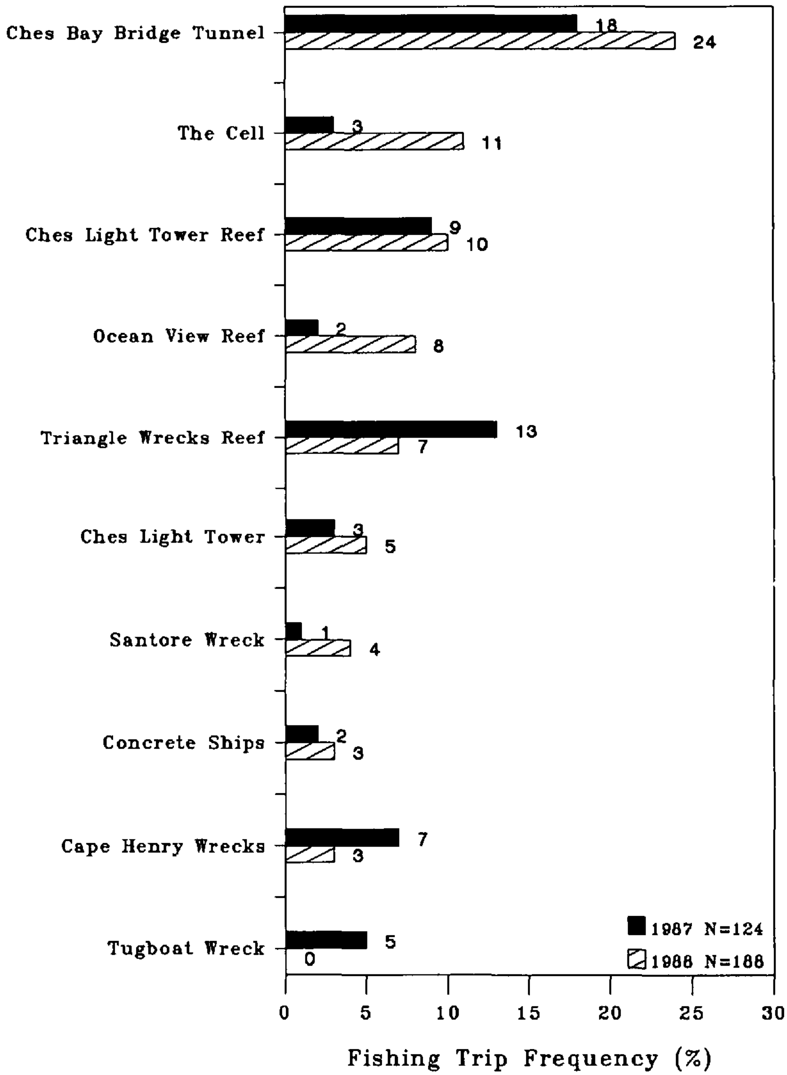



Figure 2. Distribution of sampled fishing effort for fishermen identified as fishing lower Chesapeake Bay and offshore "wreck fishing" sites; Gwynn's Island Test Reef (mid-bay reef) not included.

Tunnel (CBBT) complex (construction completed 1964) accounted for the majority of effort sampled each study year (Fig. 2). The CBBT is approximately 28 km long with two tunnel sections anchored by four granite boulder islands. Approximately 56 km offshore the bay mouth, the Triangle Wrecks Reef ranked second in 1987 sampled effort. The site contains four Liberty ship hulls placed by the state reef program and at least three World War II shipwrecks. Located approximately 24 km off the bay mouth, the Chesapeake (Light) Tower Reef ranked third in sampled effort in both years. Established in 1971, the site contains numerous structures including surplus Navy landing craft, drydock sections, barges, tire bales and tire-in-concrete units.

