Preliminary Evidence from a Tagging Study for a Gag (*Mycteroperca microlepis*) Spawning Migration with Notes on the Use of Oxytetracycline for Chemical Tagging

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ABSTRACT

A tagging study of gag, *Mycteroperca microlepis*, was initiated off Charleston, South Carolina in 1987 to provide information on the movements of gag and to validate the periodicity of ring formation on otoliths. During 1987, 68 gag, 34-82 cm TL, were tagged and injected intramuscularly with approximately 70 mg oxytetracycline (OTC) per kg body weight of OTC containing 2-pyrrolidone (OTC-2). Fluorescent marks were detected in otoliths, but open wounds 10-15 mm in diameter, at the injection sites and hard, tar-like deposits were consistently observed along the injection channels. During 1988-1990, 79 gag, 25-84 cm TL, were tagged and injected with approximately 50 mg OTC per kg body weight of oxytetracycline containing povidone (OTC-P). Fluorescent marks were detected and no side effects were observed.

Of 147 gag 25-84 cm TL tagged, 43 were recaptured at least once, most at the study site. Two recaptures were at other locations off South Carolina, indicating that localized movements may occur. The greatest movements were by large individuals. Of the six gag > 75 cm TL recaptured, three were caught at the tagging site, two in May and one in September. Recapture dates and locations of large gag, including the three individuals recaptured elsewhere (southern Georgia, central Florida, and southern Florida), suggest that at least some gag participate in a spawning migration to waters off southern Florida, and also suggest a single stock of gag for the Atlantic coast of the southern United States. Management measures to protect any spawning aggregation that may be associated with this apparent migration could result in regional stock enhancement.

KEY WORDS: grouper, reef fish, Serranidae.

INTRODUCTION

Gag, *Mycteroperca microlepis*, is a reef serranid of recreational and commercial importance along the Atlantic coast of the southeastern United States and in the Gulf of Mexico (Smith, 1971, 1978). Age and growth of gag have been estimated from examination of otolith rings from fish from the Gulf of Mexico (McErlean, 1963) and the South Atlantic Bight (Manooch and Haimovici, 1978; Collins *et al.*, 1987), but no studies have provided direct evidence for age validation. Validation of the periodicity of ring formation is

necessary to ensure the accuracy of ages determined from hard parts of fishes. Validation can be obtained from the use of known age individuals or by chemically labelling hard parts (Beamish and McFarlane, 1983). A common method of labelling otoliths is by injecting, feeding, or immersing fish in the antibiotic oxytetracycline (OTC) (Wild and Foreman, 1980; Nagiec *et al.*, 1983; Hettler, 1984). Various types, concentrations, and brands of this antibiotic are available, but these may produce variable results (Foreman, 1987).

Several tropical serranids, especially grouper, are known to undertake spawning migrations and/or form spawning aggregations (Smith, 1972; Colin *et al.*, 1987; Olsen and LaPlace, 1978). Along the Atlantic coast of the southeastern United States, however, extensive movements of serranids are unknown. Seasonal inshore-offshore migration by black sea bass (*Centropristis striata*) have been reported, but movements of other species have not been observed (Lavender, 1949; Parker, 1990).

The purpose of this report is to present preliminary evidence from a tag/recapture study for the existence of a gag spawning migration. In addition, the reactions of gag to two types of OTC used for age validation is presented.

MATERIALS AND METHODS

One hundred forty-seven gag, 25-84 cm TL, were captured by angling and trapping during 1987-1990, at a natural reef site 35 km southeast of Charleston, South Carolina in 22 m depth (Table 1). Upon capture, fish were placed in a 1.0 x 1.5 x 1.5 m container with a flow-through seawater system, swim bladders were deflated with an 18 gauge hypodermic needle, and lengths (standard, fork, and total) were measured to the nearest mm.

Table 1. Number and length of gag (*Mycteroperca microlepis*) tagged and recaptured from 1987-1990.

Year	No. Tagged	No. Recaptured	Length at Tagging (cm TL)
1987	68	25	34 - 82
1988	41	12	25 - 84
1989	15	3	35 - 84
1990	23	3	31 - 80
Total	147	43	25 - 84

Two types of tags and OTC were used. In 1987, Petersen disk tags were applied below the dorsal fin, and OTC containing 2-pyrrolidone (OTC-2) was injected into the dorsal musculature at a dosage of approximately 70 mg OTC per kg body weight (weight estimated from length-weight relationship;

Manooch and Haimovici, 1978). Thereafter, during 1988-1990 internal anchor tags were inserted into the peritoneal cavity. These tags consist of a polyethylene streamer connected to a laminated, oval-shaped anchor. OTC containing povidone (OTC-P) was injected intramuscularly at a dosage of 50 mg OTC per kg body weight. All injections were made using a 5 ml syringe and an 18 gauge needle. The tags were labelled with the address of our laboratory and the words "reward" and "save head".

