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A Preliminary Examination of Breakaway Tagging for Demersal Rockfishes

by

Victoria O'Connell

December 1991

Alaska Department of Fish and Game

Division of Commercial Fisheries

Fishery Research Bulletin

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inside cover

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ABSTRACT

A *breakaway* tagging technique was modified for demersal rockfishes in Southeast Alaska and tested as a possible tool to investigate movement and migration of yelloweye rockfish *Sebastes ruberrimus*. The tag consisted of a vinyl tubing tag attached to a circle hook. This tag was attached to a snap-on longline gangion using light-weight test monofilament. The tag gear was baited and deployed, and fish were tagged after breaking the monofilament attachment line, some in the jaw and some elsewhere. The number of tags detached was determined, but the number of rockfish tagged could not be enumerated because some tags were snagged on the bottom and lost during gear deployment and retrieval. Therefore, the number of fish tagged could only be estimated. In spite of these shortcomings, this method is useful for tagging rockfishes because their physoclistic swim bladder precludes use of conventional tagging methods at the water surface. Tagging gear was set in two areas during 1985 and 1988, and 1,263 tags were detached. Three recoveries of tagged yelloweye rockfish adults were made as of August 1991. All three fish were recovered on the same reef from which they were tagged. Feeding did not appear to be affected by the tag because all three fish were in good condition. Time between release and recovery ranged from 309 d to 570 d. Deterioration of tags due to rusting potentially limits the possible recovery period.

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INTRODUCTION

Yelloweye rockfish *Sebastes ruberrimus* are a large, up to 91 cm, demersal species. Associated with rocky reefs and boulder fields, they are found in waters of the northern Baja Peninsula to Prince William Sound, Alaska, in depths ranging from 10 to 300 fathoms. In 1983 the Alaska Department of Fish and Game (ADF&G) began to investigate the life history and population dynamics of yelloweye rockfish in Southeast Alaska, where they are the target of a nearshore commercial longline fishery. One of the objectives of this ongoing research is to determine movement and migration of this species.

Mark-recapture data has been used in fishery science to determine movements of fishes, as well as estimate stock size, growth rates, and mortality rates. However, tagging of marine fish species, like yelloweye rockfish, which have a physoclistic swim bladder is difficult because these fish often suffer serious or fatal injury due to changes in hydrostatic pressure when brought to the surface. Gotshall (1964) attempted to reduce tagging mortality of blue rockfish *Sebastes mystinus* by gradually raising fish to the surface and then venting gases from the body cavity with a syringe. Combs (1979) found that by using a weighted, inverted crab trap to lower yelloweye rockfish back to the desired depth she decreased mortality associated with surface tagging. Both these methods, however, are very time consuming, and their success has been limited, making them impractical for large-scale tagging operations.

Therefore, to study rockfish movements, I first needed to find a technique that would enable tags to be applied to rockfish without bringing them to the surface, i.e., *in-situ* tagging. Phillips (1968) experimented with detachable tags using Peterson-type plastic disks attached to hooks for tagging deepwater, schooling rockfish; fish taking the bait were hooked; as they struggled they broke a light-weight leader attached to the hook and tag. Phillips found that 1.8- to 2.7-kg test line was appropriate for detachment of tags by large rockfish. Grimes et al. (1983) developed a similar technique for tagging tilefish *Lopholatilus chamaeleonticeps* in deep water using tags applied to hooks that were fished from modified longline gear. Horn (1989) used a modification of Grimes's (1983) tag for tagging two New Zealand midwater fishes, alfonsino *Beryx splendens* and bluenose *Hyperoglyphe antarctica*.

Grimes's (1983) technique seemed practical for large-scale tagging operations necessary to ensure adequate tag returns from commercial stocks, and I believed it could be adapted for tagging rockfish. Although both tilefish and yelloweye rockfish are routinely caught on longline gear, tilefish inhabit burrows in clay, mud, and sand (Able et al. 1982), whereas yelloweye rockfishes inhabit rocky reefs, pinnacles, and other areas of high relief. This difference in habitat represented a potential problem.