Relative shifts in site fishing effort occurred between years, in part due to continued expansion of the lower bay-offshore sample population. More trips

Table 3. Mean values (standard deviation) of fishing effort characteristics for trips targeting the mid-Bay reef, lower Chesapeake Bay sites, and offshore sites

| | | Mean fishing effort per trip | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Anglers | | Hours fished | | Rods fished | | Rod hours | |
| Location | Total trips | 1987 | 1988 | 1987 | 1988 | 1987 | 1988 | 1987 | 1988 |
| Mid-bay Reef (Gwynn Is. Test Reef) | 60/83* | 3.2 (1.4) | 3.0 (1.4) | 3.2 (1.7) | 2.9 (1.5) | 3.3 (1.3) | 3.2 (1.4) | 11.6 (9.3) | 9.8 (7.7) |
| Lower Ches. Bay Sites | 41/93 | 2.6 (0.7) | 2.9 (1.1) | 4.2 (1.9) | 3.9 (2.2) | 3.1 (1.2) | 3.2 (1.4) | 13.2 (7.8) | 13.0 (10.2) |
| Offshore Sites | 39/49 | 3.2 (1.1) | 3.0 (1.4) | 4.4 (1.9) | 3.7 (2.0) | 5.0 (2.9) | 3.4 (1.6) | 23.1 (18.2) | 13.5 (11.3) |

* Total trips sampled during 1987/1988.

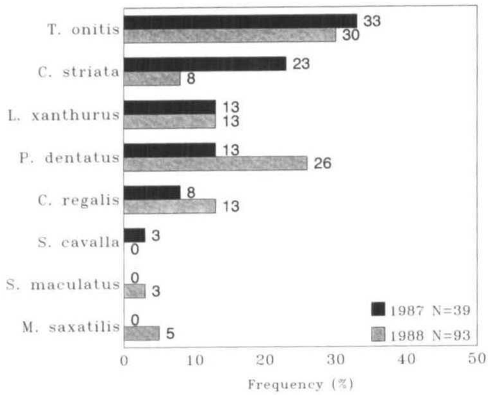
were sampled in 1988 to the Cell, a vessel degaussing station in the lower bay abandoned by the Navy during the 1950's. It consists of collapsed concrete, timber, and pipe materials. The Ocean View Reef, a lower bay site established in summer 1987 and consisting of 40 prefabricated concrete "igloo" structures (McGurrin et al., 1988), also accounted for greater second year fishing effort. Relative changes in sampled effort recorded for these two sites largely contributed to the Triangle Wrecks Reef declining in prominence the second year (Fig. 2). Sampled separately, the Gwynn's Island Test Reef is excluded from the ranking.

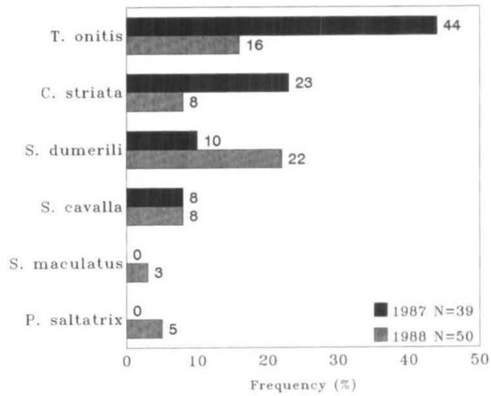
Fishing effort parameters were similar for the mid-bay Gwynn's Island Test Reef and the group of lower Chesapeake Bay sites. However, duration of actual fishing time at the mid-bay reef averaged 1 h less than fishing time at lower bay sites (Table 2). This time difference resulted in trips to the former site producing less average effort per trip (rod hours) than trips to the latter sites. Characteristics of trips to offshore sites closely paralleled those of lower bay sites, particularly in 1988. Slightly larger fishing party size and correspondingly more rods fished at offshore sites in 1987 resulted in higher effort values that year.

Fishermen targeted different combinations of species at the one mid-bay reef, lower bay sites, and offshore fishing sites. Lower bay sites provided the most diverse fishing opportunities, accounting for nine different target species specified by fishermen (Fig. 3). Sampling indicated that trips targeting *T. onitis* (tautog) and *C. striata* (black sea bass) dominated lower bay sites as well as offshore sites (Fig. 4). Offshore sites, in particular the Chesapeake Light Tower near the Light Tower Reef, also provided fishing opportunities for *Seriola dumerili* (greater amberjack).

