Manual of Hawaiian Fish Remains Identification Based on the Skeletal Reference Collection of Alan C. Ziegler and Including Otoliths*

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October, 2004

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*Special Publication 1, Society for Hawaiian Archaeology. Funding for this manual was generously provided by the Society for Hawaiian Archaeology, Haun & Associates, Cultural Surveys Hawaii, Garcia and Associates, Pacific Legacy, International Archaeological Research Institute, Inc., Leilani Pyle, Mike Carson, Carol Kawachi, Roger Blankfein, Pam Asbury-Smith, Maria Orr, T. S. Dye & Colleagues, Archaeologists, Inc., and B. P. Bishop Museum. Fishes for the otolith atlas were collected with the aid of Ross Langston and Annmarie Dehn, dive and fishing buddies extraordinaire (respectively). Jack Randall, Dave Greenfield, and Arnold Suzumoto provided taxonomic advice. Fishes were processed at the Hawaii Institute of Marine Biology. Kekapala Dye and Jeffrey Putzi prepared the fish bone plates. The otolith atlas is funded in part by a grant/cooperative agreement from the National Oceanic and Atmospheric Administration, Project # R/FM-8, which is sponsored by the University of Hawaii Sea Grant College Program, SOEST, under Institutional Grants No. NA86RG0041 and NA16RG2254 from NOAA Office of Sea Grant, Department of Commerce. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies. UNIHI-SEAGRANT-BA-02-001. Otoliths were photographed at the Biological Electron Microscope Facility at the University of Hawaii, which received support from National Institutes of Health award RR-16467. NOAA Fisheries, Pacific Islands Fisheries Science Center supported preparation of the manuscript. The otolith atlas is contribution number 2004-017 of the Hawaii Biological Survey.

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1 Introduction

Hawai‘i lost a fine scientist and Hawaiian archaeologists a good friend when Alan C. Ziegler passed away at the age of 73 in September, 2003. Trained as a zoologist at the University of California at Berkeley, where he earned the Ph.D. degree, and for many years head of Bishop Museum's Vertebrate Zoology Division, Ziegler had an active and broad interest in archaeology. In 1973 he published *Inference From Prehistoric Faunal Remains* as an Addison-Wesley module in Anthropology, which provided a generation of archaeologists with a clear-headed appraisal of the information that might be gained from a study of the bones and shells recovered during excavation. His *magnum opus*, published by the University of Hawai‘i Press the year before he passed away, is *Hawaiian Natural History, Ecology, and Evolution*, a nearly 500 page overview of Hawai‘i's natural heritage.

After he left Bishop Museum in 1983, Ziegler established an independent zoological consultancy that, among other projects, served the archaeological community by identifying vertebrate faunal remains, including fish remains, from archaeological sites. Ziegler's identifications were carried out efficiently and with a level of competence that will be difficult to replace. His work over the years produced a database of faunal identifications that archaeologists can use with complete confidence to reconstruct the interactions of traditional Hawaiians with their animal world.

This handbook is intended both as a memoriam to Alan Ziegler and as a tool that Hawaiian archaeologists can use to promote his legacy of high-quality faunal identifications. At its core are high-resolution scanned images of the fish bones in Ziegler's reference collection, now held by Bishop Museum. These images are intended to serve as a guide to the identification of fish bones. In many cases, comparing a bone with the images will be sufficient to yield a confident identification, but in many others it will be necessary to go beyond the images and make comparisons with actual bones in a high-quality fish bone reference collection. Currently, there are at least two of these in Hawai‘i; Bishop Museum holds a large number of fish skeletons in addition to the Ziegler collection (`<url:http://www2.bishopmuseum.org/anthro/fauna/fishes_query.asp>`), and the Anthropology Department of the University of Hawai‘i also holds a useful and well-organized collection of fish bones from Hawai‘i and Fiji (`<url:http://www.archaeology.hawaii.edu/collections/fishbone.htm>`).

In addition, the manual contains an atlas of fish otoliths, or ear stones. An otolith is an extremely durable fish remain that is distinctive in many cases to species level. It is routinely used by paleontologists for taxonomic identification of fossils from geologic formations. A detailed descriptive terminology for otoliths, highlighting the distinctive differences among fish taxa, has been worked out and can be applied directly to the Hawaiian materials. Given this situation, the otolith atlas should be immediately useful to archaeologists and to biologists conducting dietary studies of animals that prey on fishes.

The manual was produced as a Portable Document Format (pdf) file using pdfLATEX software. Hypertext links for the table of contents, lists of figures and tables, figure references, text citations, and a list of citation locations following each bibliographic entry were generated by the hyperref package created by Sebastian Rahtz. When this file is viewed with Adobe Acrobat Reader software in full page mode it is possible to move through the manual with relatively great speed and precision using the links. Hypertext links are indicated on the computer screen with a colored box around the link text; brown links lead to locations in the text and dark red links lead to the bibliography. The same file can be used to print out the manual on a printer capable of two-sided printing. The colored hypertext links will not appear on the printed manual; the only tell-tale sign of the document's hypertext capability will be the list of citation locations following each bibliographic entry.

2 Identification and Quantification of Fish Remains

The isolation of the Hawaiian Islands has led to a relatively impoverished fish fauna with a high degree of endemism (Ziegler 2002:144 ff.). There are approximately 530 species of native and alien bony fishes in Hawaiian waters and 51 species of cartilaginous fishes, about half the number found at islands in Micronesia, and one fifth that found in the Philippines. Still, the prospect of identifying a fish bone or otolith is somewhat daunting. The following sections provide some general guidelines for identification and discuss issues of quantification faced by archaeologists in their work with fish remains. Issues of identification specific to otoliths are discussed in section 4.2.

2.1 Taxonomic Level of Identifications

Given a collection of fish remains, how does the analyst produce useful identifications that maximize the potential information of the collection but clearly reflect the various uncertainties that are almost always present? It goes without saying that to be useful an identification must be correct, but it is also true that in most cases an identification to a low taxonomic level, such as genus or species, is preferable to one to a higher level, such as family or class. In practice, the analyst will usually want to identify the remains to the lowest taxonomic level possible. What are the limits of possibility? These are determined by the quality and completeness of the reference collection. A quality collection meets the following criteria:

- Remains are from fish that were identified correctly, preferably by a specialist, using an up-to-date and reliable taxonomic classification;

- Remains have been processed correctly so that distinguishing features are clearly expressed and not obscured by extraneous material, broken, or otherwise altered by processing;
- The collection is cataloged and stored in such a way that bones from different fish are not confused with one another; and
- The collection is held at a location or institution where it is available for scholarly use.