While considering how to modify Grimes's tagging technique, in August 1983 the department was afforded the opportunity, on short notice, to use a manned submersible for 2 d; I was assigned use of a portion of this time. Because I could use the submersible to observe the performance of modified Grimes tagging gear in operation on the bottom, I decided to initiate a tagging evaluation study. This work continued in 1985 and 1988. The objectives of these efforts were to evaluate the effectiveness of the experimental gear in tagging yelloweye rockfish and to obtain recoveries that would contribute to knowledge of their movements.

METHODS

1983 Tag Design and Evaluation Study

I modified the design of Grimes's tag for use with snap-on longline gear and adjusted gear sizes for yelloweye rockfish. The tags consisted of a 9.5-cm piece of 36-kg test monofilament inserted through vinyl tubing. One end was crimped to a #8 circle hook, and the other end was crimped into a small loop. A short section of light-test monofilament was tied to the loop and to a monofilament gangion with a snap. Total length from snap to hook was approximately 26.5 cm (Figure 1).

When fish took the bait and were hooked, the light-weight monofilament was broken, setting the hook in the fish's jaw and leaving the hook and tag attached to the fish. In this paper I have referred to this as the *breakaway tag*. Two strengths of breakaway monofilament, 1.8 kg and 2.7 kg, were tested. The breakaway line needed to be light enough to allow a fish to easily break free from the gangion but provide enough resistance to set the hook in the jaw of the fish. To distinguish the two test strengths, a small piece of white vinyl tubing was inserted through the top of the gangions attached to 2.7-kg monofilament.

A manned submersible was used to observe the gear while it fished on the bottom. The submersible schedule allowed me to use only one skate of gear per longline set for this experiment; a longliner was chartered to deploy the gear. Snap-on longline gear was used because it is the usual gear of the rockfish fleet. Standard gangions with circle hooks were interspersed between the breakaway tags. These standard hooks were used to sample species composition and abundance along the sets so that the species composition of the fish tagged could be estimated.

Tags were arranged in a series on two longline racks. Two fishermen baited and snapped the hooks on at 1-fathom intervals. The set pattern was 20 tags with

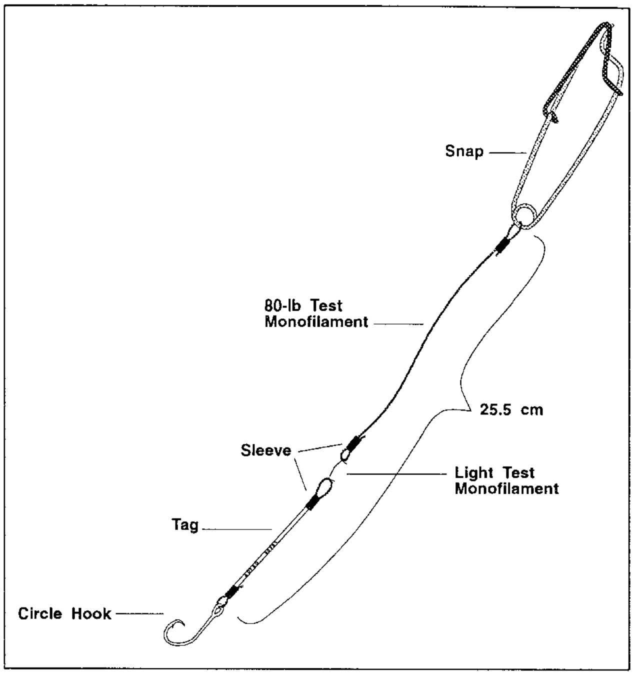

FIGURE 1.—Schematic of snap-on breakaway tag.

