Hawai‘i’s ‘O‘io: Past, Present, and Future

by Bruce S. Anderson, Ph.D., Richard W. Gushman, II and Alan M. Friedlander, Ph.D.

■ Bonefish, locally known as ‘o‘io in Hawai‘i, are popular game fish in recreational fisheries in tropical and subtropical regions throughout the world. These fisheries are often shared with subsistence and small-scale commercial fishermen who harvest with spears, nets, traps, and hooks. ‘O‘io are often referred to as the “grey ghost” because of their elusive nature and their ability to easily blend into their environment. They are highly prized for their fighting ability and for the skill required in seeking them out.

‘O‘io were also an important and very popular food resource for early Hawaiians. As described by Daniel Kaha‘ulelio in his book Hawaiian Fishing Traditions, ‘o‘io were often caught from canoes with hooks, using the ink sac of octopus as bait and the suckers on the tentacles of the octopus for chum, mostly on sandy bottoms. Near shore, long *paloa* nets or *papa* (bag) nets were used to surround schools of ‘o‘io.

Today, ‘o‘io are targeted by a mix of recreational, commercial and subsistence fishers. Most recreational anglers in Hawai‘i continue to use cut bait to catch bonefish. Salt water fly fishing is increasing in popularity on O‘ahu and to a lesser extent on the neighbor islands, and ‘o‘io are the primary target of most fly fishermen. Virtually all of the fish caught using artificial flies are released and, increasingly, sport fishermen using spinning gear are releasing ‘o‘io that they hook. State regulations have recently raised the minimum size from 9 inches (total length) to 14 inches (fork length). There is neither a closed season nor a bag limit.

Despite their popularity today as a game fish and importance in Hawaiian culture, little is known about the distribution, movement and growth patterns of ‘o‘io in the Hawaiian Islands. In fact, surprisingly little is known about them worldwide. Although ‘o‘io “fish cake” and “lomied” (mixed with limu) ‘o‘io are very popular local food items, they are not considered to be a commercially important food fish. This is probably one of the reasons why they have not been well-studied. From this standpoint, the species is highly undervalued.

Trends in Abundance

Commercial landings of‘o‘io in Hawaii have decreased dramatically over the past few decades, presumably because of over fishing and loss of habitat, from over 300,000 lbs in 1900 to less than 3,000 lbs. since 2002 (Figure 1).‘O‘io was the most important species in the commercial seine fishery between 1966 and 1970, with average annual yields of nearly 18,000 pounds. The commercial seine catch now averages only 581 lbs per year, accounting for less than 8 percent of the catch.

Dick Gushman and Bruce Anderson made this double ‘o‘io catch while fishing Kane‘ohe Bay.

Chatt Wright had a major battle on his hands with this big bonefish.

There is no recreational catch data available for comparison. However, anecdotal reports from recreational fishermen also support the decline in ‘o‘io populations. Increased fishing pressure and the use of more efficient gear, such as monofilament gill nets, are thought to have had a large impact on bonefish populations. Dredging and filling of shallow reef areas and polluted runoff from development activities have reduced bonefish habitat and undoubtedly contributed to the decrease in abundance. The relative impact of these activities on bonefish populations has not been well-defined.

‘O‘io Life History

‘O‘io are an ancestral species that have a complex life cycle. Although we have learned much about ‘o‘io in the past, there are still major gaps in our knowledge including where and when they spawn, where and when the larvae settle, and the extent of their movement within and among habitats over their lifetime. (Figure 2) **continued...**