Identifications based on collections that don't meet these criteria are clearly open to question and analyses built upon them run the risk of having their foundations fail.

The completeness of a collection determines the lowest taxonomic level possible for identification. This is most easily illustrated with a hypothetical example, in which the analyst identifies a premaxilla of what appears to be a rudderfish from the family Kyphosidae using a hypothetical reference collection that contains the high quality remains of the two most common of the family's five species in Hawai‘i, *Kyphosus pacificus* and *K. vaigiensis*. The premaxilla, after comparison with premaxillae in the reference collection is found to resemble very closely the premaxilla of *K. pacificus*. Certainly, the analyst feels the urge to identify the bone as *K. pacificus*, but the best that can be done in this instance is identify the bone as belonging to the family Kyphosidae. An identification to species is impossible because the other three species of Kyphosidae known from Hawai‘i are not in the collection and the analyst cannot be certain that one of these would provide a better match for the premaxilla than *K. pacificus*. Likewise, a confident identification to the genus *Kyphosus* is impossible because the collection lacks a specimen of *Sectator ocyurus*, the sole representative of the other genus of Kyphosidae known from Hawai‘i, though only rarely collected and quite possibly a waif from elsewhere in the Pacific.

Alan Ziegler's skeletal reference collection, which is illustrated in section 3, supports identifications to the general levels set out in appendix A. Most of the taxa correspond to families of fish, with a few exceptions. The taxon Marine Eel lumps together the ten eel families known in Hawai‘i, and Fish was used for the very many skeletal elements, such as most vertebrae, that can't be readily identified to a lower taxonomic level.

Identifications to taxonomic levels lower than those listed in appendix A are undoubtedly desirable in many situations. For example, studies concerned with where fish were caught will want to identify genera or species within families that contain members found in a variety of habitats. Studies of this type will be based on identifications made with a more complete reference collection than the one illustrated here.

2.2 Quantification Issues for Archaeological Collections

The methods useful for estimating patterns of fishery resource exploitation involve deriving estimates of the relative abundance of taxa from the identified fish remains and determining whether they reflect the full diversity of the prehistoric catch. As it turns out, estimating the relative abundance of taxa from archaeological remains is often difficult and is intimately tied to the units used to quantify the remains. This is an issue that has generated a large, often contentious literature but no reporting standards, thus complicating and often compromising efforts to summarize and synthesize published data. Investigations into the diversity of the catch are often subsumed under the heading "niche breadth." They are important for determining the influence of size on the diversity of a collection. The goal here is to know how many bones are needed to characterize the diversity of the catch(es) from which a collection derived.

At the outset, it should be noted that remains recovered from an archaeological site are several steps removed from the catch, and that at each step of the way from catch to archaeological site potential biases are introduced that complicate inferences about the abundance of taxa. A useful way to look at this considers the various statistical populations from which a collection of fish remains might be considered a sample (Klein and Cruz-Uribe 1984:3):

Life assemblage The community of live fish in their natural proportions;

Death assemblage The catch, or fish available for deposition at the archaeological site;

Deposited assemblage The fish or portions of fish that come to rest at the archaeological site;

Fossil assemblage The fish parts that survive in a site until excavation or collection; and

Sample assemblage The part of the fossil assemblage that is in the collection.

This classification makes it easy to see that the archaeological collection, or sample assemblage, is usually only a partial reflection of the catch, separated from it by the vagaries of human deposition practices, the breakdown of faunal remains in the archaeological site over time, and the recovery efforts of the archaeologist.

There are a host of methods by which fish remains can be quantified and a large literature that summarizes the methods (see Klein and Cruz-Uribe 1984; Reitz and Wing 1999; Ringrose 1993). One review of zooarchaeology counted 122 unique definitions for quantification methods (Lyman 1994). Most commonly used in Hawai‘i are the number of identified specimens, often abbreviated NISP, the minimum number of individuals, or MNI, and weight. Each of these can be used to estimate relative abundance of taxa in the *sample assemblage* with varying degrees of reliability and difficulty. None of these measures directly estimates the relative abundance of taxa in the fossil, deposited, death, or life assemblage.[1] The following discussion attempts to point out the strengths and weaknesses of each measure as an estimator of the relative abundance of taxa in the sample assemblage.

NISP

MNI

The measure with the most intuitive attraction is MNI, which estimates the smallest number of individual animals in the catch that could have produced all the remains in an archaeological collection. Relative abundances calculated with MNI are used

[1] A statistic known as the Lincoln Index, applied to paired elements, yields estimates of the relative abundance of taxa in the death assemblage (Ringrose 1993:128 ff.), but to our knowledge this has not been applied to Hawaiian archaeological remains.

by Pacific archaeologists "to convey what the catch would have looked like when laid out on a mat after a fishing trip" (Leach 1997:6), a characterization that plays up the conceptual appeal of counting individual animals, but ignores the fact that MNI estimates characteristics of the sample assemblage and not the death assemblage. MNI can be calculated from individual elements, e.g. the distinctive first dorsal spine of a Triggerfish, paired elements, such as the dentary of a fish, or multiple elements where the elements cannot be told apart, such as vertebrae. The measure is straightforward when it uses individual elements, but becomes complicated when paired or multiple elements are used, as they typically are when calculating the MNI of fish. The problem here is that MNI estimates based on paired or multiple elements are not additive; for a given taxon, the sum of MNI from sub-units of a collection unit, e.g. the individual 1 m^2 excavation units of a 20 m^2 excavation block, will generally be greater than the MNI calculated for the larger unit because paired or multiple elements of an individual animal are counted separately if they are collected from different sub-units. This characteristic of MNI is discussed at length by Grayson (1984), who refers to it as the aggregation effect. In practical terms, a literature source must report the MNI of taxa identified by paired or multiple elements for the stratigraphic unit of interest if the data are to be used for comparison. If the report gives MNI for some other unit, then direct comparison will be impossible. The MNI statistic is known to over-estimate rare taxa, over-estimate taxa with many identifiable parts in highly fragmented collections, and under-estimate these same taxa in collections with little fragmentation (O'Connor 2001:706). MNI estimates are sensitive to stochastic factors and in this way are less robust than estimates made with NISP.