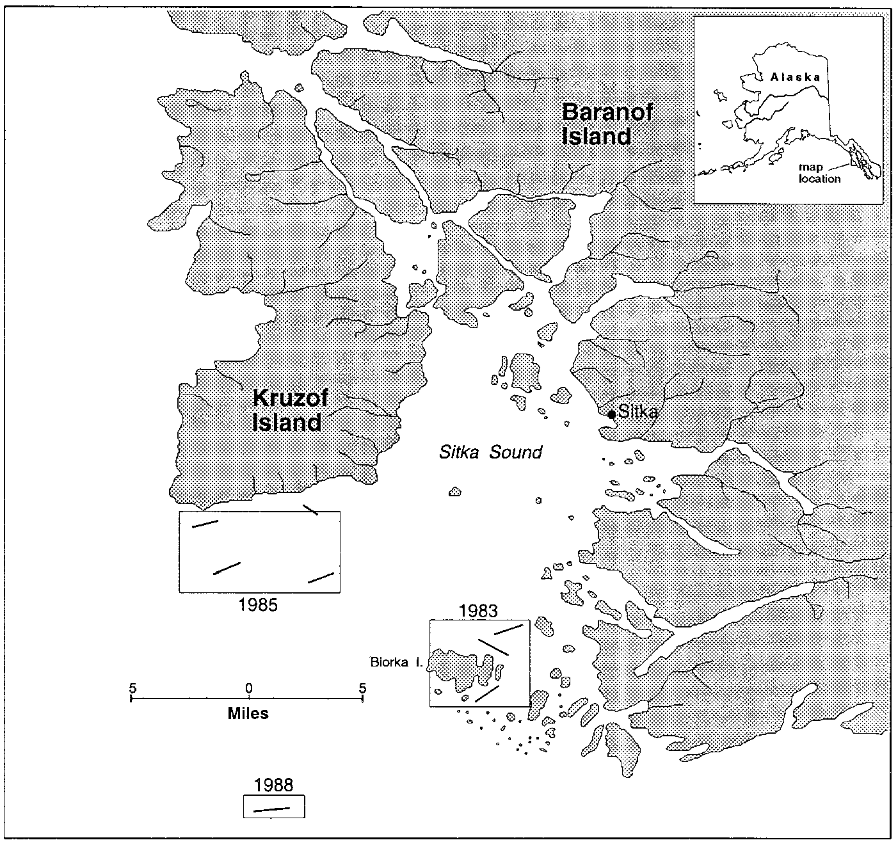

FIGURE 2.—Study site locations off Baranof Island, Southeast Alaska, 1983, 1985, and 1988. Thin bars indicate sets.

TABLE 1.—Location of sets, numbers of tags deployed and detached by attachment strength (i.e., 1.8 kg and 2.8 kg), and CPUE (catch/hook) of the standard hooks (non-tags) during the August 14 and 15, 1983, evaluation study.

		No. of Tags Deployed		No. of Tags Detached			CPUE[1]	
Date	Location	1.8 kg	2.7 kg	1.8 kg	2.7 kg	Detachment Rate	All Fish	Yelloweye Rockfish
8/14	Ataku Island 135° 30.4'/56° 49.5'	56	55	22	24	0.41	-[2]	0.00
8/15	Symonds Bay 135° 31'/56° 52.4'	69	70	57	61	0.85	0.35	0.09
8/15	Symonds Bay 135° 28'/56° 53'	17	13	14	10	0.80	0.45	0.10

[1]The catch per hook based for the standard (non-tag) hooks.
[2]Data not available.

1.8-kg test breakaway line, 5 standard gangions, 20 tags with 2.7-kg test breakaway line, and 5 standard gangions. An ADF&G observer was onboard the longline vessel during deployment and retrieval of the gear to ensure the hooks were set as planned and to record the species composition of fish caught on standard gangions.

We were constrained by the submersible schedule to August 14 and 15. Sea conditions were stormy which forced us to set in an area that is not normally fished for rockfish. Gear was deployed off Ataku Island in Biorka Channel and at Symonds Bay (Figure 2). A total of three sets were made: one at Ataku Island and two at Symonds Bay. The three-person submersible *Mermaid II*, deployed at the beginning longline buoy, ran along the length of the set. Observers were asked to record presentation of tags (snarled, broken, available to fish) and information on hooked fish and fish observed near the longline gear.

A chi-square test was used to compare the two monofilament breakaways. Calculation of the G statistics for log-likelihood ratio goodness-of-fit test was used to determine whether detachment rates differed (Sokal and Rohlf 1969).