In addition to *T. onitis* and *C. striata,* lower bay sites also provided fishing opportunities for trips targeting *P. dentatus* (summer flounder), *C. regalis* (weakfish), and *L. xanthurus-M. undulatus* (spot-croaker). In comparison, the mid-bay reef off Gwynn's Island supported less diverse fishing opportunities, being dominated by trips targeting *L. xanthurus* and *T. onitis* (Fig. 5).

Differences in target species patterns occurred between years at sampled sites. Comparing 1988 to 1987, the mid-bay reef's fishing pattern was dominated by trips targeting *L. xanthurus* (Fig. 5). Lower bay sites in 1988 demonstrated a relative doubling in fishing effort targeting *P. dentatus* and a 62% increase in effort for *C. regalis* (Fig. 3). Compared to 1987, more than twice as many trips to the Cell (lower bay site) were obtained in the 1988 telephone survey sample (Fig. 2). Anecdotal information from fishermen indicated that this site is traditionally well known for these two species. A major decline occurred in 1988 samples for trips targeting *C. striata* at lower bay sites, possibly due to increased



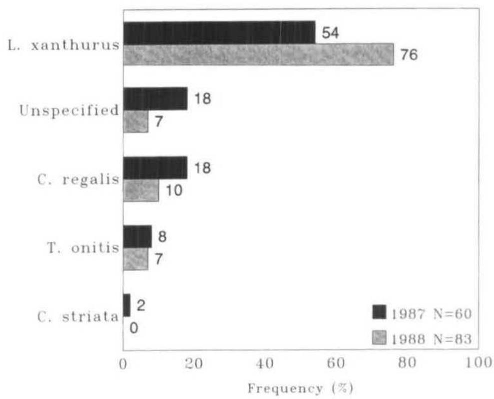



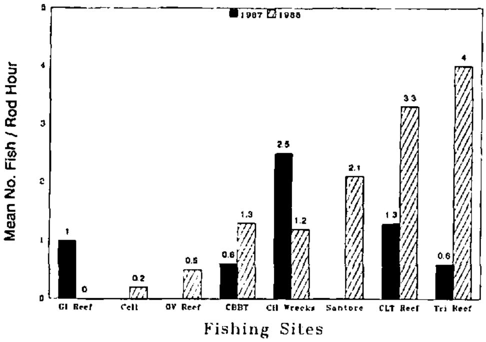

Figure 3 (left). Distribution of sampled fishing effort at lower Chesapeake Bay sites according to fishermen's preferences for target species. *L. xanthurus* represents a two species group including *M. undulatus*.

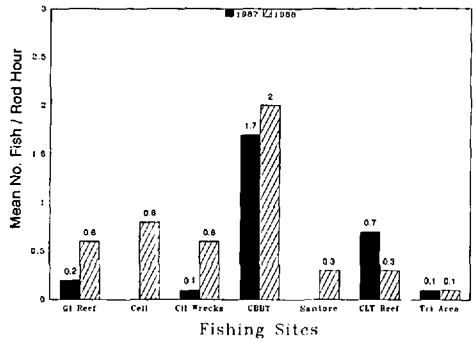
Figure 4 (right). Distribution of sampled fishing effort at offshore sites according to fishermen's preferences for target species.

Figure 5 (lower). Distribution of sampled fishing effort at the Gwynn's Island Test Reef (mid-bay reef) according to fishermen's preferences for target species.

sampling of fishing trips to the Cell that year (Fig. 3). Similarly, a relative increase in trips sampled in 1988 that targeted *S. dumerili* at offshore sites may have influenced the relative decline in sampled trips targeting *T. onitis* and *C. striata* at those sites (Fig. 4).

Mean catch rates of *C. striata* (trips targeting *C. striata-T. onitis*) were highest in 1987 for the Cape Henry Wrecks at the bay entrance (Fig. 6). Statistical differences, however, could only be demonstrated between that site and the CBBT ($P = 0.05$, $Z = -2.02$) when comparing all lower bay-offshore sites. Sampling in 1988 indicated that two offshore reefs produced significantly higher mean catches of *C. striata* than combined lower bay sites (CLT Reef—$P < 0.01$, $Z = -3.87$; Tri Reef—$P < 0.01$, $Z = -3.87$). Mean catch rates for the species increased graphically from the Gwynn's Island Test Reef (mid-bay reef) to offshore sites (Fig. 6). No statistical differences, however, were found among the lower bay sites since relatively low mean catch rates occurred at such sites (0–1.3 fish/rh).