Less intuitively attractive is the NISP measure, which, in practice, counts every identifiable element and element fragment.[2] Taxa with a large number of identifiable elements—a good example, common in Pacific faunal collections, is the spiny puffer of the family Diodontidae, each individual of which has approximately 500 distinctive dermal spines (Leach 1997:11)—will yield high NISP values compared to taxa with a small number of identifiable elements. A correction for this divides the NISP for each taxon by the number of identifiable, or identified, elements of the taxon, although this is rarely accomplished in Hawai'i. Also, taxa with identifiable elements that fragment easily are likely to be over-represented relative to taxa with sturdier identifiable elements in collections with a high frequency of fragmentary remains. Despite these potential problems, many investigators find NISP a useful measure of relative taxonomic abundance. In an analysis of fish remains from the Cook Islands, Nagaoka (1994) found that MNI and NISP values for each taxon varied in a predictable fashion, indicating that they carried similar information on relative abundances. Thus, given the relative ease of obtaining NISP estimates and their mathematical manipulability, they appear to be superior to MNI for most purposes. Alan Ziegler recommended to his clients that they report the bones he identified as NISP, in a table similar to table 1.

Use of sample weights to estimate relative abundance of taxa is relatively rare among archaeologists (Reitz and Wing 1999:191), primarily because the weight of an animal's remains varies widely among taxa. A correction for this variability multiplies the weight of identified remains by a value for each taxon that describes the relationship

[2] An alternative designation for NISP is total number of fragments, or TNF.

Table 1. Example table of identified fish remains (NISP)

	Collection				
Taxon	**1**	**2**	**3**	**4**	**Total**
Carangid	12	8	22	17	59
Chaetodontid	2	4	1	6	13
Acanthurid	34	66	21	55	176
Balistid	7	23	4	1	35
Total	55	101	48	79	283

of meat weight to the weight of inedible remains that might be deposited in archaeological sites. Corrected in this way, bone weights provide estimates of the relative weight of meat contributed by each taxon to the sample assemblage. A problem with this procedure is that, for many taxa, the meat weight ratio is not constant over the life span of the animal (Casteel 1978), a fact that might or might not introduce significant errors into an analysis. In practice, weights are often used to quantify shellfish remains, where they provide "a simple and quite effective method for establishing the relative economic importance of different shellfish taxa" (Leach 1997:8), but only rarely for vertebrate remains, where the use of MNI and especially NISP are more common.

3 Atlas of Identifiable Fish Bones

3.1 About the Atlas

The images in this atlas of identifiable fish bones are high-resolution scans made with a flat-bed scanner. They are best viewed on a computer with display software for Portable Document Format (pdf) files. The advantage of this method is that one can zoom in on a particular bone or bones to view them at greater than life size. This simulates the effect of looking at the bones through a hand lens, revealing small details of shape and structure that might be useful for identification. The manual can also be printed on a printer capable of two-sided reproduction; such printers are typically found at copy shops. When printed in this way the photographs will generally show bones smaller than life size and small details of shape and structure might be lost in the printing process. Hard copies of the handbook should prove as useful as another atlas of fish bones that includes fishes found in Hawaiian waters (Barnett 1978).

The fish illustrated in the atlas were all identified by Alan Ziegler. Most of them were purchased in markets, but others were given to him by fishermen and scientists. As the images show, most of the identifiable bones were labeled in India ink with a catalog number and often the sex of the specimen. The bones most useful in Ziegler's work identifying archaeological materials were kept in a cabinet with divisible plastic drawers, ordered alphabetically by family; other bones were kept in black cardboard boxes, each with a label indicating the taxon, family name, catalog number, locality, date collected, sex, and occasionally a note.

The bones were scanned at 1,200 dots-per-inch against a black cloth background in both medial and lateral views. The tagged image file format files produced by the scanner ranged in size from 10–97 megabytes. Using Gnu Image Manipulation Program software, the image of each bone was cut out and pasted onto a uniform background of dark gray, following a standard layout, where possible. In the standard layout the bones are arranged with the lateral view on the right and the medial view on the left, with the maxilla at the top, followed by the premaxilla, dentary, angular, and quadrate at the bottom. The bones have generally been placed so that Ziegler's india ink labels are oriented correctly and to minimize the size of each plate, without regard to the orientation of the bone in the skeleton. Variations from the standard layout, e.g. for fish that have fused one or more of the identifiable bones with other bones or that have distinctive bones from other parts of the skeleton, are noted in the figure captions. A 1 cm scale bar has been placed on each plate.

The plates have been ordered alphabetically by family and alphabetically by species within each family, a compromise that steers clear of the treacherous shoals of phylogenetic arrangement. An idea of the flux that characterizes this branch of taxonomy can be had by comparing the phylogenetic arrangement of families used by Gosline and Brock (1960) with a more modern one, such as Randall (1996). Along with many small changes in the order of families are several large ones; the lefteye flounders of the family Bothidae are placed by Gosline and Brock (1960) at the primitive end of the list, near the squirrelfishes of the family Holocentridae, and by Randall (1996) near the advanced end of the list, separated from the Holocentridae by some 40 other families! Although a phylogenetic arrangement carries some information of potential use to the faunal analyst, it is beyond the scope of the manual to choose among competing phylogenetic arrangements and the interested analyst will have to refer to other publications for this information.

3.2 A Procedure for Identifying Fish Bones

A useful procedure for identifying fish bones has been set out in detail by Leach (1997).[3] The account here outlines Leach's procedure.

After the fish bones in a collection are laid out on a table, all the bones are assigned to one or another of eight categories, one bone at a time, focusing on distinctive bones of the skull. The categories are:

special bone An unusual bone that is distinctive to a particular taxon. Examples include the first dorsal spine of *Pervagor spilosoma*, which bears a row of prominent downcurved spines on each side (Randall 1985:58) and the two-rooted dermal spines of *Diodon hystrix*.

