NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center, Honolulu Laboratory
Honolulu, Hawaii 96812

AQUACULTURE PROGRAMS IN HAWAII by Richard S. Shomura

and

AQUACULTURE OF BAITFISH by Walter M. Matsumoto

May 17, 1974

[Hawaii baitfish culture section input for the National Fisheries Plan.]

AQUACULTURE PROGRAMS IN HAWAII
(Prepared by Richard S. Shomura)

The following provides a brief summary of aquaculture activities in Hawaii. The list is far from complete; lack of time prevents an in-depth assessment:

Hawaii Institute of Marine Biology - University of Hawaii

The University of Hawaii through HIMB has a very active program in aquaculture; the program is principally funded by Sea Grant. HIMB has been working on aquaculture projects over the past several years, and various researchers have worked on various species and on a number of problem areas. Enclosed as appendix 1 is the material prepared by the program manager for 1974-75 Sea Grant support. In addition to these projects, HIMB also has a project to culture sharpnosed mollies as a possible baitfish species for skipjack fishing. Information on this project is detailed in the baitfish culture material submitted under separate cover.

State of Hawaii - Division of Fish and Game

The principal aquaculture project currently undertaken by the Division of Fish and Game involves the Malaysian prawn (Macrobrachium rosenbergii). State Fish and Game biologists have been successful in spawning this freshwater prawn and rearing the young through the larval stages with good survival rates. They have provided at least one commercial pond operator with a supply of young prawns. Data on yield and growth are currently being collected from this project.

The State has stopped work on the culture of (Crassostria virginica). This species was introduced successfully in waters of Pearl Harbor decades ago; however, because of pollution problems the State has not been able to work out a means of successfully utilizing this resource. Attempts to establish or culture these oysters in several of the bays in Hawaii have not been successful.

The State has several other aquaculture projects dealing with freshwater species. One involves the hatching of 100,000 trout eggs received annually from the National Fish Hatcheries. The trout are reared through the larval and juvenile stages and released in streams on the island of Kauai. This program is directed to the use of recreational fishermen. A second freshwater culture project involves the channel catfish. Young channel catfish are hatched in experimental tanks and released in one of the reservoirs on Oahu as fingerlings. This program is also directed to the recreational fisherman.

Tap Pryor's Kohala operation

From newspaper accounts (copy enclosed as appendix 2) Tap Pryor is on the verge of a "systemculture" venture. Tap has been engaged in a number of culture projects in the past several years, e.g., culturing of spiny lobsters in French Polynesia. I hope this one doesn't turn out to be another "cat-rat on an island" scheme.

Oceanic Institute

The Oceanic Institute has recovered from the near-bankruptcy situation they faced last year. Currently their aquaculture program includes a project dealing with the reproduction and mass propagation of the grey mullet (Mugil cephalis). The Institute's biologists have been successful in inducing spawning of the mullet in tanks. Although they have tried for over a year, attempts at artificial spawning of the milkfish (Chanos chanos) have been unsuccessful. Another fish they are trying to culture is the mahimahi (Coryphaena hippurus). I believe the basis for work on all three species is the production of food fishes. I should point out that the young of mullet and milkfish have been used successfully as baitfish for tuna fishing. The problem is producing these fish to baitfish size economically enough for tuna operations. In addition to their biological projects, some of the staff members at Oceanic Institute are working on engineering and design studies to maximize the aquaculture operation, e.g., optimal pond configurations and rates of water flow.

AQUACULTURE OF BAITFISH
(Prepared by Walter Matsumoto)

I. The skipjack fishery

The pole-and-line fishery for skipjack tuna in Hawaii is the largest fishery both in catch and in value for the entire state. The fishery averages 4,450 metric tons per year with a range of 2,700 to 7,300 metric tons. In 1972 the total catch by this fishery was 4,950 metric tons, which had an ex-vessel value of nearly $3,000,000. The pole-and-line fishery is primarily dependent upon the bait resource and problems encountered by the bait fishery ultimately affect the skipjack harvest.

