Desired Characteristics of a Bait for Skipjack Tuna, *Katsuwonus pelamis*

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ABSTRACT

Skipjack tuna, *Katsuwonus pelamis*, fishing in the central Pacific Ocean is largely dependent upon a limited supply of live baitfish, the nehu, *Stolephorus purpureus*. Experiments by the Honolulu Laboratory in a search for effective live-bait substitutes or supplements have resulted in the collection of much information on behavioral characteristics of the experimental baits. Characteristics of an effective skipjack tuna bait are: a tendency to flee towards the surface, elusiveness, a high light reflectance, a length of 2 to 6 cm, and the durability to survive in a baitwell.

INTRODUCTION

The only successful method of catching skipjack tuna, *Katsuwonus pelamis*, on a commercial scale in the clear waters of the central Pacific Ocean has been the pole-and-line method in which the skipjack tuna are attracted to the fishing boat with live bait. The major fishery for this species in the central Pacific Ocean is located in the Hawaiian Islands where the supply of nehu, *Stolephorus purpureus*, the principal bait species, is an important factor limiting the catch of skipjack tuna (June 1951). Since 1951 the Honolulu Laboratory of the National Marine Fisheries Service (then known as the Pacific Oceanic Fishery Investigations) has invested research effort in developing an artificial bait or finding a substitute species to augment the nehu.

As part of this effort studies were made of the perceptual abilities of skipjack tuna, their responses to various stimuli, their feeding responses at sea, and their responses to various species of live bait. For this paper on desired bait characteristics, I have tried to gather the relevant information from these studies.

SOURCE OF DATA

Beginning in 1957 (Strasburg and Yuen 1960), various underwater viewing facilities installed on the *Charles H. Gilbert*, a research ship of the Honolulu Laboratory, provided many opportunities to observe bait behavior and feeding responses of skipjack tuna under experimental conditions at sea. Many of the experiments were designed to compare the effectiveness of two different species as bait. In most cases nehu was one of the two species and was used as a control. With the exception of tilapia, *Tilapia mossambica*, which could be purchased, selection of experimental species was opportunistic; trials were made with whatever species could be obtained.

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Because skipjack tuna at sea respond to live bait with a wide range of variability (Yuen 1959), experiments require much replication for reliable conclusions. Many of the experiments were not replicated sufficiently or not replicated at all because the desired bait was not sufficiently available, and, therefore, was not included in an earlier publication (Yuen 1969). The experiments, however, provided the opportunity to collect many observations on the behavioral characteristics of the experimental baits and the reaction of skipjack tuna to them. This collection of field notes is the major source of information on the desired characteristics of bait.

A total of 14 species (Table 1) was involved in the experiments. The species provided a wide range of characteristics in physical attributes as well as in behavior (also see Baldwin 1977). Some fish were shiny, others were dull; some were deep-bodied, others slender; some were fast, others slow; swimming motions were different.

CHARACTERISTICS

In the fishing operation for skipjack tuna the use of live bait serves two purposes. When the ship intercepts the

Table 1.—Species used in baitfish experiments in Hawaii.

Common Name	Scientific Name
Aholehole	*Kuhlia sandvicensis*
Iao	*Pranesus insularum*
Lae	*Scomberoides lysan*
Marquesan sardine	*Sardinella marquesensis*
Moi	*Polydactylus sexfilis*
Mullet	*Mugil longimanus*
Nehu	*Stolephorus purpureus*
Northern anchovy	*Engraulis mordax*
Oama	*Mulloidichthys* sp. (mix of several species)
Omaka	*Caranx mate*
Tabai	*Limia vittata*
Thread herring	*Opisthonema medirastre*
Threadfin shad	*Dorosoma petenense*
Tilapia	*Tilapia mossambica*

school, bait is used to attract the skipjack tuna to the boat. Once the school is at the boat, the bait is used to hold the fish there so that they may be fished. A desirable characteristic for one function may not be a desirable characteristic for the other. For example, the most attractive bait should lure the skipjack tuna to the boat. On the other hand, if the bait is so attractive that the skipjack tuna always takes it in preference to the hook, it is not a desirable bait. In discussing the desired characteristics I shall consider both roles that the bait must play.