[3] Leach (1997) cites the preferential use of MNI as one reason to follow this identification procedure. As indicated in section 2.2, the use of MNI as a basic unit of quantification is not recommended. The identification procedure set out by Leach is still valid, however, because the bones it uses are among the most distinctive of the fish skeleton and were the bones used by Ziegler in his identifications. Leach's argument against the identification of bones other than those explicitly noted in the procedure, based on the use of MNI as a basic unit of quantification, should be ignored except in instances where identification of other bones yields redundant information, i.e. does not alter the relative abundances of identified taxa.

dentary The most distinctive bone of the fish skull (fig. 1). It is a paired dermal bone of the lower jaw that bears teeth in most bony fishes (Rojo 1991). The dentaries are fused together in the pufferfishes, forming a structure that resembles a parrot's beak. Landmarks on the dentary include the symphyseal margin, mental foramen, coronoid process, external wall, meckelian fossa, internal wall, and sensory canal (fig. 2).

premaxilla The second most distinctive bone of the fish skull (fig. 1), it is a paired dermal bone of the anterior part of the upper jaw (Rojo 1991). In most fish, the lower border of the premaxilla bears teeth. Landmarks on the premaxilla include the symphyseal margin, ascending process, articular process, maxillary process, and caudal process (fig. 3).

angular A paired bone directly posterior to and articulated with the dentary. It articulates posteriorly with the quadrate (fig. 1). Also known as the articular. Landmarks on the angular include the anterior process, coronoid process, quadrate facet, postarticular process, prearticular fossa, superior crest, and inferior crest (fig. 4).

maxilla A paired bone directly posterior to and articulated with the premaxilla (fig. 1). It bears teeth in some primitive fishes, but teeth are absent in more advanced forms (Rojo 1991). Landmarks on the maxilla include the premaxillary sulcus, internal process, palatine sulcus, maxillary process, caudal process, and external process (fig. 5).

quadrate The bone directly posterior to and articulated with the angular (fig. 1). Landmarks of the quadrate include the ectopterygoid margin, collus, and preopercular groove (fig.).

fish A bone that can be definitely identified as not belonging to one of the previous six categories. The great majority of bones in most collections will fall into this category.

problem A bone that cannot be assigned with confidence to any other category. Typically, these bones are re-examined at the end of the sort and classified, if possible. In some cases, the problem bones will be examined by a specialist.

It cannot be stressed too strongly that each of the assignments at this stage represents a positive statement about one fish bone.

The bones in the special bones category and the five distinctive bones of the skull are then identified to taxon by reference to the photographs in this manual and, if needed, by reference to actual bones in a reference collection. As it stands today, this is a task guided solely by experience and familiarity with the distinctive bones of Hawaiian fishes. No key for the identification of a particular skeletal element has been worked out. A key for each of the identifiable bones would be a great advance and a worthy project for the ambitious faunal analyst.

Once a bone has been identified to the lowest possible taxonomic level it is placed in a bag with a label for that taxon. In general, it is advisable to start with the most

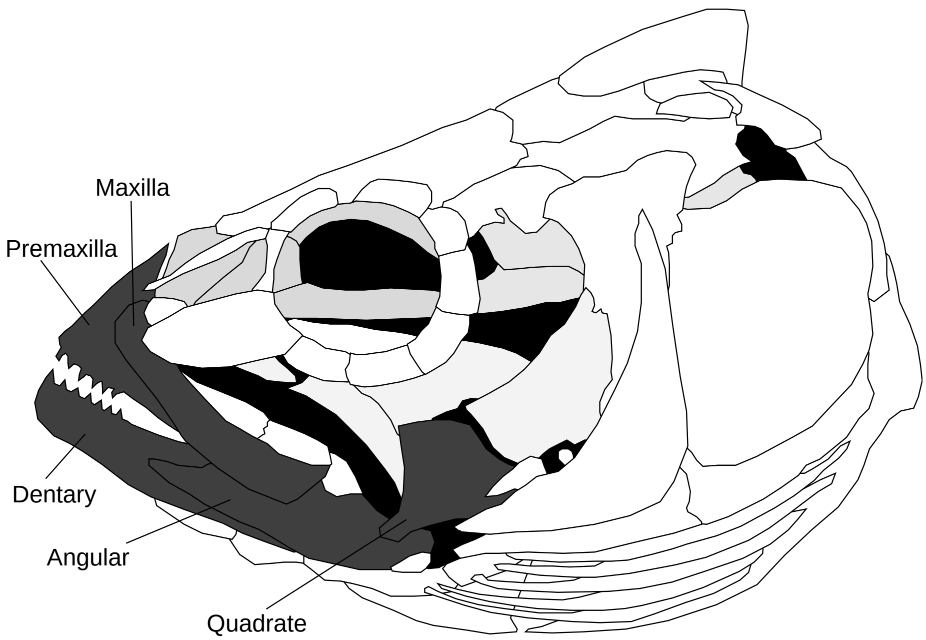

Figure 1. Distinctive skull bones of the fish. Adapted from Barnett (1978:fig. 7).

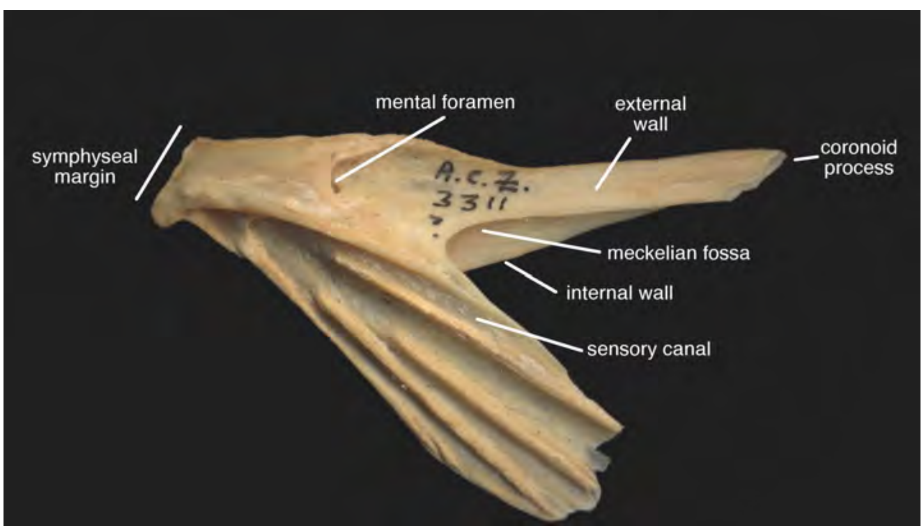

Figure 2. Dentary of *Beryx decadactylus*, showing landmarks. After Rojo (1991:fig. 17).

