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Development of Tagging Techniques for Monitoring Fish Populations at Texas Artificial Reefs

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Texas Parks and Wildlife Department (TPWD) has used a broad range of methodologies to monitor the social, economic, and biological impacts of artificial reefs in the Gulf of Mexico. Social and economic issues have been addressed through charter boat and diver mail-in questionnaire surveys and on-site creel surveys. Biological issues have been investigated through hook and line tagging, diver-based visual transects, and video traps. Assessments of hydroacoustic and remotely operated vehicle (ROV) biological survey techniques are also planned for deepwater reef sites. There is also a need to develop inexpensive biological monitoring methods to track target fish populations such as red snapper over time at specific reef sites. The Department has been investigating the use of collapsible traps to tag fish underwater as a potential long-term monitoring tool for assessing reef fish populations. The cost effectiveness and efficiency of this gear type was compared to hook and line capture techniques. During the initial effort, 223 red snapper were tagged underwater by divers after capture by three collapsible traps, and 291 red snapper were tagged on the surface by anglers after capture by hook and line techniques. The collapsible traps appeared to be more size selective for smaller sized red snapper than hook and line techniques. Fish tagged underwater had a higher recapture rate of 25.45 percent compared to the 11.89 percent recapture rate for fish caught and tagged on the surface. Although three recapture periods were used to evaluate tag return data, our findings suggest that future efforts directed at monitoring artificial reef fish populations should use multiple gear types with equal effort applied to account for size-selective capture patterns and logistical constraints.

In the western Gulf of Mexico, habitat for reef-dependant fish is limited. The bottom type offshore of Texas and Louisiana is primarily soft mud, which is not conducive to the development of natural hard-bottom habitat. According to Galloway and Cole (1997) 0.4% of the hard-bottom habitat in the western Gulf has been created by the installation of 4,500 oil and gas platforms since 1938. These stable, durable structures and similar artificial reef materials have influenced the distribution of many commercially and recreationally important reef fish, including red snapper (*Lutjanus campechanus*).

In response to potential overexploitation of reef fishes at easily accessed sites, state and federal agencies have been trying to develop monitoring protocols to understand the mechanisms and processes leading to the increased abundance of red snapper and other important reef fish near artificial reefs. Spatial heterogeneity of natural and artificial reefs has limited the use of traditional fishing gears in making accurate assessments (Bortone and Kimmel 1991).

Studies of species abundance and composition in the northern Gulf of Mexico have used a variety of methodologies, including visual surveys by scuba divers (Dokken et al., 1993), remotely operated underwater vehicles (ROVs) and fixed arrays of underwater cameras (Stanley and Wilson, 1990), catch per unit effort from traps (Gitschlag, 1986), and angling surveys (Render, 1995). The majority of studies have been short term and document only a single point in time. Further, species abundance and composition estimates using these sampling methods are not always directly comparable due to the lack of standardization. Recently, long-term studies combining stationary dual-beam hydroacoustics and visual point counts from ROVs have been adapted to measure fish density and species composition of fishes associated with petroleum platforms (Stanley and Wilson, 1996). Fish densities ranged from 0 to 10.5 fish/m^3 during monthly sampling efforts. Fish densities were highest adjacent to the platform and decreased significantly beyond 16 m of the platform. Density did not change over 24-hr periods or with water temperature. Although hydroacoustic methods can be used over longer periods of time to estimate fish abundance, this method utilizes more expensive sampling gear (approx-