Project personnel made directed efforts to recapture gag by spearfishing, and many fish were recaptured during tagging operations. Recaptured gag which had been at large for at least a year were sacrificed, measured, otoliths removed, and the tag and injection sites examined. Most fish at large for less time were measured and released, but some were sacrificed specifically for necropsy in order to evaluate the effects of tagging and OTC injection. Cross sections were made on the dorsoventral plane of the sagittae from each fish. Sectioned otoliths were viewed with a Nikon Labophot microscope with an epifluorescence attachment.

RESULTS

Retention of Petersen disk tags was poor, as indicated by wounds surrounding the tags, bent condition of tags, and diver observation. During 1987-1988, at least seven gag that had lost their Petersen disk tags were recaptured. These fish were identified by open wounds 10-15 mm in diameter at the injection (OTC-2) sites, deposits in the musculature in the injection channels, and scars or wounds where tags were torn out. The tar-like deposits in the musculature were hard, black, 23-71 mm long, and 5-18 mm maximum width (Figure 1). Analyses of these deposits were made using high performance liquid chromatography (HPLC), comparing it with a standard OTC-2 sample. However, the deposits had broken down chemically and it was impossible to compare the chromatograms with the standard. Currently there are no known reliable techniques for analyzing the compounds that have broken down from the OTC (M. Litchman, Pfizer, pers. comm.). Gag recaptured with Petersen disk tags present also exhibited the wounds and deposits associated with injection of OTC-2 (Figure 2). Fluorescent marks were visible on sectioned sagittal otoliths of all recaptured fish.

The internal anchor tags used after 1987 had a high retention rate, and the incision made for tag application was healed completely in most fish at large for a few months. No external wounds at the injection site (OTC-P) sites were observed, and no intramuscular deposits were observed during necropsies. Fluorescent marks were visible on sectioned sagittae.

Of 147 gag 25-84 cm TL tagged, 43 were recaptured at least once, representing a recovery rate of 29%. Most recaptures were by project personnel at the study site. Commercial and recreational fishermen reported nine