The principal baitfish used by the Hawaiian skipjack fishery is the nehu (Stolephorus purpureus), a small delicate anchovy which possesses most of the qualities of a good baitfish. It occurs in bays and harbors in waters that are slightly brackish, but since these areas are relatively few and limited in size in the Hawaiian Islands and since each area is able to support only a small population of nehu, bait is frequently scarce, particularly during the summer months when the skipjack season reaches its peak. Additionally, the nehu is a weak bait and suffers substantial initial mortality (as much as 30 percent) despite careful handling. Nevertheless, the nehu accounts for about 92 percent of the baitfish caught in Hawaiian waters.

II. Problems faced by the fishery

1. Limited baitfish resource

Catch statistics of nehu provide a rough estimate of the size of the usable baitfish resource. In the 5-year period 1968-72, with 16 vessels operating full time, the annual catch of nehu averaged 36,000 buckets (1 bucket consisting of 7 pounds of baitfish), with a range of 30,000 to 42,000 buckets. In an earlier 5-year period, 1948-52, with the fishing fleet composed of 25-32 vessels, the annual catch of nehu averaged 38,000 buckets, with a range similar to that of the later period. During these periods also the average catches of skipjack were similar: 4,350 MT in 1948-52, and 4,250 MT in 1968-72.

The similarities in both the average catches of baitfish and skipjack between the two periods, despite the difference in fleet size, indicate that the catchable baitfish resource had approached its maximum level and that this baitfish resource was utilized as well with 16 as with 25-32 vessels. On the basis of these statistics it is evident that expansion of the fishery from its present level cannot come about simply by increasing the fleet size.

2. Loss of fishing time due to baiting operation

The nehu are taken both by day-baiting and by night-baiting. Because day-baiting consumes a full day (actual baiting time plus resting the bait overnight) the time used for day-baiting means a day lost for fishing.

In 1965 more time was spent in night-baiting, which provided 42 percent of the total bait catch. Since 1965, there has been a tendency towards more day-baiting. The time spent in day-baiting accounted for about 40 percent of the total activity of the fleet in 1971. For some vessels, however, the time spent baiting was as much as 50 percent.

3. Threat to baitfish resource

Within the Hawaiian Islands there are several baiting grounds, the most important being situated in Kaneohe Bay. During a peak year as many as 20,000 buckets of bait have been seined from this bay (Baldwin, 1974). But Kaneohe Bay is in an area of rapid urbanization and is subject to increasing amounts of sewage and siltation. This continual environmental degradation may have a direct effect on the stocks of nehu there and eventually could result in the loss of Hawaii's most productive baiting area.

III. Consequences of the bait problem

The effects of the baitfish problems on the fishery are quite evident. First, the scarcity of bait probably has contributed to the decline in the number of vessels from a high of 32 in 1948 to the 16 presently in the fleet. Poor economics of the fishery which includes a disproportionate loss of time due to baiting operations has deterred owners from replacing lost vessels. Second, the lack of a bait strong enough to withstand the rigors of handling and capable of prolonged survival in the baitwells has prevented the development of a fleet of long-ranged vessels equipped with refrigeration capability. Only one such vessel, the Anela (136 gross tons), was added to the fleet in 1971. It was the only addition since 1955 and only the third fishing vessel built since 1948.

Consequently, the fleet is comprised almost entirely of outdated vessels with limited range and without refrigeration, and the fishery is thus restricted to coastal waters well within 90 miles of shore. The dwindling fleet and the present reluctance of the boat owners to replace lost or retired vessels should be cause for alarm, but this situation could be changed with an improvement in the bait supply.

IV. Alternate methods for increasing catches

The Hawaiian skipjack fishery is subject to large fluctuations in catch. There is some basis to believe that these fluctuations are related to the northward movement in the spring and summer of low salinity California Current Extension (CCE) water that replaces the high salinity North Pacific Central water in the Hawaiian region. Intrusion of the CCE water coincides with the seasonal increase of skipjack landings. Failure of this water to move into the fishing area results in low catches (Seckel, 1972). The present fleet of small, short-range vessels is particularly susceptible to yearly deviations in the northward movement of the CCE water. Long-range vessels could overcome this problem by seeking favorable waters and possibly areas of better fishing further offshore. The development of such a fleet, however, depends entirely upon the development of the bait resource.