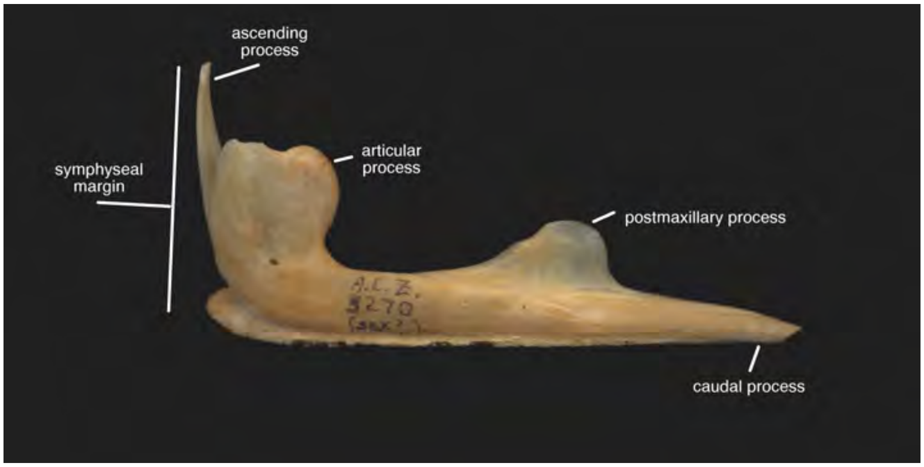

Figure 3. Premaxilla of *Seriola* cf. *dumerili*, showing landmarks. After Rojo (1991:fig. 15).

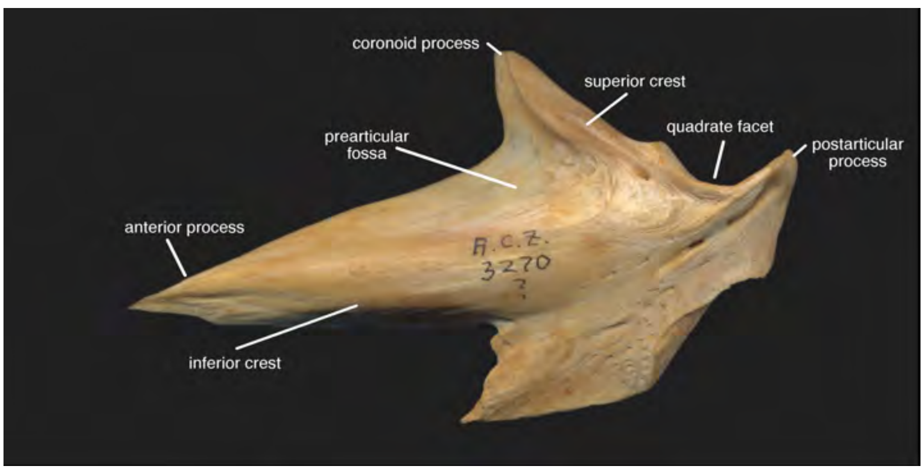

Figure 4. Angular of *Seriola* cf. *dumerili*, showing landmarks. After Rojo (1991:fig. 18).

distinctive bones and work toward the least distinctive. In this way, by the time the least distinctive of the identifiable bones—the quadrates—are being identified, the analyst has a reasonably good idea about the kinds of fish in the collection, which in many cases can speed identification of otherwise difficult bones.

At the end of this procedure there is one bag for each taxon identified in the collection, containing all of the identified bones for that taxon, plus one bag of fish remains not identified.

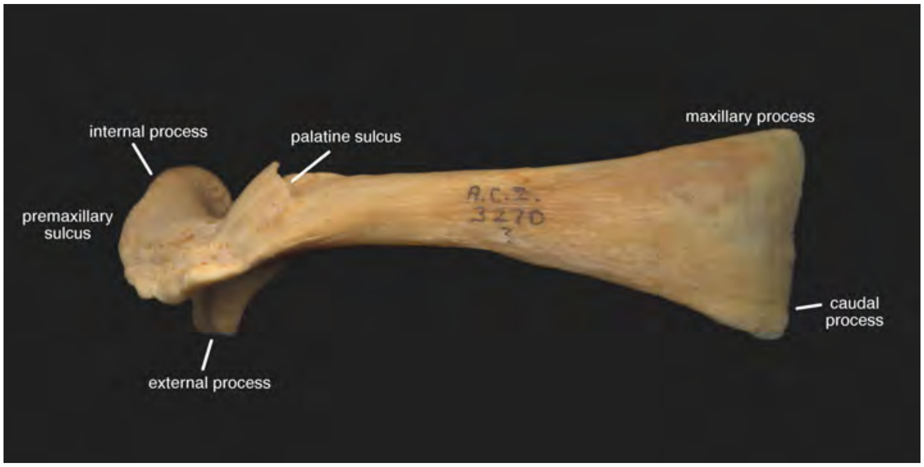

Figure 5. Maxilla of *Seriola* cf. *dumerili*, showing landmarks. After Rojo (1991:fig. 16).

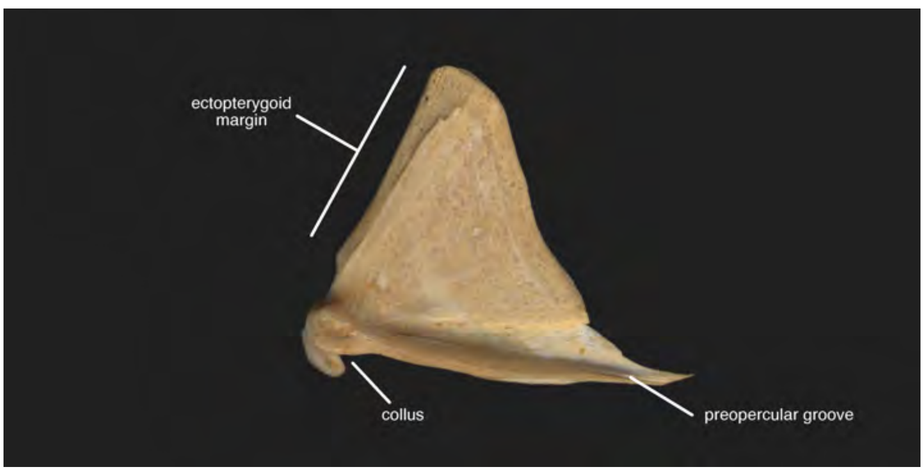

Figure 6. Quadrate of *Seriola* cf. *dumerili*, showing landmarks. After Rojo (1991:fig. 29).