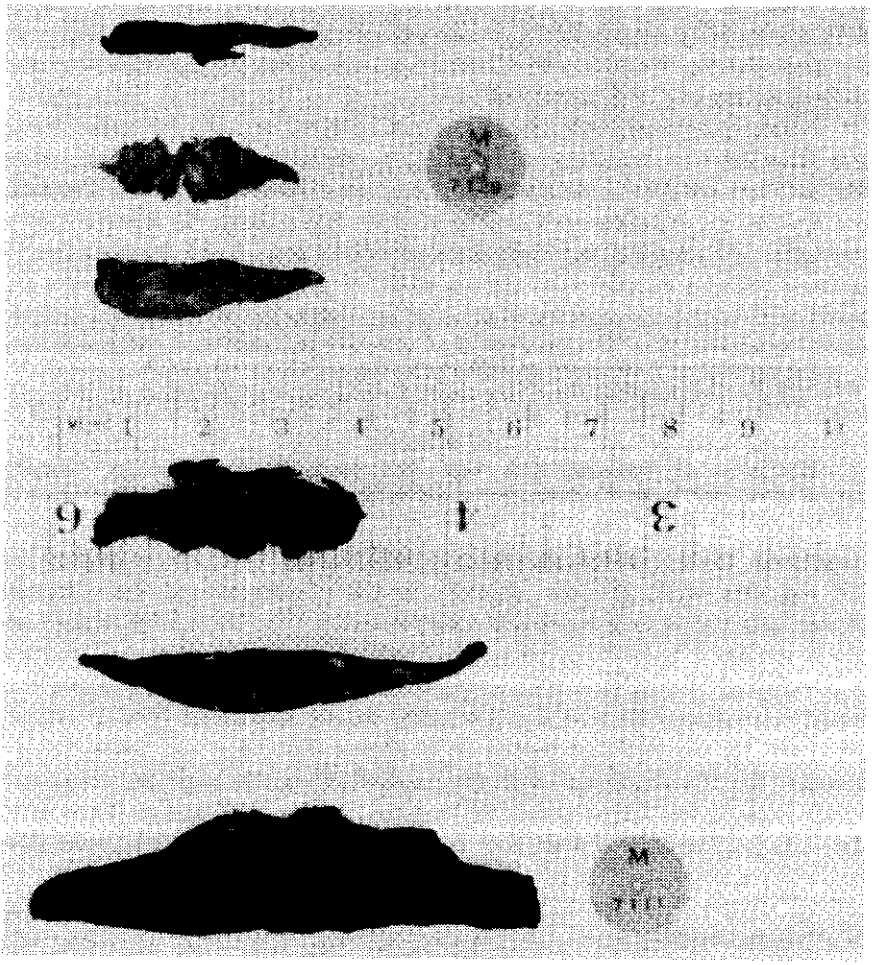

Figure 1. Intramuscular deposits removed from gag (*Mycteroperca microlepis*) at sites of injection with oxytetracycline containing 2-pyrrolidone (OTC-2).

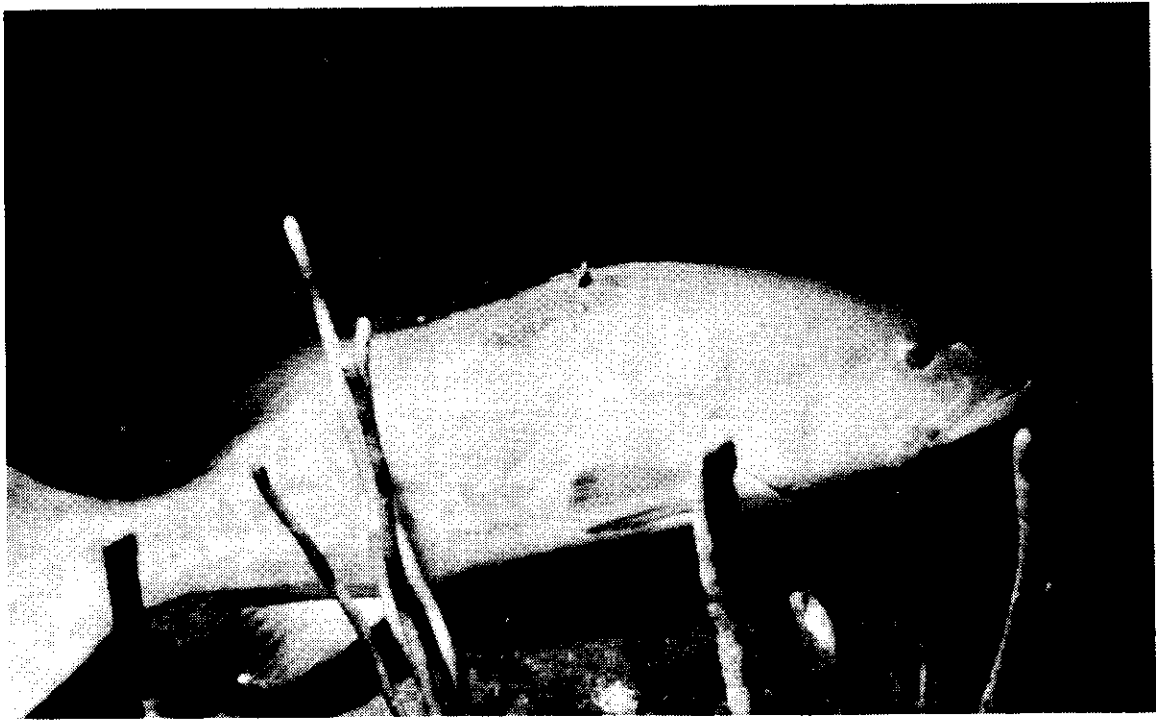

Figure 2. Underwater photograph of a gag (*Mycteroperca microlepis*) with a wound at the site of injection with oxytetracycline containing 2-pyrrolidone (OTC-2) and with a damaged Petersen disk tag.

recaptures, five of which were outside the study site. Four of the five fish recaptured outside of the study site had moved southward 54-621 km, and one was recaptured 93 km northeast of Charleston (Table 2).

Table 2. All recaptured large (> 75 cm TL) gag (*Mycteroperca microlepis*) and all gag showing movement. Recapture lengths were considered questionable (?) if fish were not measured by project personnel.

