MFR PAPER 990

A new device offers fishermen and scientists a means for tracking king crabs under water.

Sonic Tags Attached to Alaska King Crab

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ABSTRACT

A system for monitoring the location and movement of free-moving Alaska king crab in their natural environment is described. The sonic tag and related ultrasonic tracking equipment were used on crab in the Bering Sea near Unalaska, Alaska. Feasibility tests indicated the system appears to be a feasible tool for aiding in the harvest and management of king crab.

INTRODUCTION

In the last few years, there has been considerable interest in biotelemetry among fishery biologists. Biotelemetry has manifested itself in a variety of ways including "tracking" of various sea creatures from fish to lobsters, primarily to learn more about their behavior and physiology (Clifton, et al., 1970; Johnson, 1960; Moll and Legler, 1971; Trefethen, 1956; and Yuen, 1970). Recently, however, sport and commercial fishermen have become increasingly interested in direct adaptation of these research tools to increase the efficiency of harvesting techniques (Monan, 1971; Laurs, Johnson, and Yuen[1]).

The objective of our study was to explore the feasibility of utilizing sonic tags to aid in the harvest and management of the Alaska king crab. Tests were performed in Unalaska, Alaska, and aboard the MV *Dauntless* in the Bering Sea near Unalaska in September 1972. The sonic tags were fabricated by the Northwest Fisheries Center (NWFC), National Marine Fisheries Service (NMFS), in Seattle, Washington, and taken with the related tracking gear to the Unalaska area for testing.

SONIC TAG AND RELATED EQUIPMENT

Three main components make up a sonic tracking system: the sonic tag or pinger, the hydrophone, and the receiver. The tag is attached to or placed inside the animal to be tracked and transmits a signal through the water. This signal is picked up by the directional hydrophone and fed into a receiver, where it is amplified and converted to an audible tone. The hydrophone is rotated in the water until the maximum signal is heard; the direction of the hydrophone then indicates the direction of the tagged animal from the operator.

The sonic tags and hydrophone used in this study were designed and built by personnel of the Division of Coastal Zone and Estuarine Studies, NWFC, NMFS. A commercial receiver was used.

Sonic Tag

Tags for the king crab are made up in two parts fastened together to make a single unit (Figure 1). The electronic portion of the tag lies atop a molded base used to attach the tag to the crab. A schematic diagram of the electronics is shown in Figure 2, the parts list given in Table 1. The batteries and electronics, except coil T-2 and the reed switch, are placed inside the hollow hemispherical crystal. The coil and the reed switch are located just outside the crystal. The crystal is then filled with epoxy resin (Furane plastics Epocast 202[2]), which is allowed to harden. The coil and the reed switch are covered with epoxy when the electronic portion of the tag is united with the base.

The base portion of the tag is made to conform to part of the carapace of the king crab. Plaster of Paris is used to make an impression of the area surrounding the concavity between the right and left branchial regions of the carapace. A mold is subsequently made from this impression.

To assemble the tag, two lengths of nylon covered steel wire are placed in the mold so the ends protrude, two on each side of the midline on the forward edge of the tag and two on each side of the midline on the rear edge of the tag. The pre-potted electronic portion of the tag is set into the mold, flat side down, and the mold filled with epoxy to approximately ⅜-inch on the side of the crystal. Epoxy is also brushed over the crystal until it is completely covered by a thin layer.

The completed tag, including the

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[1] Laurs, Michael, James M. Johnson, and Heeny S. H. Yuen. Manuscript in preparation. Short term movements of albacore off central California as determined by ultra-sonic tracking. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California.

[2] Use of trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service.

base, is 2½ inches in diameter and 1½ inches high. Its weight is 4.9 ounces (140 g) in air and 2.9 ounces (85 g) in water. It operates at a frequency of 45 kHz with a pulse rate of 2 pulses per second. Duty cycle is 2% and tag life, approximately 5 days. Acoustic output measured on the center line of the crystal is 68 db, reference 1 μ bar at 1 yard. A magnet placed on the outside of the tag over the reed switch keeps the tag inactive until the magnet is removed just before tagging.

