SCRS/1991/053

Col.Vol.Sci.Pap. ICCAT, 39 (3) : 689-691 (1992)

A MARK-RECAPTURE EXPERIMENT ON BLUEFIN TUNA (Thunnus thynnus, LINN.) FROM THE BROWNS-GEORGES BANKS REGION OF THE CANADIAN ATLANTIC

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SUMMARY

The mark-recapture experiment on bluefin tuna from the Georges-Browns banks region of the Canadian Atlantic initiated in 1990 was continued in 1991. In addition to conventional dart tagging as part of the experiment to estimate stock size, an ultrasonic telemetry study was performed. Bluefin tuna were marked with ultrasonic transmitters to determine rates of post-release mortality.

RESUME

Les expériences de marquage-recapture de thon rouge dans la région des bancs Georges et Browns dans l'Atlantique canadien, lancées en 1990, se sont poursuivies en 1991. Outre le marquage traditionnel à dard comme élément de l'expérience visant à estimer la taille du stock, une étude de télémétrie à ultra-sons a également été effectuée. Le thon rouge a été marqué avec des transmetteurs à ultra-sons pour déterminer la taux de mortalité après marquage.

RESUMEN

En 1991 continuó el experimento de marcado y recaptura de atún rojo en la región de Georges Bank y Browns Bank, en aguas canadienses del Atlántico, iniciado en 1990. Además del marcado con dardo convencional, como parte del experimento para estimar el tamaño del stock, se llevó a cabo un estudio de telemetría ultrasónica. Se marcó atún rojo con transmisores ultrasónicos con el fin de hallar la tasa de mortalidad que tiene lugar una vez liberados los peces.

INTRODUCTION

During August, September and October 1990, the Canada Department of Fisheries and Oceans initiated a mark-recapture experiment to determine the size of the bluefin tuna stock from the Georges-Browns banks region of the Canadian Atlantic which forms the basis for the southwest Nova Scotia fishery (Porter and Hogans 1991). Sixty-two bluefin tuna were tagged and released during the experiment. While the study area comprises the region in which the most intensive commercial fishing for bluefin tuna in Canada occurs (Fig. 1), no confirmed recaptures were reported during the 1990 study period, although there was an unsubstantiated recapture reported caught off Cape Cod in the southern Gulf of Maine after approximately 35 days free. There are several plausible explanations for the low recovery rate of tagged fish: 1) dilution effect (large numbers of fish in the study area decreased the probability of recapturing marked tuna), 2) emigration of tagged fish away from the study area precluded any recaptures, 3) mortality of tagged tuna (stress induced by the capture method may have been responsible for mortality of released fish), and/or 4) post-tagging behavioral change making the tagged fish unavailable to the fishery. This lack of recapture data made the use of stochastic models (on which basis the experiment was originally designed; see Porter and Hogans 1991) unreliable for estimating population (stock) size.

In 1991, the multiple mark-recapture experiment was continued to improve our estimates of the localized population of fish. During the period 28 August-7 October, coinciding with the licensed commercial fishery, bluefin tuna were again tagged and released in the same study area used in 1990 (Fig. 1: centre of area 42°04'N, 65°35'W). Capture methods, tag types and basic experimental design were similar to those employed in 1990. In conjunction with the mark-recapture experiment, an investigation was undertaken to determine the effects of capture and tagging methods on post-tagging mortality and behavior of released bluefin tuna. This portion of the 1991 study used ultrasonic telemetry to track marked fish individually.

This paper reports on the results of the mark-recapture experiment to determine bluefin tuna stock size and the telemetry experiments to assess mortality rates and post-tagging behavior of tagged and released bluefin tuna.