3.3 Identifiable Bones of Hawaiian Fishes

3.3.1 Acanthuridae

Acanthurus olivaceus (fig. 7) is an herbivore that reaches 30 cm in length and is found over sand bottoms near reefs in waters 10 m to at least 45 m deep (Randall 1985:48, 49). It is known in Hawai‘i as *na‘ena‘e*.

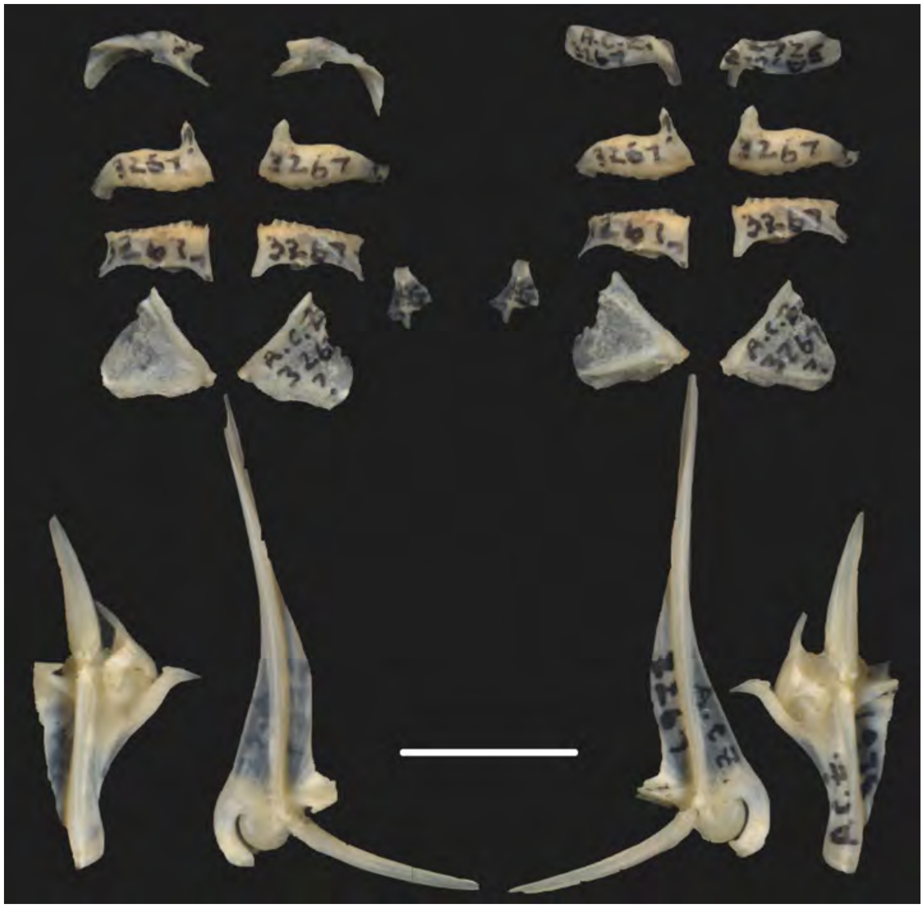

Figure 7. *Acanthurus olivaceus*, the orangeband surgeonfish, or *na'ena'e*, ACZ-3267. Original locality unknown; purchased at Honolulu, O'ahu fish market. Scale bar = 1 cm.

Acanthurus xanthopterus (fig. 8) is a large surgeonfish that reaches 56 cm in length (Randall 1985:49). It lives on coral reefs but ranges widely to 90 m depths (Randall 1985:49, 50). It eats diatoms and detritus, which it ingests with sand (Randall 1985:49). Known in Hawai'i as *pualu*, it is usually caught in a net, but sometimes takes a hook, as well (Hosaka 1973:137). The fish has a strong odor, but is eaten raw by some and broiled by others (Titcomb 1972:144).

Zebrasoma veliferum (fig. 9) grows to 38 cm on coral reefs and rocky shores, where it sometimes goes into the surge zone (Randall 1985:52). It browses on filamentous algae (Randall 1985:52). Known in Hawai'i as *māne'one'o*, it is not particularly valued as a food fish (Titcomb 1972:88).

Naso unicornis (fig. 10) grows to a length of 69 cm browsing on coarse leafy algae in shallow water (Randall 1985:52). It travels in large schools but is also seen singly at

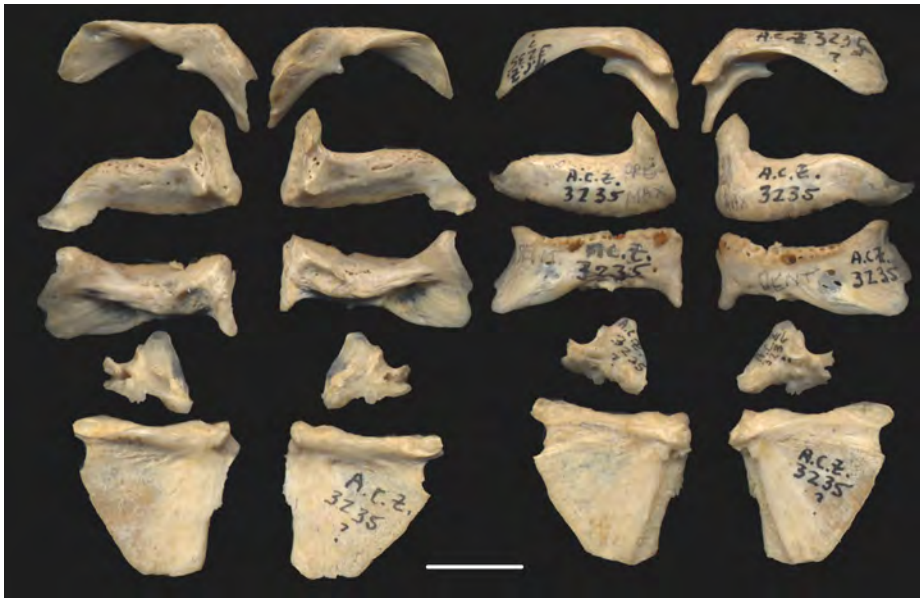

Figure 8. *Acanthurus xanthopterus*, the yellowfin surgeonfish, or *pualu*, ACZ-3235. Scale bar = 1 cm.