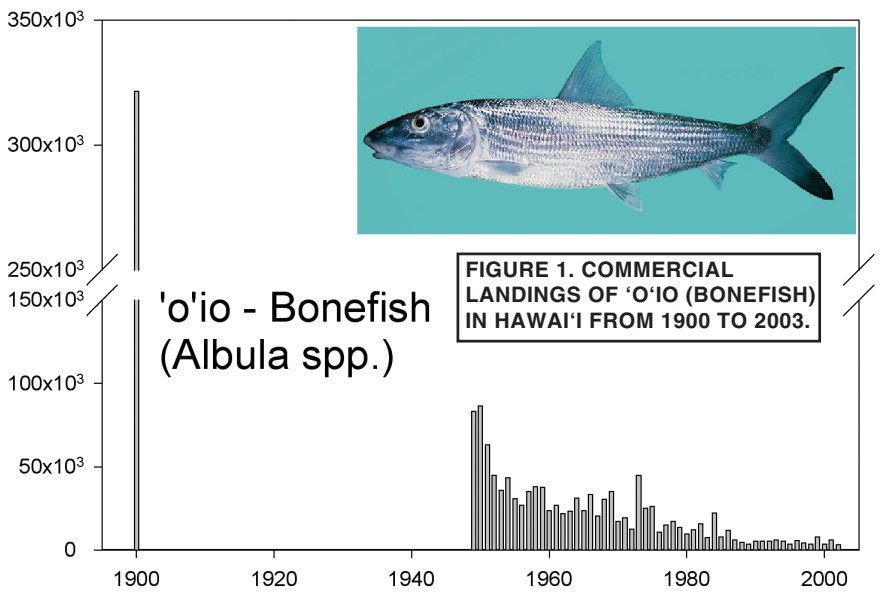
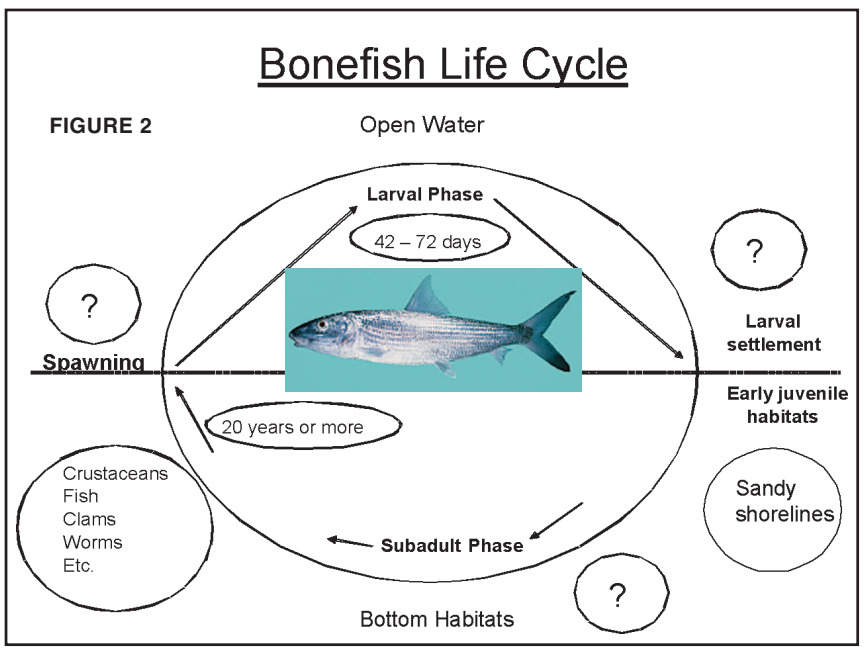
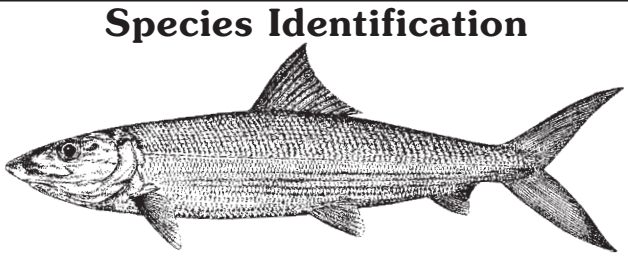


FIGURE 1. COMMERCIAL LANDINGS OF ‘O‘IO (BONEFISH) IN HAWAI‘I FROM 1900 TO 2003.



Species Identification



Two species of 'o'io are known to inhabit Hawaiian waters, *Albula glossodonta* and *Albula forsteri*. The two have been unequivocally established as discrete species. However, the only anatomical characteristic that differentiates them is the number of vertebrae. While academically useful, this fact has little practical value for fishermen trying to distinguish between them. The most practical diagnostic morphological feature is the difference in the shape of their lower jaws (Figure 3). Specimens of *A. forsteri* generally have an angular lower jaw with a more or less pointed symphysis, often with a small protuberance at the apex. *A. glossodonta* characteristically has a broadly-rounded lower jaw. Thus, they are commonly referred to as "sharpjaw" and "roundjaw" species, respectively. The distance from the tip of the snout to the end of the upper jaw of the roundjaw is shorter relative to the length of the head compared to the sharpjaw. The ratio of head length to this snout-upper jaw measurement for the roundjaw is 3.03-3.31 compared to 2.67-2.87 for sharpjaws.

Comparison of bonefish species in Hawaii

Species	Jaw shape	Head length/snout	Fork length (in)	Habitat
A. glossodonta Round jaw 'o'io		3.03-3.31	20.5	Flats
A. forsteri Sharp jaw 'o'io		2.67-2.87	16.1	Deeper channels & bays

FIGURE 3.

PHOTOGRAPHS BY CLYDE TAMARU, UH SEA GRANT COLLEGE PROGRAM

Larval Biology

'O'io are primitive boney fishes that have the unusual leptocephalus larva found only in bonefish, tarpon, ladyfish, and eels. The bonefish leptocephalus is long (ca. 50-70 mm TL) and ribbon-shaped (Figure 4). The planktonic phase is 48 to 72 days (Friedlander et al. 2007). After the planktonic larval stage, larvae move into shallow habitats where they metamorphose into more fish-like juveniles. Recruitment of larvae to inshore areas has been found to have seasonal peaks, as well as strong lunar-month, and tidal cycles.

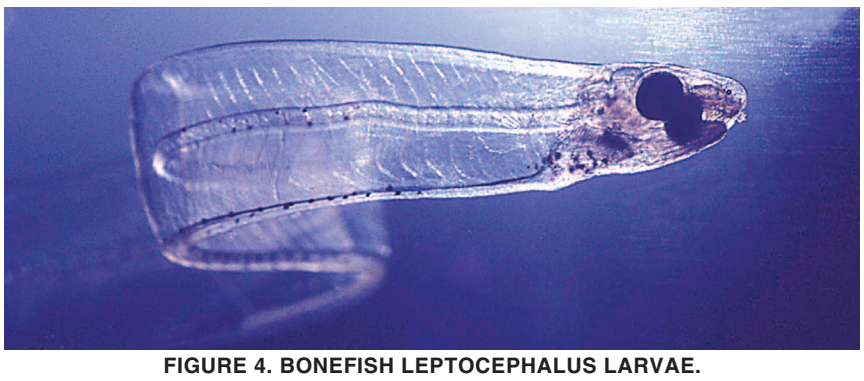


FIGURE 4. BONEFISH LEPTOCEPHALUS LARVAE.