1985 and 1988 Tagging Studies

Tag construction was the same as described for the evaluation study with two exceptions: (1) all tags were constructed with 2.7 kg-test monofilament breakaway, and (2) the numbered vinyl tubing tags were marked with the abbreviation "ADF&G." Tags were hung on longline racks and cloth strips were interwoven between tags to try to reduce tangling prior to deployment. A local longliner, the *F/V Java* was chartered to deploy the rockfish tags. On May 3, 1985, the tags were transported to the 50-fathom edge off the southern point of Cape Edgecumbe on Kruzof Island, and three sets were made (Figure 2). Tags were arranged in a series on two longline racks with a pattern of 10 tags followed by 5 standard gangions. Hooks were baited as the gear was deployed. Observers recorded the number of tags set, the number of tags detached, and the species composition of the catch taken on the standard (non-tag) hooks. Tags that were broken or fouled on deck were recovered. Posters describing the tag and requesting return information were distributed to local processors and tacked to dock bulletin boards.

Rockfish tags were set on July 17 and 18, 1988, as part of a resource assessment survey. In a further effort to reduce tangling during transportation to the site, tags were coiled in 11-kg coffee cans. The tags were set on a pinnacle offshore of Biorka Island to determine the rate of emigration by rockfish to other pinnacles (Figure 2). Standard hooks were interspersed every fifth gangion. Again, observers recorded the tags deployed and detached and the species composition on interspersed standard hooks. I alerted most of the fishermen who fished in this area about the tagging effort and the importance of recovering tags.

RESULTS

1983 Evaluation Study

At Ataku Island, 111 tags were deployed—i.e., presented or made available—and 46 tags were de-

TABLE 2.—Species composition by set and location for August 1983 tag evaluation study.

Location/set	Common name	Scientific name	Percent frequency
Ataku Is.	Pacific halibut	*Hippoglossus stenolepis*	50.0
	Silvergrey rockfish	*Sebastes brevispinis*	25.0
	Anemone	*Metridium senile*	25.0
			100.0
Symonds B. #1	Pacific halibut	*Hippoglossus stenolepis*	25.0
	Black rockfish	*Sebastes melanops*	37.5
	China rockfish	*Sebastes nebulosus*	12.5
	Yelloweye rockfish	*Sebastes ruberrimus*	25.0
			100.0
Symonds B. #2	Pacific halibut	*Hippoglossus stenolepis*	7.7
	Lingcod	*Ophiodon elongatus*	7.7
	Silvergrey rockfish	*Sebastes brevispinis*	7.7
	Black rockfish	*Sebastes melanops*	53.8
	Yelloweye rockfish	*Sebastes ruberrimus*	23.1
			100.0

TABLE 3.—Chi-square analysis of attachment strength on detachment rate by location, August 1983.

		No. Deployed		No. Detached		Sample	
Date	Location	1.8 kg	2.7 kg	1.8 kg	2.7 kg	X^2_i	$P > X^2_i$
8/14	Ataku Is.	56	55	22	24	0.216	0.642
8/15	Symonds B.	69	70	57	61	0.557	0.455
8/15	Symonds B.	17	13	14	10	0.014	0.903

[1]H_0: Detachment of tags is independent of attachment strength. Reject H_0 when X^2_i >3.841 ($X^2_{0.05,1}$).

tached when the gear was retrieved. At Symonds Bay, 169 tags were deployed and 142 were detached (Table 1). Of the tags detached, I could not enumerate the number taken by fish versus the number lost by snagging. Species composition, based on catch from the standard hooks, differed by location (Table 2). Halibut *Hippoglossus stenolepis* predominated at Ataku Island, whereas black rockfish *Sebastes melanops* and yelloweye rockfish predominated at Symonds Bay.

A chi-square test for independence indicated there was no significant difference in detachment rate between 1.7-kg and 2.8-kg test monofilament (Table 3). The detachment rate was twice as high at Symonds Bay sites, and the catch rate for yelloweye rockfish was also higher at the Symonds Bay sites (Table 1). The G-statistic for the log-likelihood ratio goodness-of-fit test indicated the difference in detachment rate between areas was significant (Table 4).