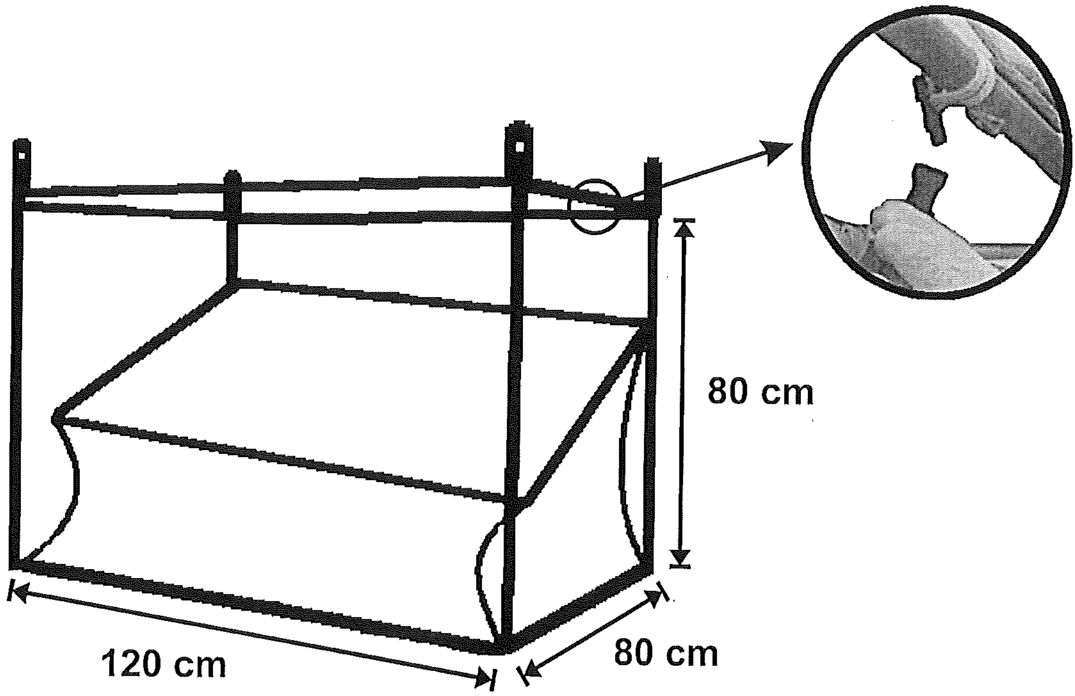

Fig. 1. Diagram of collapsible trap to tag fish underwater.

imately $100,000) and requires trained technical support to interpret the data collected.

Less expensive gear types such as hook and line have been used in the past to estimate fish abundance. A study by Render (1995) reported an average mortality rate of 20% for red snapper when captured by hook and line around platform structural habitat in depths greater than 21 m. Render observed higher mortalities in summer than fall sampling seasons and noted that gas bladder deflation did not significantly enhance survival of red snapper captured below 21 m.

To reduce mortalities usually associated with gas bladder inflation when the fish are captured by hook and line gear, National Marine Fisheries Service (NMFS) constructed a collapsible trap (Gitschlag, 1986) to capture reef fish around platforms. Fish captured in these collapsible traps were then tagged underwater by divers.

In an attempt to evaluate the cost effectiveness and efficiency of collapsible traps and hook and line methods for capturing fish, Texas Parks and Wildlife Department (TPWD) initiated a monitoring study at a state artificial reef site. Red snapper was chosen as a target species in this study because they utilize natural and artificial reefs during a portion of their life cycle. The goal of this study was to investigate the feasibility and advantages of trapping and tagging fish underwater compared to hook and line sampling efforts. The costs for vessel time and requirements for personnel using both methods were also identified.

Methods and Materials

The George Vancouver Liberty Ship Reef Site, a 20-yr-old established artificial reef, was selected for the study. The study site is located nine nautical miles offshore from the Freeport jetties and seven nautical miles from the mouth of the San Bernard River at 28°47′34″N and 95°20′51″W. The George Vancouver Liberty Ship (121.92 m by 16.6 m) rests firmly on the bottom at a depth of 18.3 m with a profile of 6.1 m.

The initial sampling effort was over a 4-d period from 23–26 Sept. 1996 (Trip 1). Three subsequent sampling trips were made within the next 8 mo. Two 1-d efforts were made 17 Oct. 1996 (Trip 2) and 20 Nov. 1996 (Trip 3), and an additional 2-d effort was made 13 and 14 May 1997 (Trip 4). Red snapper were captured for marking using three experimental collapsible traps (Fig. 1) modified from a National Marine Fisheries design (Gitschlag, 1986) and hook and line efforts from the surface.