Juvenile Recruitment

'O'io recruit to sandy beaches in Hawai'i at about 6 inches (12 cm) in size during the summer months. A second recruitment peak is often observed in the early fall. The average recruitment of juvenile'o'io on windward Oahu has declined considerably since the mid 1990s raising concerns about possible overfishing (Figure 5).

Figure 5. (A) Mean monthly number per seine haul and fork length of juvenile o'io (< 30 cm) captured in beach seines along windward Oahu from 1994 to 2004. (B) Mean annual CPUE (number per beach seine haul) of juvenile 'o'io (< 30 cm) captured in Kahana Bay, Oahu.

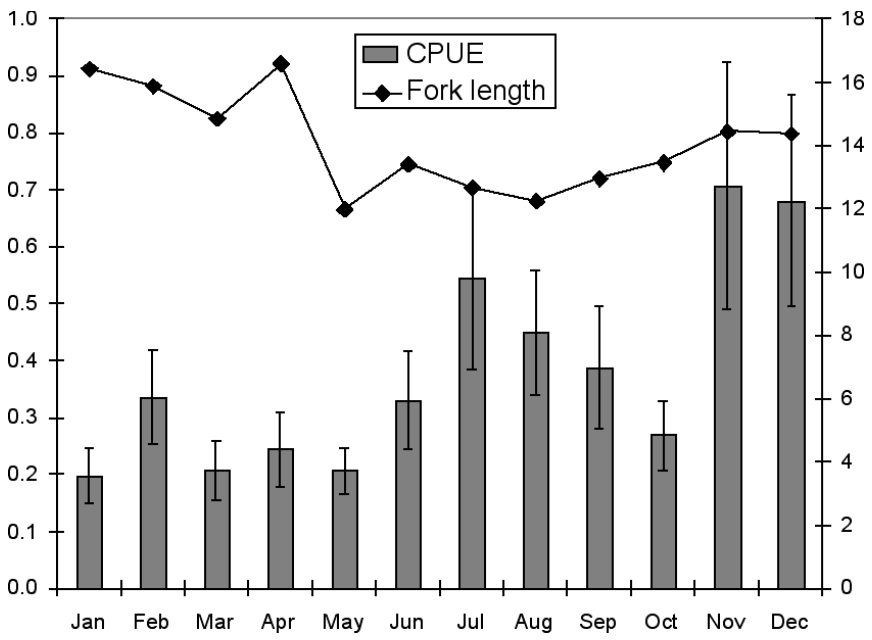


FIGURE 5 (A)

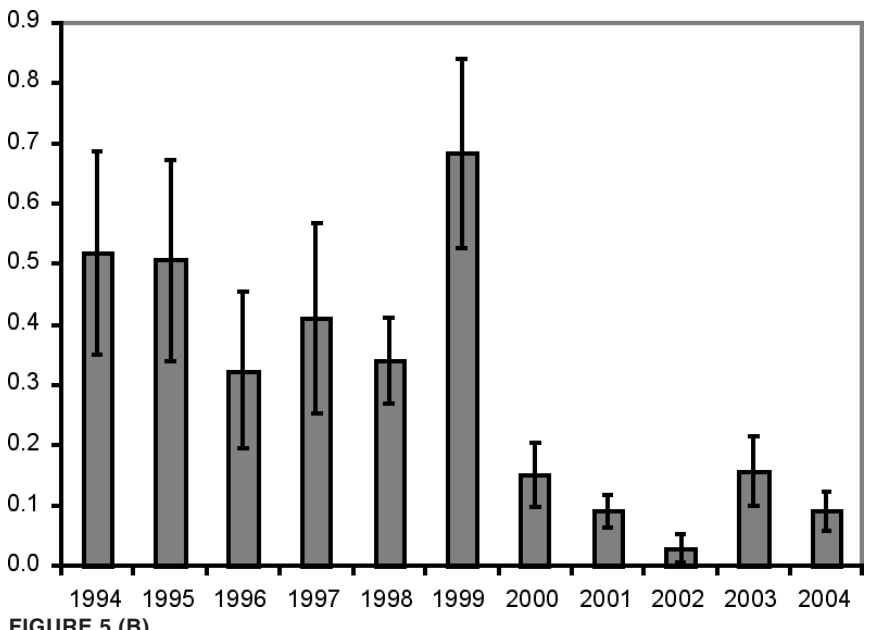


FIGURE 5 (B)

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(A) Mean monthly number per seine haul and fork length of juvenile o'io (< 30 cm) captured in beach seines along windward Oahu from 1994 to 2004.

(B) Mean annual CPUE (number per beach seine haul) of juvenile 'o'io (< 30 cm) captured in Kahana Bay, Oahu.

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About the Authors

- Bruce S. Anderson, Ph.D is president of Oceanic Institute and 'O'io Tagging Project principal investigator.
- Richard W. Gushman, II, is an 'O'io Tagging Project co-investigator.
- Alan M. Friedlander, Ph.D, is a fisheries biologist at Oceanic Institute.