Hydrophone

The hydrophone consists of a 90° conical, cork-lined, stainless steel reflector (7 inches maximum diameter), with two 50 kHz piezoelectric ceramic cylinders (Edo Western PN 17097) mounted on the axis of the cone. The sensitivity of the unit is −82 db reference 1 volt/μ bar at 1 yard. The beam pattern, conical and rather sharp, is −3 db at 12° and −20 db at 30°. During our tests the hydrophone was mounted on the side of the *Dauntless* at the end of a long steel pipe which extended vertically beyond the keel level. The pipe was fastened to the hull in a mounting that allowed the operator to rotate the hydrophone 360°. It was also possible to control the tilt of the hydrophone from an attitude approximately parallel with the water surface to a point where the hydrophone was pointed straight at the bottom of the sea.

Receiver

The sonic receiver used during these tests was a Lawson VLF-1 with a tuning range of 20 to 80 kHz and a sensitivity of 1 μ volt at 10 db signal to noise ratio.[3] The receiver operates on the superhetrodyne principle with mechanical bandpass filters to provide extremely sharp selectivity characteristics. A tunable beat frequency oscillator provides an audio tone for continuous wave signals. The unit operates on batteries or a.c., has an output of 1 watt, and a self-contained speaker and phone jack.

[3] This receiver has been discontinued by the manufacturer, but similar sonic receivers are available.

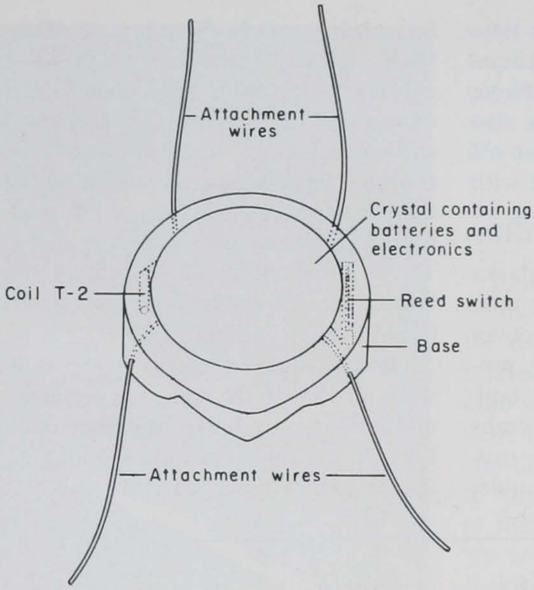

Figure 1.—A sonic tag for attaching to king crab.

FEASIBILITY TESTS CONDUCTED

Field testing was done aboard the crab boat MV *Dauntless,* fishing for king crab north of Unalaska Island. The main objectives of our tests were to: (1) develop a technique for attaching the tag to the crab; (2) examine the crab's ability to carry the tag and to observe its reactions, if any, to the tag; and (3) determine if the output of the tag provides adequate tracking range.

Additional testing on tag effects was performed with crab held in a live tank (10-ft wide, 12-ft long, and 7-ft deep) at Unalaska.

Attachment

Tags were placed on the backs of a number of various-sized king crab available in the catch of the *Dauntless* to determine if the shape of the tag base was compatible with the general curvature of the carapace. The tag fit very well on the range of crab sizes tested (approximately 6.25 to 8.0 lb). Actual fastening of the tag was accomplished by attaching the wires extending from the base of the tag to the crab's carapace. Four small holes were pierced in the carapace, two along the anterior edge and two along the posterior edge. The two wires extending from the leading edge of the tag were placed forward at about 45° to the right and left of the midline of the tag, and each was pushed through a hole in the anterior edge of the carapace. The wires were then brought over the top of the carapace and fastened at the midline with a crimped metal sleeve. The tag was held in position on the crab's back while the wires from the rear of the tag were passed, in a similar manner, through the holes in the posterior edge of the carapace. When these wires were pulled tight and fastened with a metal sleeve, the tag fit snugly into the depression on the back of the crab (Figure 3). After the wires were secured, the loose ends were trimmed. The attachment took less than 2 minutes.

Effect of Tag

Positive determination of the effect of the tag on the crab requires long-term observations which time did not permit. However, observations over several hours were made of tagged crab held in the live well on the boat. The tag was repeatedly activated and deactivated in the presence of a number of untagged crabs, during which time we watched for any apparent reactions to the ultrasonic transmissions. None were noted. A tagged crab was also observed briefly in shallow water off the beach where it moved about with no apparent concern about the tag on its back.