Due to extremely poor visibility, the observers in the submersible were unable to make observations on conditions of single gangions and tags. The gear seemed to be laying on bottom correctly without major fouling.

1985 and 1988 Studies

Tags for these studies were constructed with 2.7-kg test monofilament. Although the previous study did not indicate a significant difference in detachment rate between the two test strengths, I decided that the 2.7-kg test monofilament was probably a better choice given the large size of adult yelloweye rockfish.

Three sets were made at Cape Edgecumbe, and a total of 782 tags interspersed with 2,470 regular hooks

TABLE 4.—G-test for independence in 3-way analysis: location, areas, proportion detached.

Source	df	G statistic	P > G
Location—Attachment Strength–No. Detached	7	57.31	P << 0.001
Location—No. Detached	2	55.92	P << 0.001

TABLE 5.—Location of sets, numbers of tags deployed and detached, detachment rate, and CPUE for the standard (non-tag) hooks for the Cape Edgecumbe tagging site, May 3, 1985.

		Number of Tags			CPUE (Catch/Hook)	
Set	Depth	Deployed	Detached	Detachment Rate	All Fish	Yelloweye Rockfish
1	57 fathom	431	300	0.69	0.35	0.07
2	53 fathom	308	225	0.75	0.30	0.07
3	18–48 fathom	43	24	0.56	0.17	0.05

TABLE 6.—Species composition from the standard (non-tag) hooks fromCape Edgecumbe sites, May 3, 1985.

		Species Composition (%)		
Common Name	Scientific Name	Set 1	Set 2	Set 3
Unidentified Starfish	*Asteroidea*	3.52	0	0
Pacific cod	*Gadus macrocephalus*	11.97	0	0
Kelp greenling	*Hexagrammos decagrammos*	0	0	1.65
Pacific halibut	*Hipoglossus stenolepis*	61.97	36.51	9.89
Ratfish	*Hydrologus colliei*	1.06	0	0
Octopus	*Octopus defleini*	0	0	0.55
Lingcod	*Ophiodon elongatus*	0	0.53	1.65
Unidentified flounder	*Pleuronectidae*	0	0	0.55
Silvergrey rockfish	*Sebastes brevispinis*	0.35	1.59	3.85
Yellowtail rockfish	*S. flavidus*	0	0.53	0
Rosethorn rockfish	*S. helvomaculatus*	0.35	33.33	2.75
Quillback rockfish	*S. maliger*	0	0	36.81
Black rockfish	*S. melanops*	0	0	7.69
China rockfish	*S. nebulosus*	0	0	6.04
Tiger rockfish	*S. nigrocinctus*	0	0	1.10
Canary rockfish	*S. pinniger*	0.35	3.17	0.55
Yelloweye rockfish	*S. ruberrimus*	20.42	24.34	26.92

were fished. A total of 549 tags were detached (Table 5). Species composition in this area was dominated by halibut and yelloweye rockfish (Table 6). On several occasions rosethorn rockfish *S. helvomaculatus*, a small species, were taken on unbroken tags during gear retrieval. The circle hook was firmly set in the jaw, but the fish were not strong enough or heavy enough to break the monofilament. One tagged yelloweye rockfish was recovered from the tags deployed in this area. It was a 51-cm male yelloweye rockfish in good condition, had been tagged for 570 d, and was recovered on the same reef as tagged (Table 7). The hook and tag were set in the lower jaw, and the tag did not seem to have impeded its feeding (Figure 3). The hook was severely rusted in all areas that were not actually in contact with fish membranes, and the maxillary bone had worn the hook fairly thin.