Increases in the catches are also likely within the present fishery. One approach to increasing the present catch is to separate the bait fishery from the skipjack fishery, thus permitting the fleet to spend more time fishing for skipjack. Obviously a reduction in the time spent in day-baiting operations would provide more time for fishing. If all time lost in day-baiting were eliminated and the savings in time were channeled into skipjack fishing and if this situation were coupled with an adequate bait supply, the annual catches could be increased by about 60 percent. In 1972, for example, the catch could have been increased from 4,950 metric tons to 8,100 metric tons and the ex-vessel value from $3,000,000 to $4,800,000.

The development and maintenance of a separate bait fishery can be successful only if the net value of the increased catch substantially exceeds the cost of producing the bait. Three avenues are open to develop a separate bait fishery; (a) culture baitfish species found locally, (b) culture introduced species, and (c) transport baitfish in large quantities from areas presently endowed with a large resource, i.e., from California, on a regular basis. While transporting of baitfish from California is a more direct approach to the problem, and such a project already has been initiated by the Service, the alternatives involving aquaculture also should be pursued.

V. Aquaculture of baitfish

1. Tilapia

Attempts at aquaculture of introduced baitfish species have been made by the Service and by the Hawaii Division of Fish and Game, the most successful being with the tilapia (Tilapia mossambica). Following its initial successful introduction in ponds and reservoirs by the Hawaii Division of Fish and Game and successful tests as a baitfish (King and Wilson, 1957), a pilot study was made for tank culturing in 1958-59 (Hida, Harada and King, 1962). The pilot study was made because bait-sized young could not be produced in the wild in sufficient quantities owing to cannibalism and predation and to difficulties in harvesting. The 9,300 square feet (surface area of all tanks) pilot study plant located on the island of Maui produced about 470 buckets of bait in each of the two years. On the basis of this study it was estimated that tilapia could be cultured for $1.00 per pound in a plant having 16,000 sq. ft. of brood-tank space and 40,000 sq. ft. of fry-tank space, and that such a plant could produce up to 6,000 buckets of bait annually.

Following this study, the Hawaii Division of Fish and Game experimented with culturing tilapia in 1961 on the island of Oahu, where most of the fishing fleet is based. Although the production of bait-sized tilapia was good, the lack of interest by the fishermen in use of the bait compelled the State to abandon the operations (Hawaii Dept. Land and Nat. Res. Ann. Rep. 1964-66).

2. Threadfin shad

Another attempt at aquaculture of baitfish was made with the threadfin shad, Dorosoma petenense. This species, introduced in 1959, became established in three reservoirs within a year. Shad held in tanks failed to spawn but those released in reservoirs spawned successfully. An estimate made of the bait-sized shad in one 302-acre reservoir in the summer of 1970 amounted to a minimum 5,000 buckets. Tests of this species as skipjack bait showed it compared favorably with nehu in its behavior and was hardier and easier to handle (Iversen, 1971).

An economic feasibility study producing shad as live bait was made under the joint sponsorship of the Economic Research Center, University of Hawaii and the Service's Honolulu Laboratory (Shang and Iversen, 1972) following the successful sea trials. Results of the study indicated (a) that shad culture is feasible with an annual production of 3,600 buckets per ten-acre pond unit, (b) that the breakeven price would range from $11 to $15 per bucket, a price that the fishermen are willing to pay, and (c) that 9 to 13 ten-acre ponds would be required to produce shad equal to the amount presently used by the skipjack fishery. The study also provided a cost estimate of $63,500 for the construction of a ten-acre pond and $19,300 to operate the facility annually.

3. Mollies

The feasibility of raising large quantities of the sharpnose molly (Poecilia sphenops) under intensive aquaculture is under study at the Hawaii Institute of Marine Biology, University of Hawaii (Baldwin, 1974). Preliminary work with this species indicates that it has potential as a baitfish and can probably be supplied to the fishery in large quantities on an extended basis. Tests are sea are currently being planned to determine how effective mollies are as tuna baitfish. Since natural supplies are insufficient for these tests, it will be necessary to raise them in captivity. A program has been initiated with the cooperation of the Hawaii Division of Fish and Game to raise mollies at the State's aquaculture plant at Sand Island. This phase of the project will require at least two years to complete and could provide information necessary to determine whether or not intensive culture is warranted.