Tests in the live tank at Unalaska indicated that approximately 30 minutes were needed for crabs to recover from handling and sonic tagging procedures. When released in the tank immediately after tagging, tagged crabs settled to the bottom of the tank, usually upside down, and remained quiet for approximately 30 minutes. They then righted themselves, and their subsequent behavior was similar to that of untagged crabs in the tank. Untagged and tagged crabs that had recovered from the tagging process landed on the bottom of the tank in an upright position even when released upside down. These same crabs, if placed on the bottom upside down, quickly righted themselves.

Observations of crabs in the tank were made with the sonic tag activated and not activated. No apparent reactions to the tag were noted among either tagged or untagged crabs.

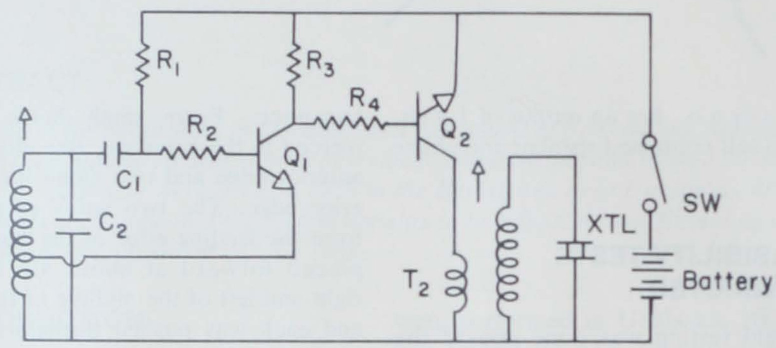

Figure 2.—Schematic diagram for the king crab tag (45 kHz, pulse rate 2 pps, duty cycle 2%). (See Table 1 for parts list.)

Table 1.—Parts lists for the king crab tag. (See Figure 2 for schematic diagram.)

T_1	= 350 turns of # 40 wire[1]
T_2	= Primary—30 turns # 32 wire[1] Secondary—325 turns # 34 wire
C_1	= 0.68 MFD
C_2	= 0.0082 MFD
R_1	= 2.4 M
R_2	= 1.5 K
R_3	= 3.3 K
R_4	= 1 K
Q_1	= 2N2925
Q_2	= 2N3702
XTL	= Edo Western part number ADO 316-1 (hemisphere 1.75 inch OD with 0.125 inch wall).
Battery	= 12 volt, 190 MAH (8 silver oxide cells-Eveready type S76E or equivalent).
SW	= Magnetic reed switch.

[1] Coils are wound on 0.1875 inch diameter coil forms and tuned with ferrite slugs.

Effects of the tag on long-term survival of the crab were undetermined in these tests. Based upon limited observations, we can say that once the crab recovered from tagging, the tag did not appear to affect the crab's behavior or immediate well being. Previous observations at Unalaska had shown that harvested crabs will survive in the live tank for approximately 6 days; our tagged crab survived approximately 6½ days.

Tracking Range

Crabs with sonic tags attached were lowered in a small shrimp pot approximately 57 fathoms to the bottom in the sheltered waters of Akutan Bay northwest of Unalaska and on the fishing grounds in the open sea. With the hydrophone in position over the side of the ship, we motored away from the tagged crabs. Periodically, we stopped the boat to listen. In both the inshore and offshore tests, we obtained strong, usable signals with good directional quality up to 0.8 nautical mile. Beyond this distance, audibility of the tag signal dropped off rapidly.

A similar test was made with a tagged crab placed in a conventional crab pot with the tunnels closed, which was dropped to 117 fathoms. Usable range in this instance was about 0.4 nautical mile. Unfortunately, the results of this test were somewhat inconclusive as the crab was not inside when the pot was brought back aboard the ship. It was theorized that the velocity of the water passing through the pot as it sunk to the bottom had broken up the crab and forced it through the web. Because of weight-balance characteristics of the tag, there was reason to believe the crab was upside down on the bottom. Unfortunately, we had no more tags with which to repeat the deep-water tests.

CONCLUSIONS AND RECOMMENDATIONS

The sonic tag and tracking system appears to be a feasible tool for aiding in the harvest and management of king crabs. We consider the design of the tag and the method of attachment to be satisfactory. Improvement undoubtedly can be made in the tracking system.