TAGGING		RECAPTURE				
Date	cm TL	Date	cm TL	Days at large	Min. distance traveled (km)	Recapture location & depth
09-28-87	67	07-17-90	65?	1,021	54	46 km E of mouth of Savannah River; 16 m
05-18-87	69	02-21-89	78?	646	93	NE of Charleston, SC;49 m
04-11-88	75	02-02-89	78?	297	621	7 km E of JupiterInlet, FL; 20 m
09-28-87	77	05-25-89	83?	603	0	Study site
07-07-87	81	09-28-87	81	82	0	Study site
05-24-89	81	11-06-89	—	16	241	28 km E of Cumberland Is., GA; 15 m
05-06-88	82	05-08-88	82	2	0	Study site
09-20-88	84	12-12-88	—	83	416	30 km NE of Ponce de Leon Inlet, FL; 20 m

Of the 147 gag tagged, 27 were large (75-84 cm TL), six of which were recaptured with tags (Table 2). In addition, two large gag (78 and 83 cm TL) without disk tags but with intramuscular OTC deposits were recaptured at the study site in May 1988. Three of the six large gag recaptured with tags moved extensively southward 241-621 km. One of the three was recaptured in November at an artificial reef in 15 m of water off Cumberland Island, Georgia. Another was recaptured in December off Ponce de Leon Inlet, Florida in 20 m of water. The third large gag was recaptured in February off Jupiter Inlet, Florida in 20 m of water. The remaining three large gag were recaptured at the study site.

DISCUSSION

The poor retention of Petersen disk tags was probably caused by the

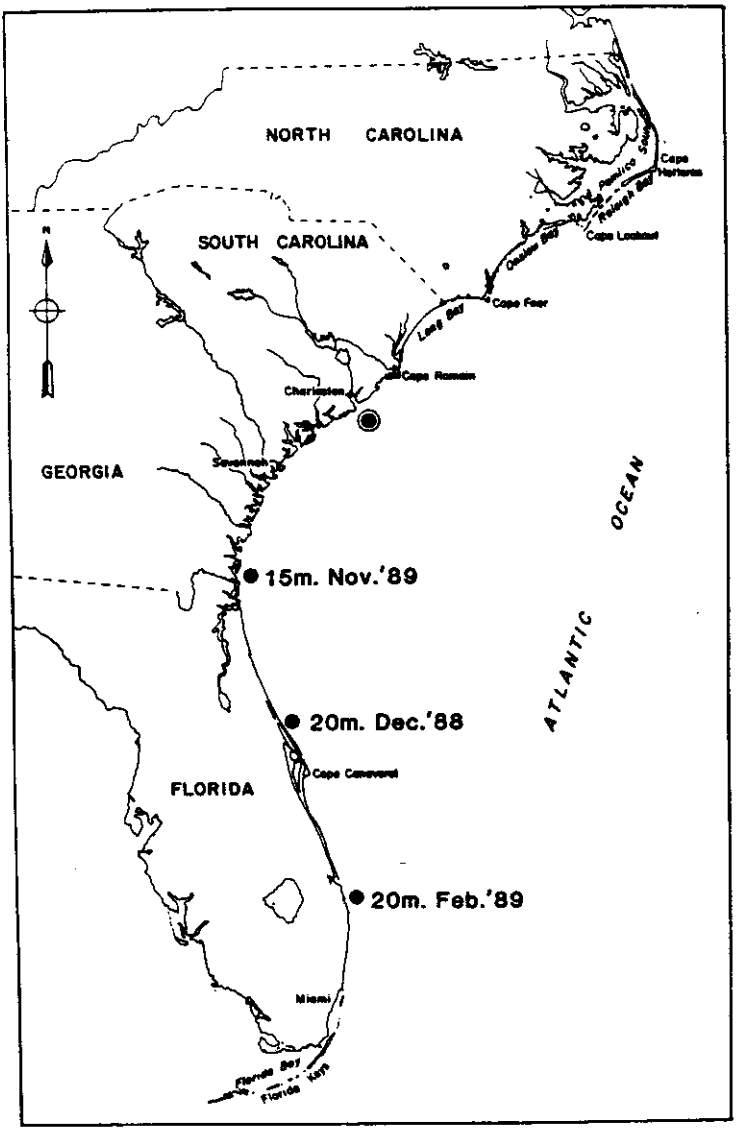

Figure 3. Study location (double circle) and locations and dates of recaptured gag (*Mycteroperca microlepis*) > 75 cm TL showing greatest movement.

flashing behavior of gag (sweeping of lateral surfaces against the substrate) observed by divers. The pins connected to the disk tags were usually bent posteriorly and the surrounding flesh torn and inflamed on recaptured fish. In a few fish, the pins had moved up through the dorsal musculature and lay loosely in the membrane of the dorsal fin. Internal anchor tags were apparently not subject to damage from flashing activity. Thus, we observed severe tag wounds from Petersen disk tags and shedding as reported by others (Volpe, 1959; Thomson, 1962; Topp, 1963). Parker (1990) observed that Petersen disk tags were retained better than dart tags in laboratory and field tests, but he did not test internal anchor tags. Internal anchor tags have been shown to be superior to Petersen disk tags for long-term tagging studies (Rounsefell and Everhart, 1953; Moe *et al.*, 1970).