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Jimmy Buffett, Jim Romig, and the drummer in Jimmy’s band catching ‘o‘io K-bay.

Feeding

‘O‘io feed primarily in the sand on shrimp and crabs which account for 66% of their total diet (Figure 6). Fish, shellfish, and worms comprise an additional 17% of ‘o‘io stomach contents.

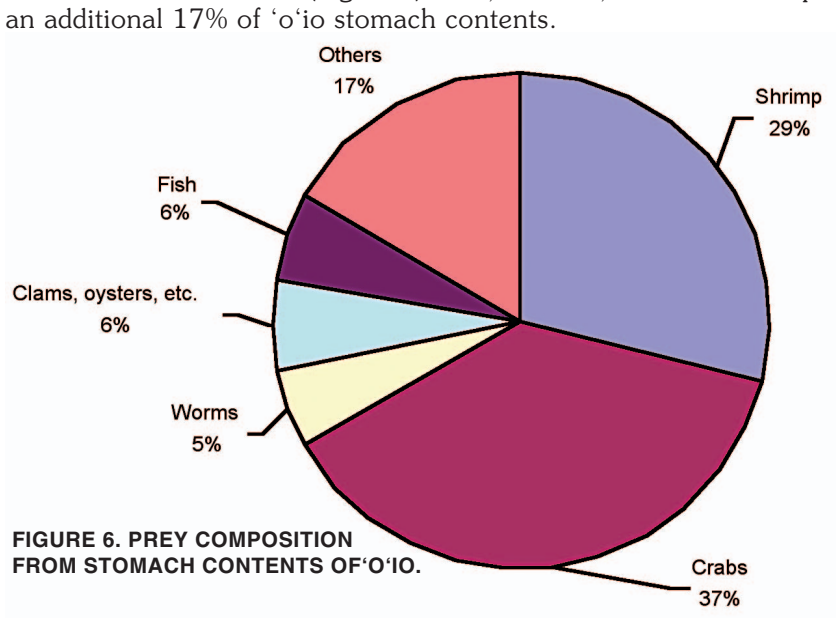


FIGURE 6. PREY COMPOSITION FROM STOMACH CONTENTS OF‘O‘IO.

‘O‘io Tagging Project

In 2003, the ‘O’io Tagging Project was initiated to characterize the resource for the purpose of supporting appropriate resource management and conservation programs, as well as helping to encourage a catch-and-release ethic among fisherman. The specific objectives were to determine the size and distribution of bonefish species on the Island of O‘ahu, to determine movement patterns, and to document bonefish growth rates in their natural environment.

FIGURE 7. ANDREW ANDERSON TAGS AN ‘O‘IO BELOW ITS DORSAL FIN USING A TAG APPLICATOR.

Methods: During the two-year study period, more than 50 recreational fisherman and professional guides were recruited to tag and recapture fish on a voluntary basis. All bonefish were tagged utilizing anchor tags and methods similar to the “Ulua Tagging Project” and adapted to ‘o‘io. Detailed instructions, equipment and supplies for tagging fish were provided to all participants. Essentially, the tagging method involves inserting a small (3mm diameter) dart tag in the area high on the back just below the dorsal fin (Figure 7).

The tags were obtained from Hallprint Pty. Ltd., a well-known manufacturer of fish tags in Australia. The tag has imprinted on it an identifying number and telephone number to call when the fish is captured (Figure 8). After the fish is tagged, the tag number, the species, the fork length (measured from the tip of the mouth to the fork of the tail), the date and time of capture and the location were recorded on data cards provided to participants.

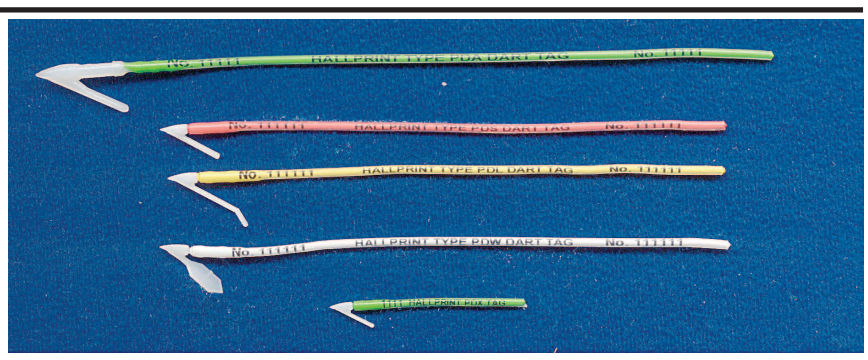
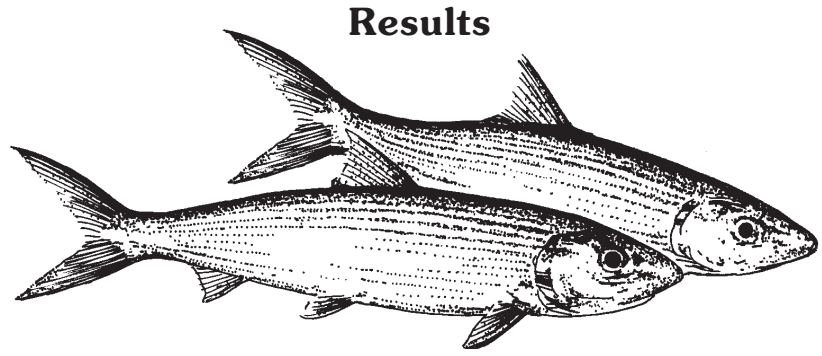


FIGURE 8. Note: The dart tags used in the ‘O‘io Tagging Project were similar to the orange tag (second from the top) and were placed just below the ‘o‘io’s dorsal fin.