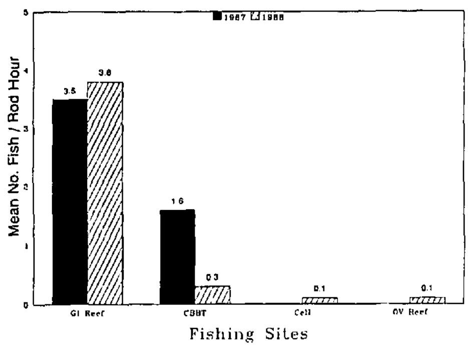




Figure 6 (left). Mean catch rates (fish caught per rod hour) of *C. striata* on trips targeting *C. striata-T. onitis* at bay and offshore sites. For Figures 6–8 the absence of zero catch rate data (0) for any site in a given year indicates no trips sampled at that site for the specified target species. Fishing site abbreviations in Table 1.

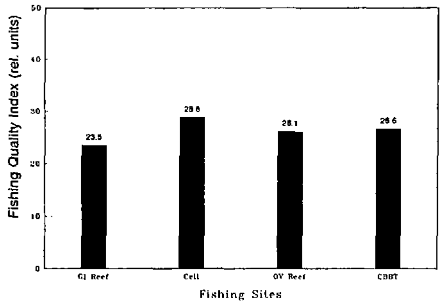
Figure 7 (right). Mean catch rates (fish caught per rod hour) of *T. onitis* on trips targeting *C. striata-T. onitis* at bay and offshore sites. Site abbreviations in Table 1.

Figure 8 (lower). Mean catch rates (fish caught per rod hour) of *L. xanthurus* for trips targeting *L. xanthurus-M. undulatus-C. regalis-P. dentatus* species group comparing Gwynn's Island Test Reef (mid-bay reef) with lower bay sites. Site abbreviations in Table 1.

The CBBT site (Fig. 7) produced significantly higher mean catch rates of *T. onitis* compared to one lower bay site in 1987 (Cape Henry Wrecks—$P = 0.01$, $Z = -2.71$) and the offshore reef sites in both years (CLT Reef—$P = 0.05$, $Z = -1.98$ and $P = 0.01$, $Z = -2.44$, respectively; Tri Reef—$P < 0.01$, $Z = -3.00$ and $P < 0.01$, $Z = -3.34$, respectively). In 1988, the Cell (lower bay) also exhibited higher catch rates for this species than the offshore Triangle Wrecks Reef ($P = 0.01$, $Z = -2.49$). Apparent between-year increases in mean catch rates of *T. onitis* at bay sites during 1988 could not be statistically confirmed (Fig. 7).

Based upon 1988 trips targeting *C. striata-T. onitis,* fishing quality indices demonstrated that a lower bay site (Cell) and the Gwynn's Island Test Reef ranked above all other sites (Fig. 9). The most recently developed site (Ocean View Reef) received the lowest quality score. Insufficient quality rating data were obtained for the Cape Henry Wrecks site.

The mid-bay Gwynn's Island Test Reef was examined further based upon two target species consistently available at the site during certain months, *T. onitis* (October–November) and *L. xanthurus* (May–October). The mean catch rate of



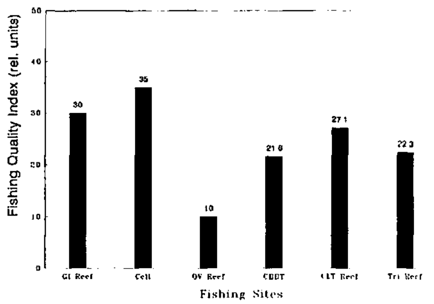




Figure 9 (right). Fishing experience quality rating indices for sites based upon trips targeting *C. striata-T. onitis* species group (1988). Abbreviated site names in Table 1.