MATERIALS AND METHODS

TAGGING WITH DART TAGS (MARK-RECAPTURE EXPERIMENT, 1991)

Capture methods and conventional dart tag types were similar to those used during the 1990 study (Porter and Hogans 1991). Three tagging periods were used in 1991 (28 August-1 September, 16-21 September and 3-7 October) to duplicate the effort of the previous year. All bluefin tuna were double-tagged to assess the tag shedding rate. The only capture gear modification in 1991 was the use of special bronzed release type hooks (Mustad Model #7731BR, size 9/0). These hooks are designed to be more easily thrown by fish and to deteriorate rapidly in seawater, thus reducing stress on released fish. In 1990, conventional galvanized "circle" hooks (the type used in the commercial fishery) were employed to capture tuna. In 1990, fishing was done from smaller commercial boats (12-15 m) and tagging trips were limited to 1 or 2 days fishing time. In 1991, tagging was conducted from the CSS E.E. PRINCE (overall length 40 m) which stayed on station in the study area for 4-5 days continually. The research vessel was provided with support staff who aided in capturing tuna, and the amount of time required to hook, tag and release an individual bluefin tuna in 1991 was reduced significantly from that recorded in the previous year.

ULTRASONIC TELEMETRY

Tracking vessel

Because bluefin tuna are capable of high swimming speeds, it was necessary to utilize an equally fast, specially equipped small boat to track fish tagged with ultrasonic transmitters. A Boston Whaler (4.6 m overall length) equipped with VHF radio, Loran C navigational aid and ultrasonic signal receiver was used during the experiments. This small craft was carried on, and launched from, the larger research vessel. Due to the small size of the tracking boat and the necessity of having visual contact between this craft and the larger vessel, tracking could only be accomplished during periods of optimal weather conditions (i.e. no fog, calm seas, etc.). The bow of the whaler was modified to support a depth-adjustable pole to which the hydrophone was attached. The hydrophone pole could be rotated manually to pinpoint directional signals from the transmitter, or fixed straight ahead which allowed the boat to determine direction of the fish.

Tracking materials
Ultrasonic transmitters

The transmitters used provided directional data only and were supplied by Vemco, Halifax, Nova Scotia. Directional types (5) were 32.8 kHz frequency; normal operating depth range was surface to 680 m. Transmitters were powered by lithium batteries and had an operational life of approximately 7 months. Maximum range (distance) at which signals could be discerned was approximately 1.5 km during calm seas and minimum noise from the commercial fishing fleet. The cylindrical transmitters were identical in size (155-mm length, 30-mm diameter) and weight (218 g in air; 26.4 g in seawater). A nylon strap was embedded in the end opposite the transmitter for use in attaching the unit to the fish. Transmitters were activated by connecting two wires projecting from beneath the nylon loop. The nylon loop on the transmitter and was attached to two 120-lb test nylon monofilament tracer (see Fig. 2). The trace ends were provided with two metal anchors of the same shape as those used on conventional plastic dart tags, although approximately twice as large. The space between the transmitter end and nylon loop was filled with epoxy putty to make the transmitter more hydrodynamic.

Signal receiver

The amplifier/receiver was powered from a 12-V DC marine battery mounted in the tracking boat (this power source also ran the VHF and Loran C systems). The receiver (also made by Vemco), Model VR-60, had a frequency range of 10-100 kHz and is designed to operate with high gain, low noise hydrophones. Ten preset channels were stored in the receiver, ranging from 12.5-76.0 kHz, adequately covering the range of transmitter signals recorded during the present study. The VR-60 receiver contains a 64K data storage memory and logging software option and can be operated by interface with an external keyboard and/or computer. An additional receiver (CAI, Model CR-40) with channel selection capability (and smaller frequency band width) was used in conjunction with an omnidirectional hydrophone (unmounted) on the large vessel to supplement tracking.