the edge of the reef. Known in Hawai‘i as *kala*, it is caught in nets or with a spear; it never takes a hook (Hosaka 1973:142). Its flesh has a strong odor and is rarely eaten raw; it is best broiled or dried and broiled or baked (Titcomb 1972:85).

Naso brevirostris (fig. 11) travels in schools and can reach a length of 50-60 cm (Hosaka 1973:141–142). Younger fish browse benthic algae, but adults feed primarily on zooplankton (Randall 1985:53). Known in Hawai‘i as *kala lōlō*, it is one of about a dozen varieties of *kala* recognized traditionally (Titcomb 1972:84). It is generally caught in nets or with a spear (Hosaka 1973:142). The flesh has a strong odor and is rarely eaten raw; it is often broiled or partially dried and broiled (Titcomb 1972:85).

3.3.2 Albulidae

Albula sp.[4] (fig. 12) is a fish of sandy bottoms that often runs in large schools (Hosaka 1973:73). It attains a maximum length of about 90 cm feeding on crustaceans in the sand (Gosline and Brock 1960:95). It is caught with a hook and line or in *hukilau* nets (Hosaka 1973:73). Known in Hawai‘i as *‘ōi‘o*, it is an “exceedingly popular food fish, flesh is delicious, white; liked raw when its may fine bones are supple and slip down the throat without any trouble: often eaten ‘lomied’ with *limu kohu*” (Titcomb 1972:119).

[4] Alan Ziegler identified this fish as *Albula vulpes* at a time when it was believed there was a single circumtropical species of bonefish. Two species, difficult to distinguish, are now recognized in Hawai‘i, *A. glossodonta* and *A. argentea* (Randall 1996:27).

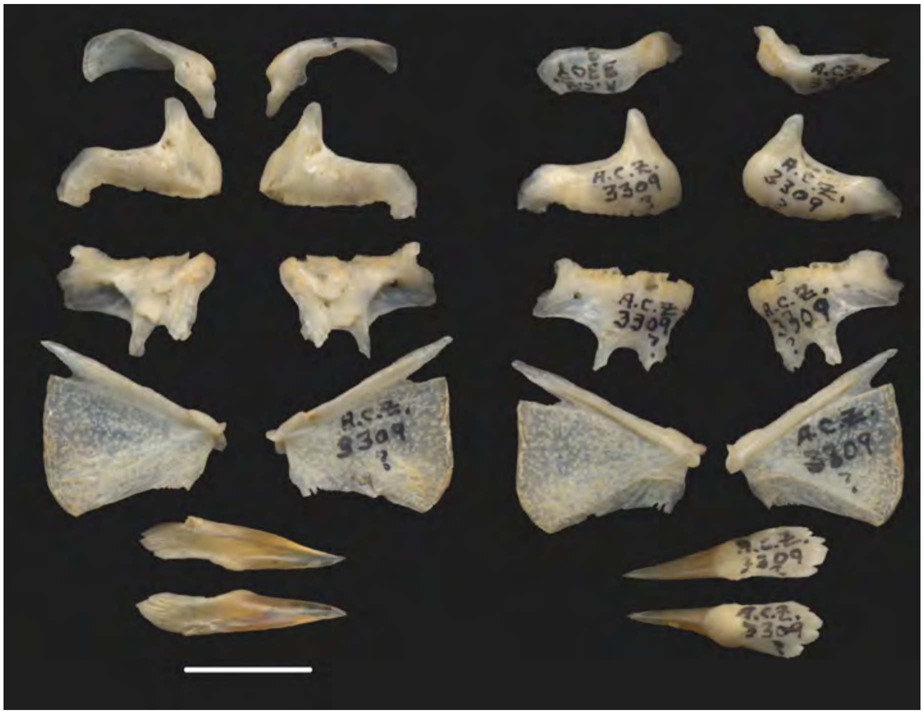

Figure 9. *Zebrasoma veliferum*, the sailfin tang, or *māne‘one‘o*, ACZ-3309. Original locality unknown; purchased at Honolulu, O‘ahu fish market. *Bottom*, peduncular spines. Note angular missing from collection. Scale bar = 1 cm.

3.3.3 Antennariidae

Antennarius sp. (fig. 13) is a bizarre-looking fish that sits on the bottom, where it lures small fish with an unusual first dorsal spine that resembles a fishing pole (Randall 1985:10). It grows to a length of 30 cm on a carnivorous diet of small fish. It is blends in very well with its surroundings and rarely moves, so that it is not often seen.

3.3.4 Apogonidae

Apogon menesemus[5] (fig. 14) is a carnivorous, nocturnal fish that feeds on zooplankton and reaches a length of about 18 cm (Randall 1985:17, 18). Known in Hawai‘i as *‘upāpalu*, it is an easy fish to hook (Hosaka 1973:120), primarily on moonlit nights (Titcomb 1972:158). Its “sweet, soft, and tender” flesh is good “raw, broiled, or wrapped in *ti* leaves and broiled” (Titcomb 1972:158). When fried, the bones become brittle and the fish can be eaten whole (Hosaka 1973:120).

[5] Ziegler identified this specimen as *A. taeniopterus*, which is found elsewhere in the Indo-Pacific and was, at the time of Ziegler’s identification, thought to occur in Hawai‘i, as well.

Figure 10. *Naso* cf. *unicornis*, the bluespine unicornfish, or *kala*, ACZ-3192. Collected at ʻĀpua Point, Hawaiʻi. Scale bar = 1 cm.