Figure 10 (left). Fishing experience quality rating indices for sites with trips targeting *L. xanthurus-M. undulatus-C. regalis-P. dentatus* species group (1988). Abbreviated site names in Table 1.

*T. onitis* (trips targeting *C. striata-T. onitis*) at the Gwynn's Island Test Reef was similar in 1987 to that at the Cape Henry Wrecks (lower bay) and two offshore sites, but significantly lower ($P < 0.05$, $Z = -2.19$) than the rate at the CBBT in the lower bay (Fig. 7). In 1988, the site's mean catch rate for *T. onitis* was similar to that of lower bay and offshore sites.

Mean catch rates of *L. xanthurus* (trips targeting *L. xanthurus-M. undulatus-C. regalis-P. dentatus*) were higher in 1988 at the Gwynn's Island Test Reef than at other lower bay sites (Fig. 8). The mid-bay reef's mean catch rate for the species during 1987 was not statistically different from the CBBT, the only other site for which sufficient data were obtained.

Based upon trips targeting the Sciaenidae-*P. dentatus* species group, fishing quality indices indicated that the mid-bay Gwynn's Island Test Reef ranked below other lower bay sites (Fig. 10). Sampling obtained no trips targeting the species group for the Cape Henry Wrecks site.

## Discussion

A principal tenet of this study was that recreational fishermen who regularly fish reef and other structure sites uniquely possess practical experience and frequency of interaction with sites. Therefore, systematic collection of relative catch data and other quantifiable information from fishermen for sites may provide a means for reef programs to improve their monitoring functions. Improved monitoring of the fishery component of reefs is needed (McGurrin et al., 1988; Reeff et al., 1990), particularly with regard to growing numbers of estuarine reefs (Steimle et al., 1990).

Determining targeted species fishermen expected to catch at various reef and structure sites provided insight as to what desirable species were typically available at sites. Such information also supplied background from which to evaluate relative fishing performance of sites and indicated something about fishermen's needs met by sites. In the latter case, occurrence of significant trips to the Gwynn's Island Test Reef (mid-bay reef) on which fishermen targeted no specific species, or sought "anything that could be caught," indicated that the mid-bay reef provided fishing opportunities for less experienced or more casual fishermen (Fig. 5). Sampled fishermen utilizing lower bay and offshore sites regularly targeted a specific group of species.

Changes in fishermen's patterns of targeted species between years can result

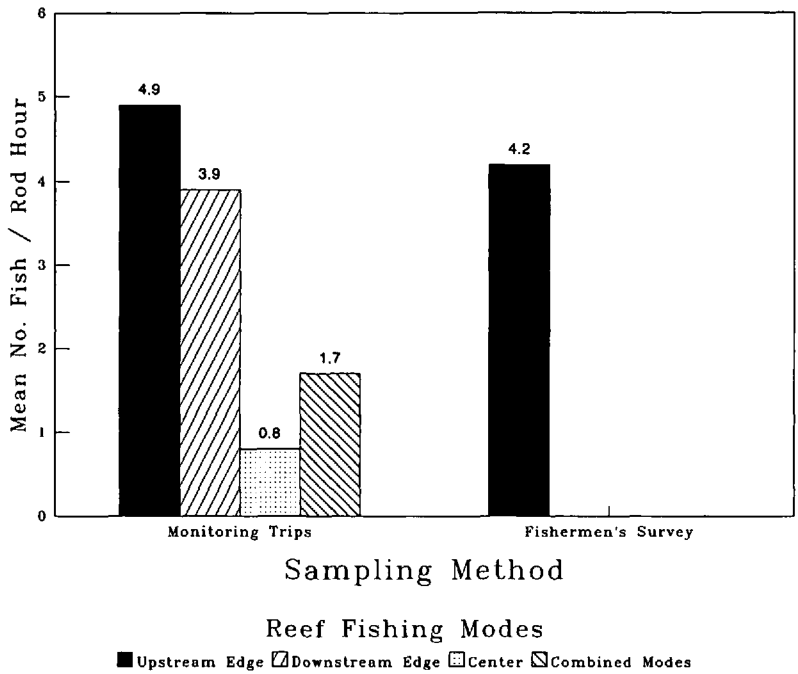



Figure 11. Mean catch rates (fish caught per rod hour) of "desirable" species at the Gwynn's Island Test Reef (mid-bay reef) determined from separate, but concurrent studies; monitoring study trips (N = 14) versus fishermen survey trips (N = 60).