Hydrophone

Three hydrophones were utilized to track fish during the study. The hydrophone mounted on the tracking boat was made by Vemco (Model No. V-11). This high gain hydrophone was attached to the bottom of the pole mounted on the whaler bow. The hydrophone was modified by incorporating a fibreglass shield to leading edge after the design of Holland et al. (1985). This shield helped protect the face of the hydrophone from impact damage and served to reduce noise from water as the boat moved forward. Sonic-tagged fish were followed at speeds up to 15 knots using this modified hydrophone. A smaller, hand-held directional hydrophone mounted on a short wooden pole was used in the tracking boat, a supplement to, and backup for, the bow-mounted device. A cylindrical, omnidirectional hydrophone was used from the research vessels to supplement small boat tracking, and to check for the presence of tagged fish on subsequent days.

Tagging and tracking technique

Bluefin tuna used in the telemetry experiments were caught in a manner identical to that used for conventional tagging, i.e. on tended line gear. Activated transmitters with tracer and anchors attached, and hardened putty were mounted on the end of a harpoon pole and the metal anchors inserted in the tagging pins (see Fig. 2). When brought to boat side, the tuna was harpooned with the sonic transmitter. The metal anchors were inserted into the fishes' musculature near the base of the posterior dorsal fin, the attached transmitter pulling free of the harpoon mount at the same instant. The leader was then severed as close to the hook as possible and the fish released.

Good weather days were reserved exclusively for ultrasonic experiments. On these days, the tracking boat was launched before fishing started. When a tuna was hooked, the boat was brought close to the stern of the large vessel (where tagging took place), the hydrophone lowered to a depth of 0.5 m and the receiver switched on. After the tagged fish was released, the boat followed at a distance of 100-500 m, while attempting to retain an optimal signal (determined by audio strength and/or microampere level as shown on the receiver), and leaving enough distance between boat and transmitter so as to not influence the fish's behavior. The larger vessel followed the tracking boat at approximately 500-800 m, more if machinery or propeller noise noted on the receiver was causing interference to signal reception. Generally, data gathered every 5 minutes while following the tagged bluefin were: 1) navigational position, 2) depth (pulses per minute), 3) compass heading, 4) time. During tracking of fish, XBT (expendable bathythermagraph) probes were launched from the research vessel very 30 minutes and water temperature, thermocline profiles recorded.

Fish tagged with directional data output transmitters were followed to determine if mortality resulted from the capture procedure. If a directional transmitter-tagged tuna swam continuously for longer than 2 hours, the fish was assumed to be in good condition and not adversely affected by capture stress. At the beginning of each day, an attempt was made to locate fish which had been previously tagged with transmitters and, when found, their positions and behavior were recorded.

RESULTS AND DISCUSSION

In 1991, 68 bluefin tuna were double-tagged with conventional dart tags and released: period 1 - 36 fish, period 2 - 26 fish, period 3 - 6 fish. The first tuna was tagged on 29 August 1991. The average capture time (from hooking to release) was 8 minutes; the longest capture period was 18 minutes, the shortest 1.5 minutes. The additional personnel on the research vessel enabled a significant reduction from 1990 in the time from hooking to release. Visual observations indicated that most tuna swam away actively after release. Each tagging trip lasted an average of 4 days in 1991, 2 days longer than that recorded during 1990.

One confirmed recapture from the study has been made - a fish tagged in 1990 was recaptured in the study area in 1991. Another unconfirmed recapture was made during the 1991 fishery in the study area. Two as yet unconfirmed recaptures have been made in the US fishery (Mass.) in the same year as tagging.

In 1991, three bluefin tuna were tagged with ultrasonic transmitters and released. The first tuna released was tracked for 2 hours, 33 minutes; during this period, it swam actively away from the tagging location and was considered to have survived the tagging procedure. The second tuna tagged in this experiment apparently sounded below the transmitter's functional depth range (680 m) immediately after it was released. It is not known if this represents a mortality after release or an intentional movement by an unharmed fish. The third tuna marked with a telemetry tag was never received by any of the tracking equipment after its release; adverse weather conditions were recorded as responsible for this result. Generally, the predominance of unsuitable weather conditions hampered our efforts to implant ultrasonic transmitters and track the bluefins. Only good weather periods could be utilized for the telemetry experiments and there were very few of those in 1991.