Why open wounds and intramuscular deposits were associated with injection of OTC-2 but not with OTC-P has not been determined. Dosages were slightly higher in 1987 when OTC-2 was used than in later years, but dosages never exceeded the 100 mg OTC per kg body weight recommended for young salmon (Weber and Ridgway, 1962). Kobayashi *et al.* (1964) and Weber and Ridgway (1962) noted that mortality increased at dosages in excess of 100 mg OTC per kg body weight for goldfish and salmon, respectively. McFarlane and Beamish (1987) concluded that, based on numbers of tag returns, mortality of tagged sablefish injected with OTC (without 2-pyrrolidone) at 100 mg OTC per kg body weight was greater than that of sablefish tagged but not injected, but the difference in mortality could not be duplicated in laboratory trials. None of the previous studies reported deposits or open wounds at the injection sites. However, Marking *et al.* (1988) using multiple injections of higher dosages (165-275 mg OTC per kg body weight per injection; brand unknown), found tissue swelling and hardening, sloughing of the skin, and open lesions in lake trout. Kula (Pfizer, pers. comm.) suggested that open wounds and deposits may be partially caused by injecting > 1 ml per site intramuscularly.

OTC-2 contains the slow-release agent 2-pyrrolidone, which is intended to extend the antibiotic effects over time, whereas the povidone found in OTC-P is not a slow-release agent. Foreman (1987) suggested that 2-pyrrolidone diminishes the brilliance of the fluorescent marks produced on otoliths. We observed no difference in brilliance of marks produced by the two brands of OTC, although our dosages were higher than those of Foreman (1987). We believe that 2-pyrrolidone may be responsible for the negative effects associated with injection of OTC-2 since it is the key ingredient missing from OTC-P. Downing (Pfizer, pers. comm.) believes that the black deposits are OTC and not 2-pyrrolidone, since 2-pyrrolidone is a colorless liquid. Downing states that all OTC can cause irritations and lesions when injected into the muscle, and OTC containing propylene glycol or 2-pyrrolidone is more irritating than that containing the povidone. The 2-pyrrolidone may result in increased irritation

and intramuscular deposition since its long-acting formulation slows down absorption. We have no evidence that the open wounds and intramuscular deposits increased tagging mortality or slowed growth rates, but these possibilities should be investigated due to the widespread use of OTC. In addition, discovery by anglers of large black deposits in the flesh of tagged fish could adversely impact public reaction to tagging studies that include OTC injection.

Gag are generally considered to be rather sedentary (Beaumariage and Wittich, 1966; Moe, 1966), and our recapture data from smaller size classes of gag support this. Some movement of gag has been reported from tagging studies in the Gulf of Mexico (Moe, 1966; Beaumariage, 1969; Moe *et al.*, 1970), but most were relatively short distances over a several year period by immature fish. Small gag (< 56 cm TL; 18 tagged) were present at the study site in winter and evidently did not participate in the southerly migration. Divers on a reef off North Carolina observed large numbers (50-110) of gag in October and November and noticed that they vacated the reef when water temperatures dropped below 11° C and returned when temperatures increased (Parker, 1990). Anecdotal evidence from SCUBA divers (M. Gilligan, Savannah State College, pers. comm.) and from recreational and commercial fishermen indicates that local abundance of large gag increases in November-December off Georgia and during winter off Florida. Observations of gag aggregations were made off the central east coast of Florida during the winter that may be related to spawning (Gilmore and Jones, 1991). The movement of large gag may be significant since gag are known to mature > 60 cm TL and size at sex succession ranges from 75-95 cm TL (Collins *et al.*, 1987). Recapture of large gag off South Carolina in May and September, southern Georgia in November, central Florida in December, and southern Florida in February, together with other evidence, suggest that at least some mature gag migrate south during fall, remain off southern Florida during winter, and return north during spring.

Since peak spawning of gag in this region takes place during February-April (Collins *et al.*, 1987; Keener *et al.*, 1988), migration may be related to spawning activity, suggesting a single stock of gag along the Atlantic coast of the southeastern United States. Because spawning aggregations of other groupers appear particularly susceptible to overfishing (Craig, 1969; Olsen and LaPlace, 1978), further investigation into the possibility of a spawning aggregation of gag forming off southern Florida during winter is recommended. If an aggregation is located, protective measures to prevent overfishing may be necessary for regional stock conservation and enhancement.

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