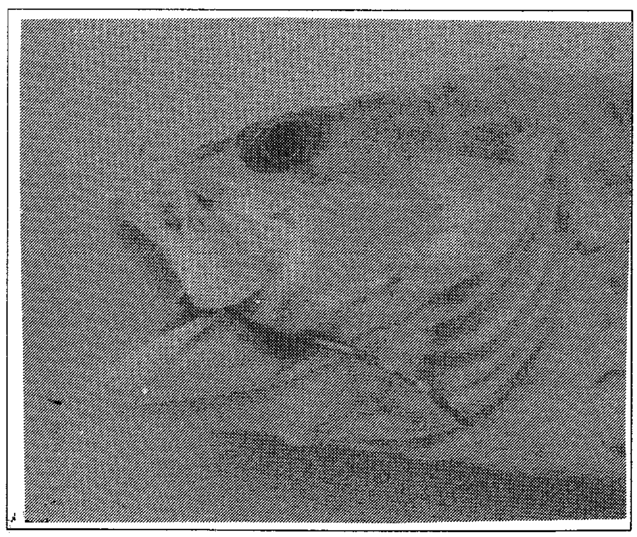

FIGURE 3.—Tagged yelloweye rockfish recovered 570 days after tagging.

TABLE 7.—Returns from yelloweye rockfish tagged from 1985 and 1988 tagging.

Tag No.	No. Days Tagged	Length and Tagging Site and Date	Retrieval Site	Condition
#306	570	Cape Edgecumbe 3 5/2/85	tagging site	51 cm, good
#894	323	Biorka Pinnacle 2 7/17/88	tagging site	NA, good
#926	309	Biorka Pinnacle 1 7/18/88	tagging site	45 cm, good

At the Biorka Pinnacles survey site 828 tags were deployed in two sets in July 1988. Of these, 714 tags were detached (Table 8). Yelloweye rockfish comprised 51% of the catch from the 164 standard hooks fished (Table 9). A total of four tags from the first set were recovered from yelloweye rockfish that were taken on standard hooks during the second set: two tags were regurgitated by fish as the fish were being brought on board, and two tags were found in the stomachs of fish. Two more tagged fish were recovered through August 1991. Both were adult yelloweye rockfish in good condition; one had been tagged for 309 d and the other for 323 d (Table 7). Both were recovered on the same reef on which they were tagged. One of the fish had a sore in the area of the tag but did not seem otherwise affected. The tags were both beginning to rust on the eye end of the hook.

DISCUSSION

This tagging technique seems applicable to demersal rockfishes, particularly the larger species like yelloweye. Although I did not test J-hooks, the retrieval of jaw-hooked rosethorn rockfish and recovery of tagged yelloweye rockfish indicate that circle hooks are effective. Intuitively they also seem to be the best choice for correct hooking angle and tag retention. Grimes (1983) used both circle and J-hooks but did not recover any fish tagged with J-hook tags. Horn (1989) found circle hooks to be the most effective for tagging, and he had no problem with foul-hooking of circle hooks as he did with other hook types.

Breaking strength is important to the success of this type of tagging program. There was no significant difference found in detachment rates between the 1.8- and 2.7-kg monofilament; however, sample sizes and areas fished may limit this finding. I chose to use the heavier test breakaway line in the 1985 and 1988 studies because yelloweye rockfish are large fish. The retention of rosethorn rockfish on unbroken tags indicates that 2.7-kg monofilment may be too strong for smaller rockfish to break.

Some problems with this tagging procedure are the expense of the tags—including the time involved in construction—tangling of tags prior to deployment, and hook rusting. Materials for the tag design described cost about $1.00 per tag, of which $0.60 was the cost of the snap. Construction of tags for conventional longline gear would be much less expensive. Substituting cotton gangion material for the monofilament and sleeves would also reduce cost and possibly

TABLE 8.—Location of sets, number of tags deployed and detached and CPUE for standard (non-tag) hooks for Biorka pinnacle sites, July 17 and 18, 1988.

		No. of Tags			CPUE (catch/hook)	
Set	Depth	Deployed	Detached	Rate	All fish	Yelloweye
1	91-95 fm	479	435	0.91	0.45	0.23
2	83-96 fm	349	279	0.80	0.41	0.19

TABLE 9.—Species composition of tagging sets, Biorka Pinnacle, July 17 and 18, 1988.