from various situations, including changes in relative abundance of desired species, changes in fishermen's relative interest in a given species or interaction between these two factors. Accordingly, caution should be exercised in drawing conclusions about the significance of temporal pattern changes at fishing sites. For example, the relative increase in trips targeting *S. dumerili* during 1988 at offshore sites likely resulted from a new initiative to provide citation plaques for releases of large amberjack by the Virginia Salt Water Fishing Tournament, a state program to promote marine recreational fishing (Bain, 1990).

Fishing quality rating data provide a tool for integrating fishermen's background and catch expectations into reef performance evaluations, and a reef's fishing performance is largely judged by fishermen relative to their historical fishing experience (McGurrin and Fedler, 1989). Domination of the mid-bay test reef's target species pattern by *L. xanthurus* clearly distinguished the site from other bay sites (Figs. 3, 5). As a result, fishermen's catch expectations for the site were different compared to other sites. Considering desirable species available to fishermen in the general area where the test reef was located, the site provided acceptable fishing experiences, as evidenced by its relatively high fishing quality index (Figs. 9, 10). However, had the mid-bay reef been fished heavily by fishermen more accustomed to fishing sites at the Bay mouth or offshore, its fishing quality index might have been comparatively lower.

Differences in mean catch rates of *C. striata*, significantly higher for offshore sites than bay locations, were expected. Populations of *C. striata* in the Mid-Atlantic Bight consist of mostly juvenile fish inside estuaries while greater numbers of adults typically occur offshore in higher salinity water (Musick and Mercer, 1977).

Mean catch rates of *T. onitis* demonstrated the reverse pattern, higher rates occurring at the CBBT inside the bay entrance than observed at offshore reef rites. The amount and diversity of structure associated with the 28.3 km long CBBT complex, particularly the four granite boulder islands anchoring the tunnel sections, may have contributed to the site's relatively higher catch rates.

A wide size range of *T. onitis* utilizes the Virginia portion of Chesapeake Bay from spring through fall, being locally abundant in the areas of Gwynn's Island, the Cell site, and CBBT in association with hard-bottom and/or structure (Hostetter and Monroe, 1993). Higher than average stream flows throughout the bay watershed in April 1987 (U.S. Geological Survey, 1987), while reducing bottom salinities at the mid-bay Gywnn Island reef to 13‰ in late April-early May (Feigenbaum, 1988), did not inhibit occurrence of tautog at the site. Feigenbaum (1988) and this survey reported catches of *T. onitis* at the test reef during May 1987. Bottom salinities in the general area of the site ranged from 16–27‰ between October 1987 and September 1988 (Curling and Neilson, 1992), a salinity range over which the species commonly occurs in the lower bay (Musick, 1972). Like *C. striata,* larger *T. onitis* specimens occur offshore in association with suitable hard-bottom and structure habitat (Richards and Castagna, 1970; Musick, 1972; Hostetter and Monroe, 1993).

The dominant role of *L. xanthurus* as a targeted species at the mid-bay reef (Fig. 5), and some fishing interest in the species at lower bay sites (Fig. 3), indicate that, while not considered a "reef" associated species, it occurs in the vicinity of structure in the bay. Lindquist et al. (1985) observed *L. xanthurus* in association with new and existing rubble-mound jetties established in a North Carolina ocean inlet. Feeding habits, however, do not link *L. xanthurus* to structure. Analysis of stomach contents and mouth-gill structures indicate that the species feeds mostly on infauna, even foraging into the sediment for prey (Chao and Musick, 1977). Association of the species with sediment bottoms is supported by fishermen's observations in this study, whereby they preferentially fished the edges of the reef and adjacent bottom area to obtain the species rather than directly over structure.