The frames of these collapsible traps (80 ×

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80 × 120 cm) were constructed of 190-mm schedule 40 aluminum pipe with a moveable top and a hinged bottom door. The overall design was composed of an outer frame with an internal collapsible frame. The entire unit was designed to collapse for easy transport and storage.

Stretch mesh (38 mm) made of #15 nylon twine dipped in green Plasti-net was used to construct the walls and mouth of each trap. Two seams on the back panel of the trap were sewn with Lehigh #530 jute twine to provide a biodegradable panel in the event the trap was lost. The trap opening, a funnel terminating in a 15-cm vertical slit, was held in place using green twine (#20) tied from the funnel to the side panels.

Sampling stations were set by securing one end of a line to the deck of the George Vancouver Liberty Ship and the other end to a surface float. The collapsible trap was baited with squid and lowered to the deck (12.2 m) where it remained for a minimum 2-hr soak time. The trap was examined in situ for captured fish after the minimum soak time during daylight hours. The traps were allowed to fish undisturbed overnight. If the trap contained fish, it was raised with a lift bag to 8 m, where it was then secured to the stationary sampling line. Eight meters was chosen because it provided a safe working depth for the dive team and produced no observable distension in the trapped fish. The trap's netting was released from the top frame and secured to the bottom frame to immobilize the fish before tagging. One diver would restrain the fish while the other diver made a small incision with a scalpel and inserted an abdominal anchor tag. Total length (mm) was obtained using a ruler placed against the immobilized fish. Fish species, tag numbers, and total length measurements were communicated to the surface using MKII buddy phones and an Aquacom surface transceiver. The procedure for tagging and measuring was repeated for all captured fish. The trap's netting was returned to its normal configuration after tagging was complete, and the fish were released by opening the hinged bottom. The trap was then baited and redeployed. Fishing time for each trap was measured from the time the trap was set on the reef until divers retrieved it for tagging fish or it was relocated.

Hook and line efforts were initiated during all four sampling periods during random day and night hours. Fishing was conducted using medium action rods and sportfishing reels with either a 3/0-Mustad Kirby or 12/0-Mustad circle hooks. Squid was used exclusively for bait.

TABLE 1. Catch per unit effort for red snapper by gear type.

Sample effort	Gear used	Red snapper caught[a]	Total hours fished	CPUE
Trip 1	Collapsible trap	237	159.96	1.48
	Hook and line	320	87.80	3.64
Trip 2	Hook and line	96	111.40	0.86
Trip 3	Hook and line	68	26.22	2.59
Trip 4	Collapsible trap	0	57.00	0.00
	Hook and line	93	28.27	3.29

[a] Includes red snapper not released due to mortality and recaptures.

Each fish was brought to the surface, measured in millimeters, tagged, and observed. If there were any signs of distension, the fish was vented and placed in a holding tank for observation. The fish was only released if it appeared to be in good health.

Catch per unit effort was calculated during the initial and subsequent sampling periods. Length frequency analysis of the population captured by each gear type during Trip 1 was evaluated using a log-likelihood ratio test (Zar, 1984).

RESULTS

Catch per unit of effort.—During the initial 4-d tagging effort (Trip 1), 557 red snapper were captured by both methods. Eight hook and line mortalities occurred and 43 tagged fish were recaptured. Table 1 illustrates the results of the four sampling efforts, including the catch per unit of effort (CPUE) by gear type. Divers were in the water during all four sampling efforts and observed that red snapper were on the up-current side of the George Vancouver Liberty Ship reef each time. However, safety concerns for divers prevented the deployment of the collapsible traps during Trip 2 and Trip 3. Sea conditions during Trip 2 also prevented the research vessel from anchoring directly over the George Vancouver Liberty Ship, which affected hook and line efforts. No fish were captured in the two traps deployed during Trip 4. During Trip 1, 237 red snapper were captured in the traps yielding a CPUE of 1.48. Hook and line efforts resulted in capturing 320 red snapper (CPUE = 3.64) during Trip 1, 96 red snapper (CPUE = 0.86) during Trip 2, 68 red snapper (CPUE = 2.59) during Trip 3, and 93 red snapper (CPUE = 3.29) during Trip 4.