Species	Scientific Name	Species Composition (%) Set 1	Set 2
Pacific cod	*Gadus macrocephalus*	0.0	7.1
Basket star	*Gorgonocephalus eucnemis*	2.3	3.6
Pacific halibut	*Hippoglossus stenolepis*	32.6	32.1
Spiny dogfish	*Squalus acanthias*	2.3	0.0
Redbanded rockfish	*Sebastes babcocki*	9.3	3.6
Rosethorn rockfish	*S. helvomaculatus*	0.0	7.1
Yelloweye rockfish	*S. ruberrimus*	51.2	46.4
Urchin	*Strongylocentrotus pallidus*	2.3	0.0

reduce the problems with tangling. Corrosion of tags limits the number of years that that tag will remain attached. I was unable to find a supplier for stainless steel circle hooks that would have been more durable. Options currently available are galvanized, tinned, and cadmium-plated hooks with the latter being the best choice for durability. Horn (1989) manually bent stainless steel Mustad Beak hooks into circle hooks. Although this is an option for future studies, stainless steel hooks are fairly brittle, making them difficult and time-consuming to uniformly bend.

Tagging mortality may be increased when fish swallow the bait and are foul-hooked in the stomach or gills, etc. During the 1988 study, four fish (0.73% of tags detached) were retrieved that had swallowed tags., but none of these fish had actually been foul hooked. Rather, the hooks were loose and unattached to their stomachs, and I could find no wound indicating that the fish had actually been hooked in the stomach or elsewhere. The future effect the ingested tag would have had on the fish is unknown. When the tag is correctly attached to the jaw, feeding may be impaired; however, the three fish recaptured with tags in their mouths showed no signs of feeding stress.

All three of the long-term recoveries were taken from the same reef structure as tagged as were the four fish that had swallowed tags and were recovered the next day at the Biorka site. Although the data is limited, this suggests that adult yelloweye are residential. Because tagging and recovery both occurred during summer months there is no way of determining if seasonal movements occurred. Coombs (1979) also found no evidence of movement of adult yelloweye from the tagging site. She tagged 33 yelloweye rockfish, of which 8 were recovered. All of the fish recovered were taken from the same reef as tagged, the longest having been tagged 308 d.

The detachment rate of tags was generally 2 to 2.5 times higher than the CPUE for the regular hooks. Grimes (1983) reported a detachment rate approximately equal to CPUE. The higher detachment rate in this study is probably a result of tags snagging on the rocky bottom in our study sites. Breakaway tagging will not provide the actual number of fish tagged, but rather the theoretical maximum. I was unable to enumerate the number of tags taken by fish versus the number lost by snagging on bottom. Unlike tilefish, which are fairly monospecific, rockfishes occur in multispecies assemblages (Bracken and O'Connell 1986; Rosenthal et al. 1982). An indication of the percentage of tagged fish that are target species, i.e., yelloweye rockfish, was derived from the catch composition of the standard hooks.

An overall tag recovery rate of 0.24% in the 1985 and 1988 studies was based on the theoretical maximum number of tagged fish: i.e., all the detached tags equalled tags properly attached to the mouth of fish. A more reasonable estimate of the number of yelloweye rockfish tagged was based on the proportion of yelloweye rockfish taken on the regular hooks. Using the following equation I was able to estimate that 230 yelloweye rockfish were tagged:

$$\text{total tagged} = \sum\nolimits_{set} [(\text{no. tags deployed}) \times (\text{yelloweye CPUE})] \, , \qquad (1)$$

where CPUE was the catch per standard hook. Based on that number, the recovery rate for tagged yelloweye was about 1.5%, which is comparable to that reported for tagging studies of deepwater marine reef fishes using "conventional" tags (Grimes et al. 1982).

The four fish that had unembedded tags in their stomachs may have bitten down on the baited tag and, without being hooked, broken the leader and swallowed the bait. Conversely, they may have swallowed loose tags on the bottom that were broken off the gear during deployment or retrieval. Because these fish were not traumatized by a hooking wound, they may have been more likely to take another bait a short time later. The fact that none of the four short-term recaptures had embedded hooks seems to support the likelihood of short-term bait avoidance by hooked fish.