The experience with the tilapia and shad culture and the present work on the mollies point to the possibility of aquaculture as a means of increasing the baitfish supply, not only to meet current demands but also to permit an increase in the number of vessels in the fleet. Additionally, these studies have shown that the technological skills exist and that there is a willingness of the State, University and industry to cooperate in such ventures.

4. Other species

The Pacific Island Mariculture Conference held in Hawaii in 1973 suggested other likely candidates for baitfish species. The include the mullets (Mugilidae), the goatfishes (Mullidae) and the cardinalfishes

(Apogonidae). All of these have been used as baitfishes on occasions and have proven to be excellent. With the exception of the mullets, there is a lack of knowledge concerning the culturability of these fishes. Studies to determine their biology may well be worth the effort. The biology of the mullets is reasonably known and although these fish have been cultured from beyond the juvenile stages, recent advances in techniques to induce spawning in tanks of at least one species, Mugil cephalus, make this a prime candidate for further study.

VI. Answers to questionnaire relative to baitfish culture

Public aquaculture

At the present time there is no public aquaculture of skipjack baitfish in Hawaii, the only area in the Southwest Region with such a need. While the technological base is adequate to permit development of public aquaculture, other problems such as the scarcity of suitable lands for aquacultural plants could seriously limit such developments. Nevertheless, some aquaculture has been done before and is needed to develop a better bait resource.

The successful culture of tilapia has been proven; however, the lack of interest in its use makes this a questionable species. In defense of tilapia as a baitfish, it should be pointed out that the rearing program was carried out in two consecutive below-average fishing years, when the demand for bait was not great. Successful use of this species requires breaking down of the fishermen's ingrained distrust of tilapia. Barring this, further studies are needed on the shad, a baitfish that has proven to be as effective as the nehu and more readily acceptable to the fishermen than tilapia.

Past work with shad has involved only pond culture and, as in the case with tilapia, harvesting the fry could be a problem. Trials involving tank culture are in order, now that some knowledge has been gained about its spawning habits. Tank culture would insure that all of the fry produced would be utilized.

Private aquaculture

At the present time there is no private aquaculture of baitfish in Hawaii. While there is a potential for private aquaculture, the possible development of other means of fishing not requiring the use of baitfish, such as an improved purse seine or seining technique suitable for local waters, could affect it adversely. The development of a purse seine fishery, however, would not eliminate all pole-and-line fishing, as witnessed in the eastern Pacific fishery. The need for baitfish would still exist, at least for the present fleet. If private aquaculture at this level is contemplated, there would be a need perhaps for a pilot study plant and certainly for commercial scale production tests to provide likely entrepreneurs with sufficient data to allow a determination of profitability. The baitfish species, initially, would have to be the shad, which is acceptable to the fishermen.

The culture tanks on Sand Island could serve as a pilot plant and eventually as a bait-holding facility. Since the tanks are operated by the State, these studies could be made in cooperation between the State and Federal governments.

References

Baldwin, W. J.
1974. Raising mollies for skipjack bait may eliminate use of frail nehu. Nat. Fisherman, Jan. 1974, 54(9):7.

Hida, T. S., J. R. Harada, and J. E. King
1962. Rearing tilapia for tuna bait. Fish Bull, U.S. 62(198):20 p.

Iversen, R. T. B.
1971 Use of threadfin shad, Dorosoma petenense, as live bait during experimental pole-and-line fishing for skipjack tuna, Katsuwonus pelamis, in Hawaii. NOAA Tech Rep. NMFS SSRF-641:10 p.

King, J. E., and P. T. Wilson
1957. Studies on tilapia as skipjac bait. U.S. FWS, SSR-F. No. 225: 8 p.

Seckel, G. R.
1972. Hawaiian-caught skipjack tuna and their physical environment. Fish Bull, U.S. 70(3):763-787.

Shang, Y. C. and R. T. B. Iversen
1972. The production of threadfin shad as live bait for Hawaii's skipjack tuna fishery: an economic feasibility study. Univ. Hawaii, Econ. Res. Center (ERC):42 p.