Percentage of tag returns by original capture method for each gear type are shown in Table 2. Excluding recaptures and mortalities, 506

TABLE 2. Percentage of tag returns by original capture method.

Original capture method	Number of tag returns				Total fish recaptured	Fish tagged trip 1	% Recaptured
	Trip 2	Trip 3	Trip 4	Anglers			
Trap	12	18	18	8	56	220	25.45%
Hook and line	11	4	5	14	34	286	11.89%

fish were tagged and released by both gear types during Trip 1. A total of 90 recaptures, including tag returns from local anglers, were recorded during the three subsequent sampling efforts. Fifty-six (25.45%) of the 220 tagged fish initially captured in the traps were later recaptured by hook and line efforts, whereas only 34 (11.89%) of the 286 fish initially captured by hook and line were recaptured by subsequent hook and line sampling efforts. Although local anglers reported recapturing 19 tagged red snapper at the reef site following the initial tagging operation, these results are not conclusive since they also reported releasing several tagged red snapper (under size limit) without noting the tag numbers.

Length frequency analysis.—A comparison was made of the length frequency for all red snapper captured using both gear types from the initial tagging effort during Trip 1 (Fig. 2). Trapped fish ranged in size from 154 to 278 mm. Fish captured by hook and line ranged in size from 185 to 475 mm. The log-likelihood ratio test (Zar, 1984) was used to compare the two distributions and showed that there was a significant difference between gear types. The traps were able to capture smaller fish not easily captured by the hooks used. Using both