All participants were given a “tagging kit” which included tags, a stainless steel applicator, a tape to measure the fork length and tagging instructions. Detailed tagging instructions were prepared with the assistance of the Sea Grant College Program Communications Office. This included a laminated photograph showing the two different species of bonefish to assist in identifying species. Participants reported that they had no problem in differentiating between the two species based on descriptions and the photographs provided. Upon recapture, the tag number, time and date of recapture, the location of capture, and fork length were recorded and reported.

The recruitment and training of participants, the distribution of tags, tagging supplies and equipment, and information on tagging procedures and the identification of bonefish species were handled by staff at Nervous Water Fly Fishers. Data collected from fishermen were reported through a “hot line” established at their store. Brochures describing the project are distributed at sporting good stores on O‘ahu and an article describing the project and alerting fishermen to the possibility of catching tagged fish were published in the August 2003 edition of *Hawaii Fishing News* (Volume 27, No. 7).

Results



A total of 1147 ‘o‘io were tagged between May 2003 and February 2006. Of the fish identified to species, 81% were roundjaw. The vast majority of sharpjaws (72%) were captured in Kane‘ohe Bay. Catch data shows very little mixing of the two species. Roundjaws were predominantly captured on sand, mud and coral flats in less than 6 feet of water while sharpjaws are commonly caught in deeper water (e.g., the Sampan Channel in Kane‘ohe Bay).

On average, the roundjaws are larger (mean = 20.3 in.) than the sharpjaws (mean = 15.9 in.) (Figure 9). The largest roundjaw was 39 inches while the largest sharpjaw was only 23 inches.

The major tagging locations included Kane‘ohe Bay, Hickam/Keehi Lagoon, and Hawai‘i-kai (Table 1). Other important ‘o‘io fishing locations were Kailua, ‘Ewa, Ala Moana, and Waikiki (Figure 10). These locations may reflect access and distance to population centers rather than abundance of ‘o‘io.

Of the 1147 ‘o‘io tagged, there were 19 total recaptures (1.6% recapture rate), with one individual recaptured twice. Most fish were recaptured close to their initial tagging location but one fish tagged off Hawai‘i-kai was recaptured off Kaunakakai Harbor on Moloka‘i after 609 days at-large (Fig. 11). The average time at-large was 290 days with a maximum of 792 and a minimum of five hours. The average distance traveled was 4.6 miles, and 2.0 miles excluding the one fish that was recaptured on Moloka‘i.

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Table 1. Number of o‘io tagged in Hawai‘i Between May 2003 and February 2006.

Location	Bonefish	Sharpjaw	Roundjaw	Total
Kaneohe Bay	43	96	134	273
Hickam/Keehi Lagoon	79	1	167	247
Hawaii Kai	84	7	116	207
Kailua	60	10	18	88
Unnamed	58	14	6	78
Ewa	22		52	74
Ala Moana	63		4	67
Waikiki	39		18	57
Kahala	8		18	26
Diamondhead	7		3	10
North Windward Oahu		2	3	5
Pearl Harbor	1		4	5
Kapoho, Hilo		2	2	4
Molokai			2	2
North Shore			2	2
Waimanalo	1	1		2
Total	**465**	**133**	**549**	**1147**

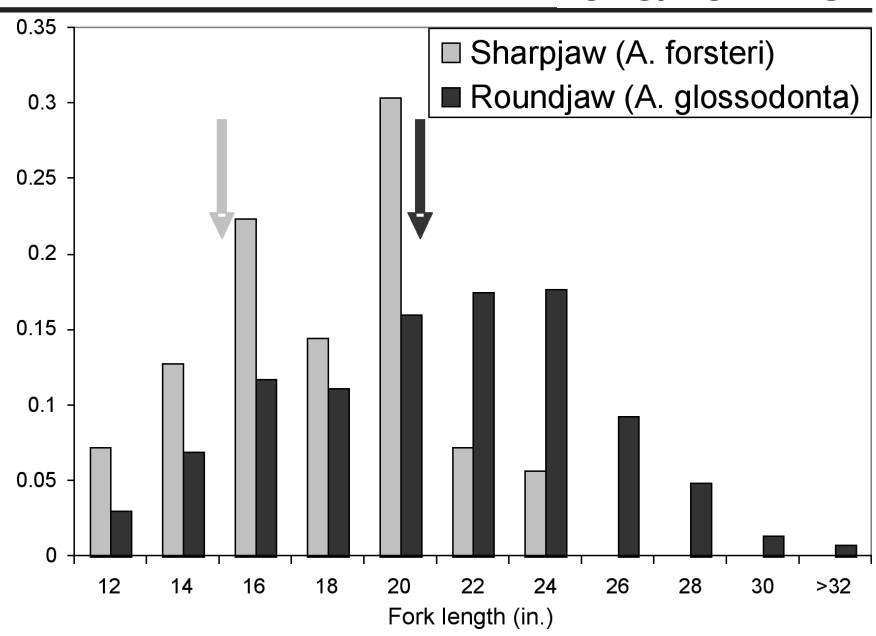

FIGURE 9. LENGTH FREQUENCY DISTRIBUTIONS FOR SHARPJAW AND ROUNDJAW ‘O‘IO FOR TAGGING PROGRAM ON O‘AHU BETWEEN 2003 AND 2006. ARROWS REPRESENT MEANS FOR EACH SPECIES.