The probable reasons for the low recovery rate of tagged fish remain essentially those proposed following the 1990 season: 1) high population size, decreasing the probability of recapture. Given that 133 fish were tagged in the 2 years and the high intensity of the commercial fishery, this is suggestive of a potentially large stock size, but is in no way conclusive; 2) tagged fish migrated away from the commercial fishing area. Two unconfirmed recaptures from the US fishery of fish tagged in that same season suggest at least some migration from the study area; 3) mortality of fish unacceptably high. After this year's field program, visual observations after release of tagged fish, recaptures (confirmed and unconfirmed) reported, and the telemetry experiments, although not conclusive, show that at least some of the tuna survive the tagging process; 4) post-tagging behavior makes the fish temporarily unavailable to the fishery. The results from the second telemetry tag could be due to a post-tagging behavioral response (sounding), though equally plausible is fish mortality.

The results presented here are preliminary and the study is still in progress. Further efforts are being made to obtain recapture data (letters to all licensed tuna fishermen in Atlantic Canada, presentations to industry, and contact with US fishing and tagging groups). Recapture data from 1991, combined with tag and release data from both years plus the telemetry experiments should provide a more realistic estimate of bluefin tuna population size than was calculated in 1990 (when no recaptures were recorded).

It is the intention to continue both conventional population studies using dart tags and ultrasonic telemetry experiments on the Georges-Browns banks bluefin tuna in 1992.

LITERATURE CITED

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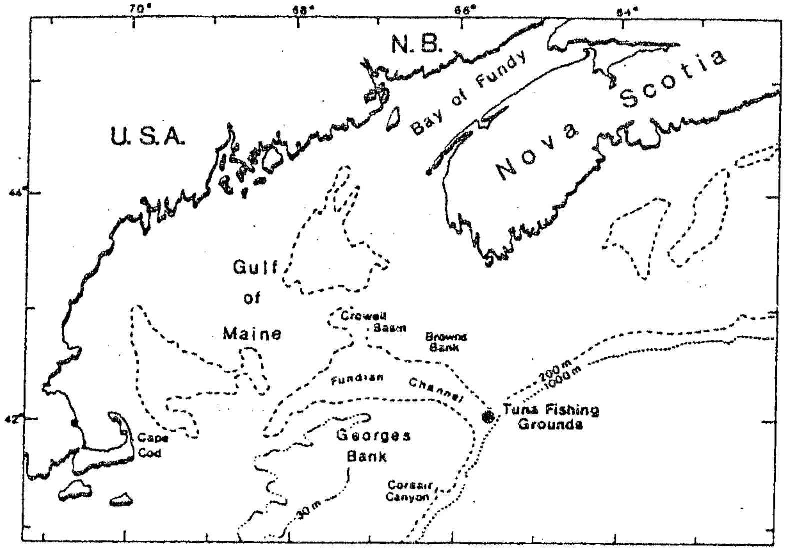

Figure 1. Location of the southwest Nova Scotia bluefin tuna fishery and site of mark-recapture and telemetry experiment.

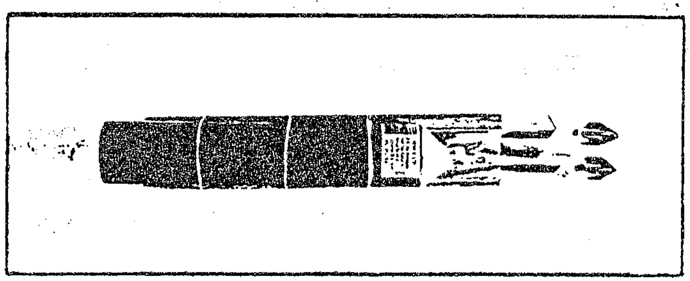

Figure 2. Photograph of the telemetry tags used in the 1991 experiment.