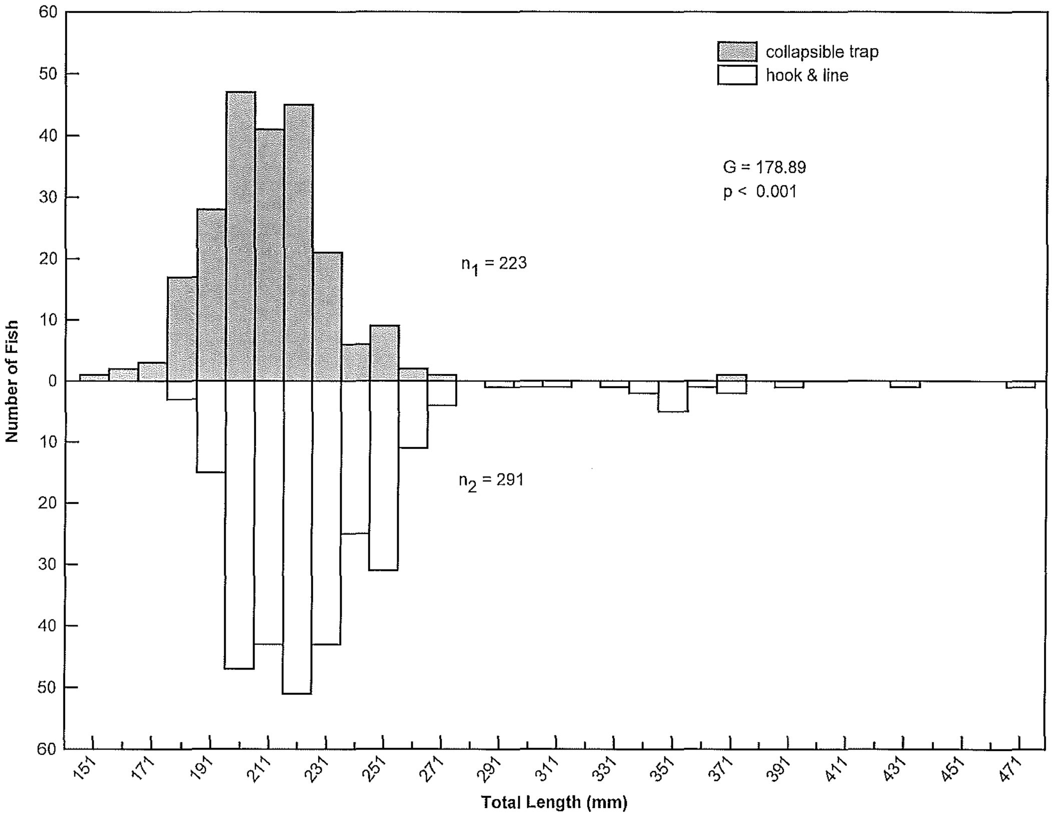

Fig. 2. Length frequency distributions for red snapper captured by trap and hook and line 23–26 Sept. 1996.

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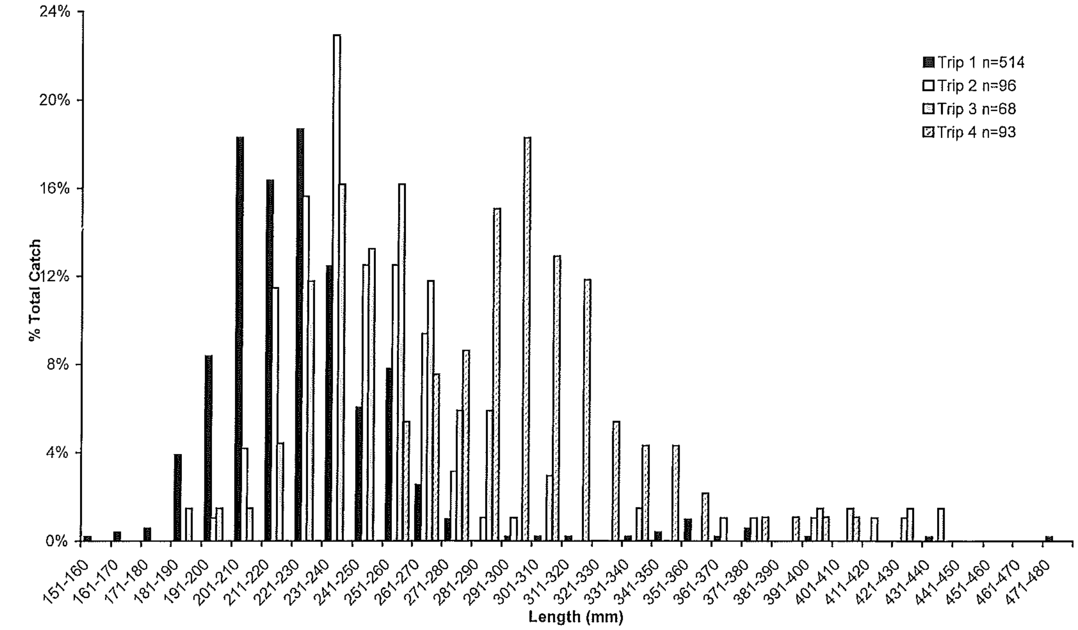

Fig. 3. Comparison of length frequency distributions of red snapper for the sampling efforts.

gear types allowed the capture of a wider range of size and year classes.

A comparison of the length frequency of all fish captured using all gear types during the four sampling efforts is shown in Figure 3. The majority of red snapper captured from Trip 1 were age 1 fish, ranging in size from 154 to 280 mm with a few individuals up to 475 mm. Red snapper caught by hook and line alone during Trip 2 ranged in size from 191 to 421 mm. During Trip 3, red snapper caught by hook and line were slightly larger, ranging in size from 211 to 421 mm. During Trip 4, although no red snapper were captured in the traps over a 57-hr period, fish captured by hook and line (251–410 mm) were larger than previously collected by this gear type.