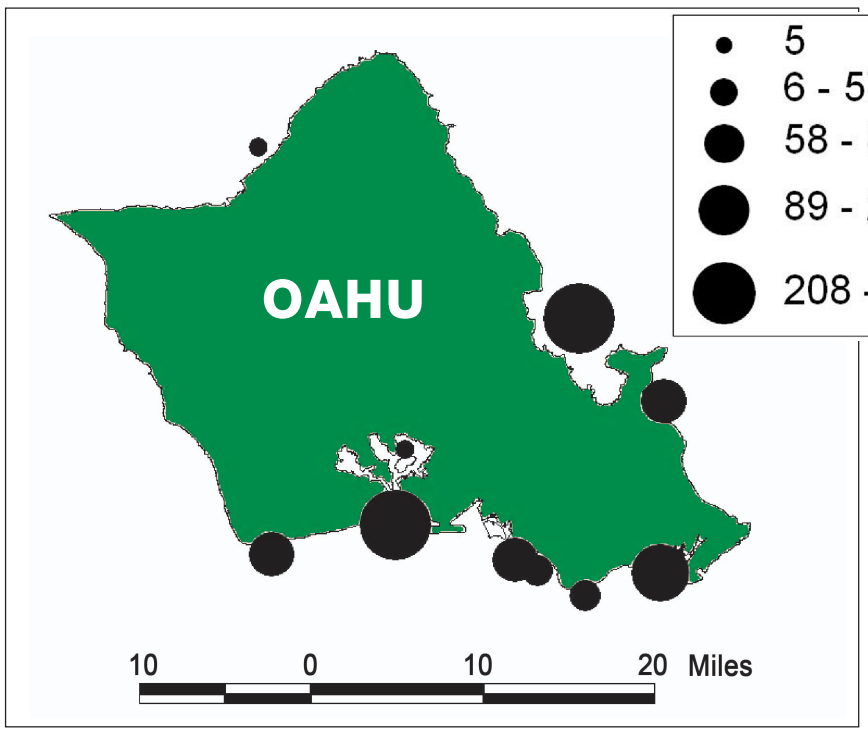

FIGURE 10. MAJOR TAGGING LOCATIONS FOR ‘O‘IO ON O‘AHU FROM 2003 TO 2006.

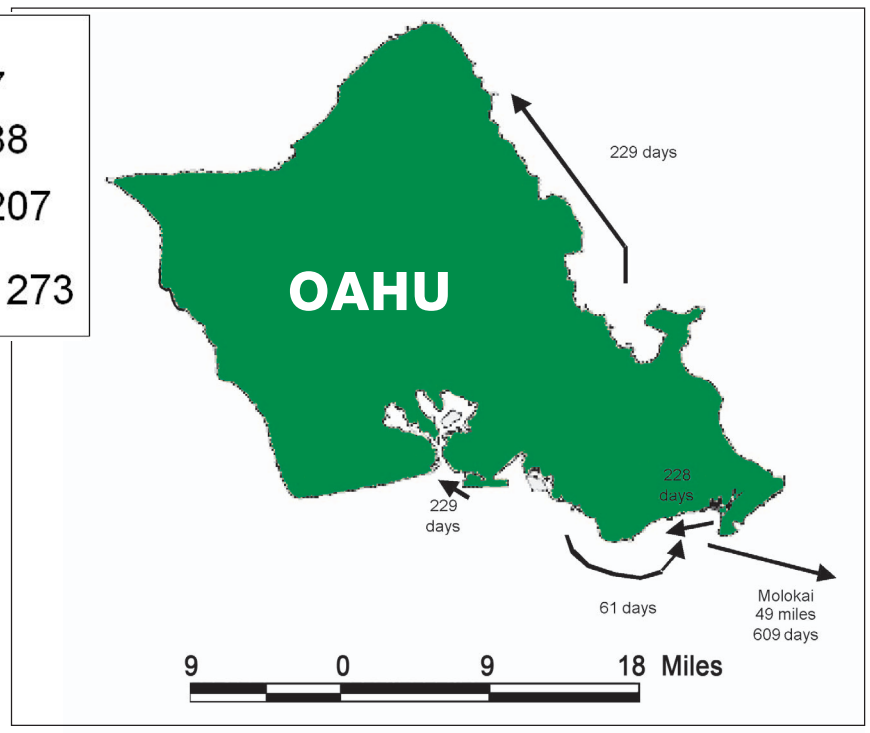

FIGURE 11. LONG DISTANCE MOVEMENTS OF ‘O‘IO FROM TAGGING LOCATIONS ON O‘AHU.