Although tracking range was adequate, it can be substantially increased with more sensitive receiving equipment. Hydrophones with variable beam patterns would be helpful—a wide pattern for use in searching for tagged crabs and a narrow beam for tracking. In our tests the hydrophone was manipulated by hand from the deck of the ship. The operation would be more practical if the hydrophone were manipulated remotely from the ship's wheelhouse so that the receiver would be protected from the elements and the operator would be in close proximity to the steering controls of the ship. Instead of mounting the hydrophone on the side of the vessel, a through-hull unit could be installed in a location

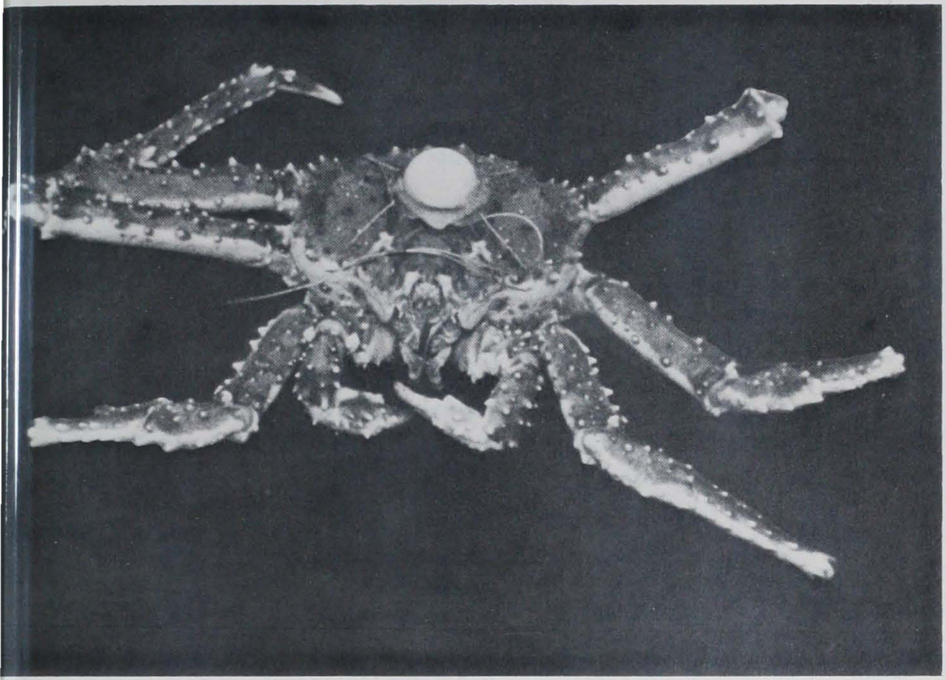

Figure 3.—Male king crab with sonic tag attached.

with a minimum of acoustic interference. As used in the recent test, the cone-shaped hydrophone set up an excessive turbulence when the ship was under way and severely limited its effectiveness. This problem can be greatly reduced by placing the hydrophone inside a faired housing.

A number of applications of the system are readily foreseeable, provided that the presence of the tag does not significantly alter the normal behavior of the crab (additional tests are needed for positive determination). Crabs that are caught, tagged, and released on the fishing grounds could be used by fishermen to monitor their movements and, presumably, the presence of other crabs. This would assist fishermen in keeping their pots set in productive areas and materially reduce the amount of unproductive time spent searching for crab concentrations. Research and management agencies also could use sonic tracking to develop information on crab behavior and short-term migration patterns. As interest develops and more individuals become familiar with the technique of electronically tracking free-moving crabs in their natural environment, additional studies will almost certainly suggest themselves.

ACKNOWLEDGMENTS

In addition to the authors, members of the research team responsible for the development of the sonic tag and related tracking techniques for king crab were Gordon F. Esterberg, Kenneth L. Liscom, James H. Johnson, and Charles D. Volz. We are grateful to Arnie Madsen, owner and skipper of the MV *Dauntless*. Special thanks are also due to Mark Buckley, Peter Jackson, and Robert Tamburelli of the Alaska Department of Fish and Game for their cooperation and assistance in making these tests.

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MFR Paper 990. The paper above is from Marine Fisheries Review, *Vol. 35, No. 7. Reprints of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*