Fish that swallowed loose tags would be excluded through the adjustment for snagging loses (equation 1). However, unembedded tags broken off the gear by fish rather than snags would not be excluded through the snag-loss adjustment, and there was no procedure to quantify and exclude these loses. The incidence tags detached in this manner would inversely affect the estimate of fish tagged. For example, if 50% of the fish in my study took baits in this manner, then for long-term return analysis only about half of my estimate of 230 tagged fish would actually have been tagged, and the tag recovery rate would have been twice as high.

For several reason, however, I suspect that the incidence of unembedded tags detached by fish was negligible or low. It is difficult to believe that a large number of the rockfish could have broken the baits off the sets without being foul-hooked. Also, because the detachment rate of tags was about twice the CPUE of the regular hooks in all sets (Tables 5, 8), it is very likely that a large number of baited tags were loose on the reef. Because, yelloweye rockfish are aggressive feeders, it is reasonable to conclude that many of these baited tags would have ended up in their stomachs (Rosenthal et al. 1988).

Because it seems reasonable to believe that most unembedded tags had been ingested as loose baits that were broken off by snags, I believe that the estimate of 230 rockfish tagged does not need further adjustment. Nevertheless, because I cannot rule out the possibility that fish with unembedded tags broke the baits off the set without being hooked, this question may warrant attention in future studies. The breaking strength of the line might be examined further.

For short-term mark recapture studies requiring non-avoidance of recapture, this problem could be turned to an advantage. Extremely light breaking strength could allow presentation of loose tags that, when swallowed, would mark the fish without traumatizing it towards taking another bait shortly thereafter. This would only be practical for studies of very short duration and when all landed fish are eviscerated for tag recovery.

In conclusion, breakaway tagging is useful for investigating movement and migration of demersal rockfish species. This technique may also be useful for estimating stock size, but the number of fish tagged, the rate of tag loss, the occurrence of swallowed tags, the extent of tagging mortality, and the correct weight for the breakaway line may affect such estimates. These variables will need more study before population estimates should be attempted using breakaway tags.

LITERATURE CITED

Able, K.W., C.B. Grimes, R.A. Cooper, and J.R. Uzmann. 1982. Burrow construction and behavior of tilefish, *Lopholatilus chamaeleonticeps, in* Hudson Submarine Canyon. Environmental Biology Fishes 7(3): 199-205.

Bracken, B.E., and V.M. O'Connell. 1986. Longline fisheries monitoring in the eastern Gulf of Alaska, 1980-1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 258, Juneau.

Combs, C. 1979. Reef fishes near Depoe Bay, Oregon: movement and the recreational fishery. Master's thesis, Oregon State University, Corvallis.

Gotshall, D.W. 1964. Increasing tagged rockfish (Genus *Sebastodes*) survival by deflating the swim bladder. California Fish and Game 50: 253-260.

Grimes, C.B., S.C. Turner, and K.W. Able. 1983. A technique for tagging deepwater fish. Fishery Bulletin 81(3): 663-666.

Grimes, C.B., C.S. Manooch, and G.R. Huntsman. 1982. Reef and rock outcropping fishes of the outer continental shelf of North Carolina and South Carolina, and ecological notes on the red porgy and vermillion snapper. Bulletin Marine Science 32: 277-289.

Horn, P.L. 1989. An evaluation of the technique of tagging alfonsino and bluenose with detachable hook tags. New Zealand Fisheries Technical Report. 16.

Phillips, J.B. 1968. Review of rockfish program. California Department of Fish and Game, MRO Ref. 68-1.

Rosenthal, R.J., L.J. Haldorson, L.J. Field, V. Moran-O'Connell, M.G. LaRiviere, J. Underwood, and M.C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the southeastern Gulf of Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries unpublished report, Juneau.

Rosenthal, R.J., V. Moran-O'connell, and M.C. Murphy. 1988. Feeding ecology of ten species of rockfishes (Scorpaenidae) from the Gulf of alaska. California Fish and Game 74(1):16-37.

Sokal, R.R., and F.J. Rohlf. 1969. Biometry: the principles and practice of statistics in biological research. W.H. Freeman, San Francisco, California.