A comparison of the length frequency distributions for recaptured fish during the four sampling efforts is shown in Figure 4. The size range of recaptured fish from Trip 1 was 191–370 mm. Recaptured fish from Trip 2 and Trip 3 had similar size ranges of 211–380 mm and 211–371 mm, respectively. Recaptures from the Trip 4 effort spanned a larger size range than previously recaptured, with three red snapper up to 410 mm. Of the 23 fish recaptured during Trip 2, 12 were originally captured by trapping and 11 were originally captured by hook and line. Trip 3 and Trip 4, however, had substantially higher numbers of recaptured fish that were originally captured in the trap (18 recaptures each trip) than fish originally captured by hook and line (4 and 5 recaptures, respectively).

Cost and time comparisons.—A cost and time comparison of the efforts is shown in Table 3. Vessel costs were considered fixed costs for each sampling trip regardless of whether both gear types were utilized. Total vessel costs were $22,550. The salaries for the number of TPWD divers and anglers used to complete this study were considered variable costs. Eleven divers were required to set traps, spending approximately 28.7 hr deploying traps, sampling and tagging fish underwater, and retrieving traps during the four efforts. Although divers could contribute to hook and line efforts while on board the vessel, not all anglers could contribute to the underwater trapping efforts. Costs for TPWD divers' salaries were approximately $4,877. Thirty-six anglers were used during hook and line efforts, providing approximately 32.2 hr for capturing and tagging fish on the surface. Costs for TPWD anglers' salaries were approximately $6,377 for assisting in the hook and line effort. No costs were associated with the volunteer divers and anglers.

Total time in man-hours among the four sampling efforts was not equal because the traps were not set during Trip 2 and Trip 3. Traps also require a soak time not required by the hook and line method. Total cost for the

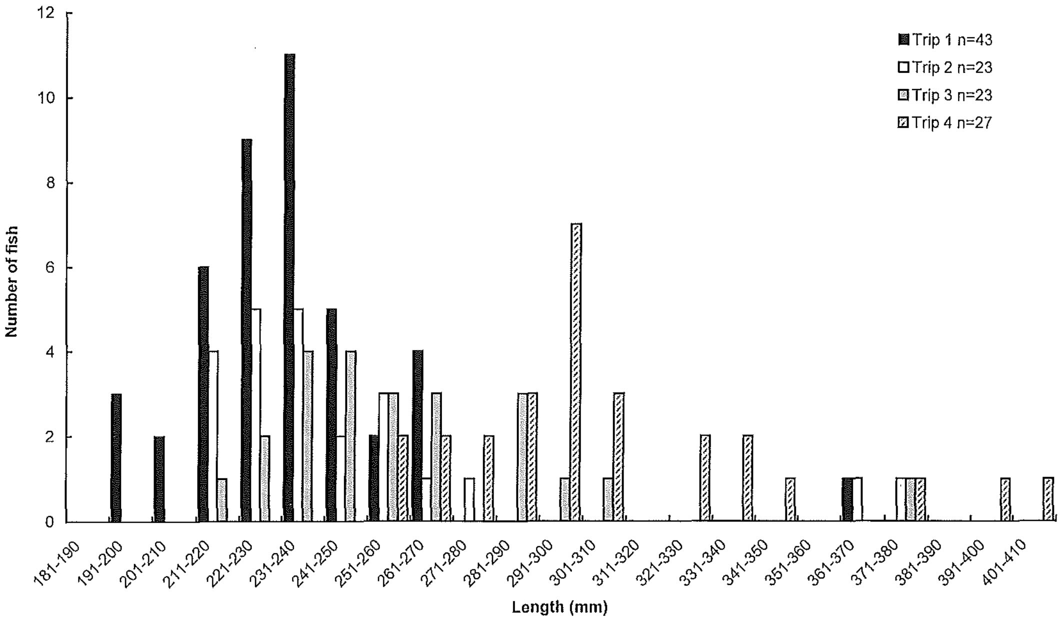

Fig. 4. Comparison of length frequency distributions of red snapper for recaptures during the four sampling efforts.

entire sampling effort was $33,804, far less than a single hydroacoustic/ROV visual point count survey (D. R. Stanley, pers. comm.).