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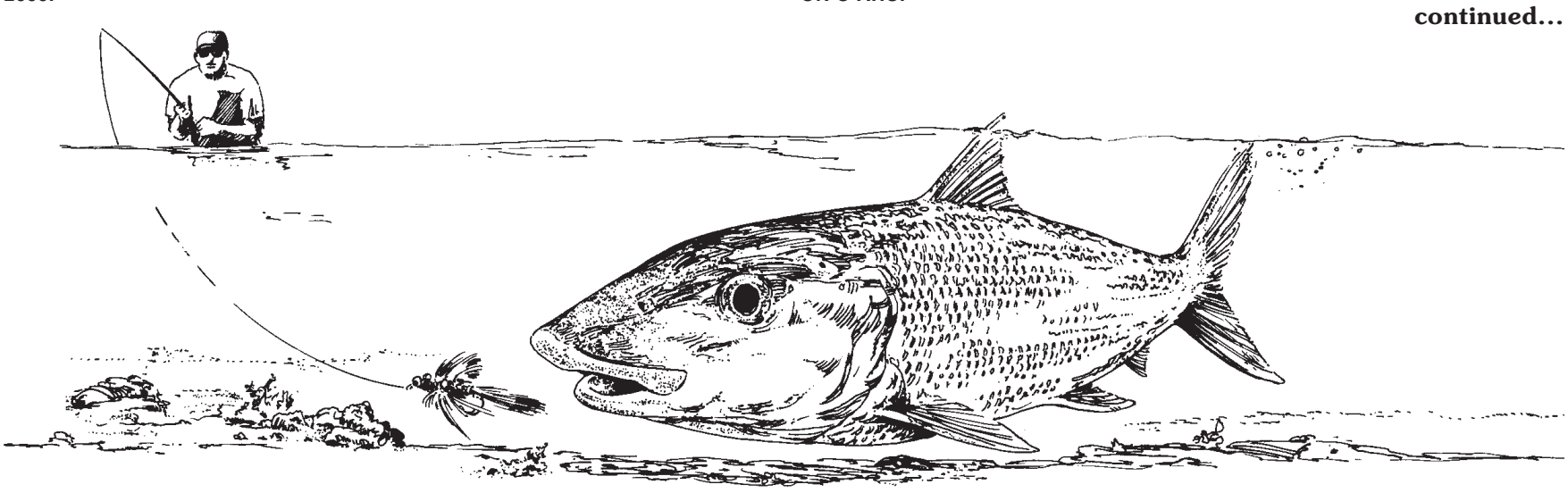

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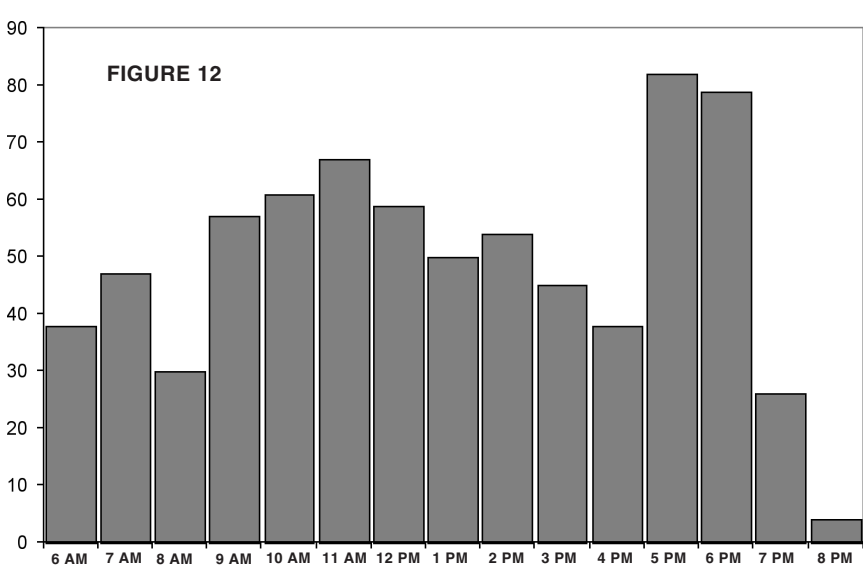
Catch Information

The major peak in ‘o‘io tag numbers was between 5 and 6 p.m. with a second peak between 10 a.m. and 1 p.m. (Figure 12). This afternoon peak may reflect increased “pau hana” fishing efforts.



Discussion

The results of this study suggest that the site fidelity for ‘o‘io is strong. Most of the fish recaptured (14/19) were in the same general area where they were first tagged. Only five fish traveled a significant distance, including one fish that was tagged in Kane‘ohe Bay and recaptured off the pier at Kaunakakai, Moloka‘i (49 miles away) 609 days later. This was an 18-inch (fork length) roundjaw that did not grow perceptively between captures. It is possible that smaller fish tend to school and may travel long distances looking for new, desirable habitat in contrast to larger fish which, presumably, are comfortable where they are.

The geographic isolation of the individual Hawaiian Islands and long distances and deep channels between the islands provides a very different habitat for fish than in most other parts of the world. In the Caribbean, for example, fish can travel for hundreds of miles along coastlines with similar habitat without encountering substantial barriers. The deep ocean channels between the Hawaiian Islands may pose a formidable barrier and dramatically curtail bonefish movement. Thus, the results of studies in other areas may not be applicable to Hawai‘i and visa versa.

Roundjaws and sharpjaws were found to occupy different habitats in this study. In this study, sharpjaws were rarely captured in water less than six feet (2 meters) in depth. Aside from the capture data, the shape of lower jaw differs suggests they prefer different foods and that there are ecological differences between the two species. Incidently, limited collections from Hawaiian fishponds in Kane‘ohe Bay have found that only one species (roundjaws) in these shallow waters.