Behavior

Perhaps the most important characteristic to consider in examining the effectiveness of a bait is its behavior. The baits that were most effective in attracting the school to the boat were those that hastened back to the boat only after they were under attack by the skipjack tuna. Nehu, Marquesan sardine, *Sardinella marquesensis*, and mullet, *Mugil longimanus*, belong to this group. Most nehu gathered into a school before swimming away, almost always heading down. Mullet and Marquesan sardine swam away singly or in groups in no preferred direction. When attacked they all returned to the ship by following the wake.

Once the skipjack tuna are at the ship the most desirable bait behavior is initial diving and then fleeing towards the surface. With species that flee by diving only, results have been mixed. Catches have been good when the feeding frenzy of the skipjack tuna was great and each piece of bait was consumed as soon as it hit the surface. When the skipjack tuna were feeding lethargically or when the bait was especially elusive, diving bait took the skipjack tuna below the range of the hooks.

Some baits moved quickly to within a few centimeters of the hull of the boat for protection. These lost much of their effectiveness, because skipjack tuna did not seem to come closer to the ship than approximately a meter. Quickly moving the ship ahead to expose the bait was sometimes successful, but usually it was impossible to stop the ship before the skipjack tuna were beyond reach of the poles.

Iao, *Pranesus insularum*, did not move close to the ship but stayed exclusively at the surface. In general this behavior was effective in keeping the skipjack tuna within striking distance of the hooks. However, a common behavior of skipjack tuna is to move away from the boat and dive. In this circumstance, a bait that dives may attract the tuna back to the boat, whereas a bait that stays at the surface will not.

I have noticed that a bait that has a quick, short darting movement will excite skipjack tuna much more than a bait which swims in a slow steady manner. On occasion a slow steady bait has been completely ignored by the skipjack tuna. Excited skipjack tuna are more apt to take a hook than those that are not. An excited fish will snap at a hook unhesitatingly but an unexcited one may come up to a hook and veer away. A very quick and elusive bait can whip the school into a frenzy. It seems that excitement builds up with every unrewarded attack. If, however, the bait is very elusive and flees by diving, which is true with thread herring, *Opisthonema medirastre*, it can quickly draw the skipjack tuna down below the range of the hooks.

Size

Vision is the primary sense used by skipjack tuna during feeding. Therefore, large bait size would be expected to be desirable because the bait would then be detected at a greater distance. The largest size bait I have found in the stomach of a 60-cm skipjack tuna is 20 cm. A rough estimate of the maximum bait size for 70-cm skipjack tuna is 23 cm.

Water clarity and a high reflectance of the bait are important in the visibility range of the bait. Let us assume that water clarity limits the visible range to 50 m in extremely clear water. What size would the bait have to be to be seen? The visual acuity of skipjack tuna is about 0.18 (Nakamura 1968). The bait would have to be 8 cm long to be detected at 50 m. Under most circumstances 50 m is an unusual range so that 8 cm is as large as a bait needs to be.

If the bait behavior is such that it swims towards the ship when attacked, it can extend the effective range of the ship much more than a large bait can.

Another consideration in size of bait is the bait carrying capacity of boats. The number of fish to be caught with a load of bait depends on the number of pieces of bait. To the extent that the carrying capacity is fixed, one can carry a lot more pieces of small bait than large bait; therefore, a smaller bait is better.

Another argument against large bait is that large bait will satiate the skipjack tuna faster.

Survival

An obviously important characteristic for a bait is that it should be able to survive in a baitwell. The duration it needs to survive depends upon how far the fishing grounds are.

Flavor

Although aqueous extracts of skipjack tuna, shrimp, and squid have evoked positive and often violent responses from captive tuna, the use of these extracts at sea on "wild" skipjack tuna schools did not heighten their responses during feeding (Tester et al. 1954). From this I conclude that the taste or flavor of the bait is not important.

DISCUSSION AND SUMMARY

Yuen (1969), in discussing the effectiveness of water sprays in increasing the catch rate, felt that each skipjack tuna caught represented an error in discrimination by the skipjack tuna: a hook was mistaken for a live bait. Any strategem a pole-and-line fisherman uses to cause

more mistakes by the skipjack tuna will increase his catch. He can make it more difficult for the skipjack tuna to discriminate between bait and hook by designing his hooks to look more like the bait or use sprays to distort vision. He can also cause the fish to be less discriminatory by exciting them with the use of a more elusive bait.

The most important characteristics of an effective bait are its behavioral characteristics. The bait should flee toward the boat when the predator is encountered. It should be elusive with fast, darting movements. It should be durable enough to survive in a baitwell. It should have a high light reflectance. It should be 2 to 6 cm long. The flavor of the bait is not important.

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