Examining the weighted quality rating for fishing experiences at the mid-bay Gwynn's Island Test Reef indicated that it ranked relatively close to other lower bay sites in providing quality fishing experiences. The site's fishing quality rating for trips targeting *C. striata-T. onitis* ranked ahead of key lower bay sites and several offshore artificial reefs. The site's close proximity to boat launching facilities may have contributed to its relatively high quality rating. In comparison to lower bay sites, the Gwynn's Island Test Reef's positive fishing performance contrasted with results of a 1984–1985 standardized, hook-and-line monitoring study. The study demonstrated relatively low catch rates (all species combined) for the Gwynn's Island Test Reef compared to other lower bay and offshore test reef sites (Feigenbaum et al., 1989).

A follow-up monitoring study (Feigenbaum, 1988) was conducted in 1987 on the Gwynn's Island Test Reef concurrent with, but independent from, this fishermen survey study. In the former study, mean catch rates for desirable species (excluding toadfish-*Opsanus tau,* sharks and rays) were statistically similar between the reef and nearby control sites containing no reef materials. However in May and October, hook-and-line sampling demonstrated significantly higher mean catch rates on the test reef than the control sites, largely the result of *T. onitis* catches (Feigenbaum, 1988). This lends support to our findings regarding fishermen's relatively high quality rating index for the site based upon trips targeting *C. striata-T. onitis.*

The fishery-independent monitoring study (Feigenbaum, 1988) provided the opportunity to validate, in part, fishermen's telephone survey catch reports obtained in 1987 for the Gwynn's Island Test Reef. Desirable species (Feigenbaum, 1988) were *L. xanthurus, M. undulatus, C. striata, T. onitis, Pomatomus saltatrix* (bluefish), and *Bairdiella chrysoura* (silver perch). All but the latter "desirable" species was reported as caught at the site by fishermen in this study. However, fishermen also reported catching *C. regalis* at the site (Lucy et al., 1988; Lucy and Barr, 1989), making the "desirable" species group comparable in size for both studies.

The mean catch rate for desirable species, based upon 1987 telephone survey data, was 4.2 fish per rod hour (total "desirable" fish caught/total rod hours fished; N = 60 trips). The upstream and downstream fishing modes of the monitoring study (Feigenbaum, 1988) most closely represented the fishing strategy practiced by the majority of surveyed fishermen, i.e., they fished around the reef perimeter or within its enhanced fishing zone (Bohnsack and Sutherland, 1985) when targeting sciaenid species or *P. dentatus* (Lucy et al., 1988). Mean catch rates for desirable species in the upstream-downstream fishing modes (Feigenbaum, 1988) ranged from 3.9–4.9 fish per rod hour (total "desirable" fish caught/total rod hours fished; N = 14 trips). For comparable fishing modes, results of the fishery-independent monitoring study closely paralleled those of the recreational fishermen's survey (Fig. 11), providing validation for the random telephone survey data.

Telephone survey studies for monitoring fishing performances of reefs have definite limitations. When initiated, dockside sampling of fishermen's catches should be incorporated into such studies to verify reported catch data. Neither fishermen's surveys nor hook-and-line studies should be the only monitoring tools employed by management programs. Such studies only provide an index of larger specimens of reef-associated species susceptible to rod and reel fishing and do not provide a comprehensive sampling of the total reef fish community (Chester et al., 1984). Other monitoring techniques, in particular systematic observations by trained divers (Adams, 1991), should be used where possible to document reef site productivity, particularly relative to use of the site for spawning or recruitment.

Monitoring studies incorporating hook-and-line fishing techniques, one of the only practical means to sample artificial reefs in waters characterized by low visibility, should attempt to incorporate local fishermen's knowledge into the study design. Such efforts can produce results which more accurately describe how the site performs relative to the user audience for which it is intended. This may prove particularly important in evaluating estuarine sites.

Finally, in this study small sample sizes hampered catch rate comparisons among sites, particularly for fishing trips targeting *C. striata-T. onitis.* Small sample sizes contributed to the inability to detect significant differences in mean catch rates among sites, differences which graphical presentations indicated may have existed. Future monitoring studies comparing the relative recreational fishing performance of reef sites should focus on fewer sites and/or increase the number of fishing trips sampled per site to resolve this problem.

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