Discussion

This initial monitoring study of a state artificial reef provides some insight for future protocols using collapsible traps and hook and line. The advantages and disadvantages for each method were identified and can be modified for future monitoring efforts. One advantage of the collapsible trap was a greater return rate (25.45% vs 11.89%) of tagged fish. Greater tag returns from the traps may be a result of the underwater tagging process being less stressful to the fish, allowing for quicker recovery rates and fewer mortalities. Another possibility is that smaller fish captured in the trap may never have been captured by hook and line and did not exhibit hook and line avoidance behavior. There is the potential that a different assemblage of traps of different sizes and mouth openings could be used to provide a wider representation of the entire population instead of the smaller individuals captured in this study.

Utilizing traps is labor intensive due to the planning and logistical support required with using divers. The traps must remain undisturbed for several hours before fish enter the trap. Longer fishing times, such as leaving the traps deployed overnight, lower the CPUE. Poor visibility also makes it difficult for the divers to deploy or retrieve the traps. However, when environmental conditions are favorable, the traps can be used effectively to achieve desirable results.

Table 3. Cost and time comparisons for divers and anglers.

Sampling effort	Vessel costs ($)	TPWD divers	TPWD salaries ($)	Volunteer divers	Dive time (hr)	TPWD anglers	TPWD salaries ($)	Volunteer anglers	Angler time (hr)
Trip 1	6,600	5	3,751	2	18.1	4	3,001	3	14.8
Trip 2	4,650	0	0	0	0.0	10	1,876	2	9.3
Trip 3	2,000	0	0	0	0.0	2	375	9	2.4
Trip 4	9,300	3	1,126	1	10.6	3	1,125	3	5.7
Totals	22,550	8	4,877	3	28.7	19	6,377	17	32.2

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Successful use of the traps is also dependent on current velocity. The traps were successful during Trip 1 because there was very little observable current affecting the divers' ability to set the trap. On subsequent sampling trips, the current was too strong for divers to deploy the traps or move the traps to other locations. Current vector data was not measured during these sampling efforts and should be investigated further before finalizing any future monitoring protocols.

One advantage of the hook and line gear was that it captured larger size fish. This gear type also has the ability to be used regardless of visibility or sea condition. However, the sampling effort during Trip 2 shows that current vectors can also influence the CPUE of anglers when the research vessel can not anchor directly over the reef. Results indicate that the CPUE can very considerably depending on environmental conditions.

A disadvantage of hook and line gear is that there appears to be higher mortalities in capturing and tagging fish on the surface. This gear type is also labor intensive in terms of man-hours required to capture and tag fish.

The vessel costs remain the same regardless of the gear type used. All personnel can be used for hook and line efforts, but only scientific divers can be used for trap tagging operations underwater. Costs were calculated to be less than half of one hydroacoustic-combined ROV survey.

Summary and conclusions.—Collapsible traps appear to have the advantage of capturing young of the year recruits to a reef site. Although this gear type requires diver support and is affected by environmental conditions, 13.57% more fish were recaptured that had been originally tagged in the traps. This initial monitoring study suggests a potential to set traps on subsequent sampling efforts. Greater planning is needed for more equal sampling to occur on future monitoring efforts.

Hook and line gear type appears to have the advantage of capturing a broader range of fish from different year classes. However, this gear type is also labor intensive and is affected by environmental conditions. The greatest disadvantage of using this type of gear remains with the lower survival rate of tagged fish that cannot be recaptured for a population estimate. Render (1995) showed in his study of red snapper populations around oil and gas platforms that 70% of the mortalities from tagging occurred in the first week after tagging.

A significant factor that needs to be addressed before either gear type is used in future monitoring efforts involves a more accurate evaluation of currents around the structure. By moving the traps or reanchoring the vessel on the up-current side of the structure, greater CPUE for both gear types may be expected and therefore a great potential for successful tagging operations will exist.

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