Observations of anglers participating in this project are probably important in this regard. They reported that ‘o‘io were most often seen traveling across shallow sand, mud and coral flats in loose schools. Presumably, they spend most of this time feeding on shrimp, shellfish, and crabs. Mature fish are commonly found feeding on inshore, shallow flats, usually over mud, coral and grass and, occasionally, over white sand. While most are typically seen traveling in loose schools or pairs, larger specimens (26 inches fork length or greater) often travel alone. Occasionally, large schools are seen composed primarily of smaller ‘o‘io, most often around the time of a full moon. It is speculated that this is a pre-spawning aggregation, but it is not known where ‘o‘io in Hawai‘i actually spawn.

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Information from Other Pacific Locations

Stan Wright hangs on to his fly reel as a Christmas Island ‘o‘io screams out line.

‘O‘io have been studied in a number of locations throughout the Pacific and these results provide an interesting comparison with Hawai‘i.

Kiritimati (Christmas Atoll) is world-renowned for its bonefishing and has active recreational and commercial/subsistence bonefish fisheries as well as local knowledge concerning the life history of the species. Interviews with guides, fishermen, and others with local knowledge indicate that fish spawn monthly during the full moon and form pre-spawning staging locations inside the lagoon but are thought to spawn out on the forereef. In the past, the selective removal of large females resulted in a skewed sex ratio that was a cause for concern but recent actions by the government of Kiribati to conserve ‘o‘io should aid in their recovery.

Bonefish are the most important fish harvested in Tarawa Lagoon, but recent studies have demonstrated significant declines in abundance and average size of bonefish in the catch between 1977 and the late 1990s (Beets 2000). Of great concern is the shift in sex ratio, similar to that observed at Kiritimati. Spawning runs in Tarawa have been impacted by the construction of causeways, as fishermen reported that a causeway had effectively destroyed a spawning run.

The relatively unspoiled condition of Palmyra Atoll renders it one of the few places on earth to examine the unperturbed biology and ecology of bonefish. Our results from Palmyra show a large population of ‘o‘io but their size and age is limited by the large number of sharks in the lagoon. Sex ratios of bonefish at Palmyra indicate a healthy population compared to the highly skewed sex ratios observed at both Tarawa and Kiritimati Atolls (Table 2). Heavy fishing pressure and degradation of habitat at Tarawa and Kiritimati atolls has resulted in the loss of pre-spawning aggregation sites and spawning migration routes. These losses may be responsible for the declines observed in catch, size, and sex ratio of bonefish at these locations. The average size of fishes among these atolls was similar but smaller than those observed on O‘ahu, a high volcanic island in Hawai‘i (Table 3). Genetic isolation and varying environmental factors likely explain these differences.

Table 3. Comparisons of Size and Sex Ratio for *Albula glossodonta* Among Locations in the Pacific.

Location	Mean FL in.	Max	Sex ratio(F:M)	Source
Palmyra	16.34	26.38	1 : 1.25	Friedlander et al. 2007
Tarawa	16.03	21.93	1 : 6.75	Beets 2000
Kiritimati	17.17	23.62	1 : 15 (one area–no females)	Kamatie et al. 1995
Hawaii (Windward and south shore Oahu)	20.43	29.02		Oahu Tagging Study

Conclusions

This project has provided valuable information on ‘o‘io biology and the recreational fishery. It has also helped to encourage anglers to release their catch. The tagging program has been an effective public education tool. Certainly, without information on ‘o‘io distribution and behavior, it is difficult to develop plans or programs for inshore fisheries management and resource sustainability appropriate for Hawai‘i.

Given the declining commercial catch and anecdotal reports from anglers, further actions are needed to assure that ‘o‘io populations are not further depleted. Nearly 22,000 lbs of ‘o‘io were taken in lay gillnets between 1997 and 2006. ‘O‘io are particularly vulnerable to gillnets because of their movement patterns back and forth through sand channels along the reefs to feed in the shallow flats. The recently enacted partial ban on lay gillnets may help to improve the health of stocks in some areas. However, it will be important to monitor trends to determine the effectiveness of this and other management measures.

There is still much to be learned about the biology and fisheries for ‘o‘io. Important information on larval recruitment, age and growth, movement patterns and habitat utilization, and fisheries dynamics are still missing. Studies using acoustical tags, implanted transmitters and remote receivers, will help to establish localized movement patterns. In addition, we need to understand the dynamics between the two species of ‘o‘io and how they interact with one another and their environment.

Data are also needed on size and numbers of fish caught to examine trends in the fishery and determine fishery benchmarks for resource sustainability. Owing to the elusive nature of bonefish, much of the information necessary to manage this species can only be obtained by anglers and guides. Collaboration with them provided valuable data as well as recommendations for management strategies for ‘o‘io.

Finally, we need to begin to collect data that will allow us to define the “catch-and-effort” for the fishery around O‘ahu. At present, there are no traditional “catch-and-effort” data available to describe fishery dynamics, size of the catch, or the effects of exploitation because the catches of recreational fishermen are typically not reported.

Effective management requires a sound understanding of biology and fisheries dynamics of the species. Only by understanding factors that are important to their life cycle and growth can appropriate resource management measures be developed to assure the sustainability of ‘o‘io populations. This fishery is a valuable resource to the state of Hawai‘i.

Acknowledgements

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