3.3.5 Aulostomidae

Aulostomus chinensis (fig. 15) ranges from shallow water to at least 113 m. It is often found swimming with herbivorous fishes, using them as cover to prey on small fish, which it sucks into its elongated snout (Randall 1985:9). Known in Hawaiʻi as *nūnū*, it is eaten either broiled or dried (Titcomb 1972:117).

3.3.6 Balistidae

Sufflamen fraenatus (fig. 16) grows to a length of about 38 cm on a primarily carnivorous diet that includes a wide variety of urchins, fish, crabs, shrimps, and other animals (Randall 1985:61). Known in Hawaiʻi as *humuhumu mimi*, it is one of about ten traditionally recognized varieties of *humuhumu* (Titcomb 1972:79, 80). Some *humuhumu* are caught with hook and line (Hosaka 1973:157) or with a baited basket (Titcomb 1972:81). They generally have a strong odor and are eaten broiled, or nowadays fried (Titcomb 1972:81).

3.3.7 Belonidae

Platybelone argalus platyura[6] (fig. 17) is the smallest of the three needlefish in Hawaiian waters, growing to a length of 38 cm. It is a carnivore that travels in schools in the surface layers of the ocean, often moving far from shore (Gosline and Brock

[6] Ziegler identified this specimen as *Belone platyura*. The name has changed since Ziegler's identification.

Figure 11. *Naso brevirostris*, the spotted unicornfish, or *kala lōlō*, ACZ-3306. Original locality unknown; purchased in Honolulu, O‘ahu fish market. Scale bar = 1 cm.

1960:129). Known in Hawai‘i as *‘aha* when full grown, or as *‘aha‘aha* when young (Titcomb 1972:57), it is caught with a hook and line or, occasionally, in surround nets (Hosaka 1973:80). It is eaten broiled (Titcomb 1972:58).

Tylosurus crocodilus[7] (fig. 18) grows to a length of 1 m on a carnivorous diet of shrimps and crabs (Hosaka 1973:79–80). Its habits, Hawaiian name, and methods of capture and cooking are identical to *Belone platyura* (pg. 21).

3.3.8 Berycidae

Beryx decadactylus (fig. 19) lives in the high seas at “presumably . . . moderate depths” (Gosline and Brock 1960:136).

[7]Ziegler identified this specimen as *Strongylura gigantea*. The name has changed since Ziegler’s identification.

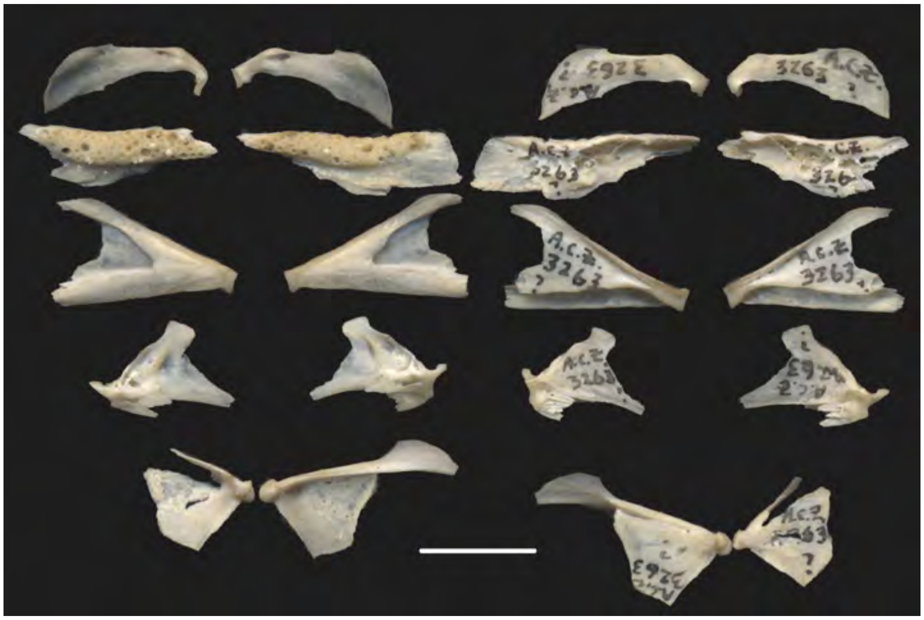

Figure 12. *Albula sp.*, the bonefish, or *‘ō‘io*, ACZ-3263. Original locality unknown; purchased at Honolulu, O‘ahu fish market. Scale bar = 1 cm.

Figure 13. *Antennarius* sp., the frogfish, ACZ-3347. Original locality unknown; received from Kāne‘ohe, O‘ahu aquarium fish store. Scale bar = 1 cm.

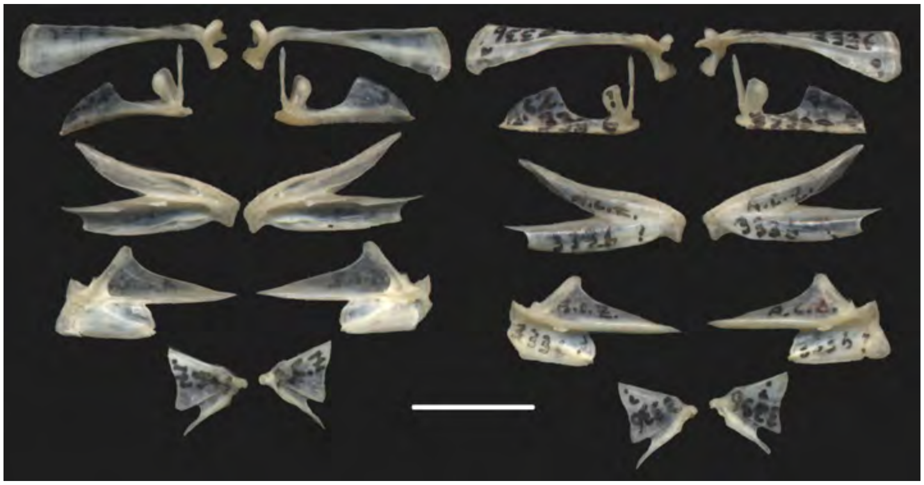

Figure 14. *Apogon menesemus*, the bandfin cardinalfish, or *‘upāpalu*, ACZ-3336. Collected at ‘Anini, Kaua‘i. Scale bar = 1 cm.

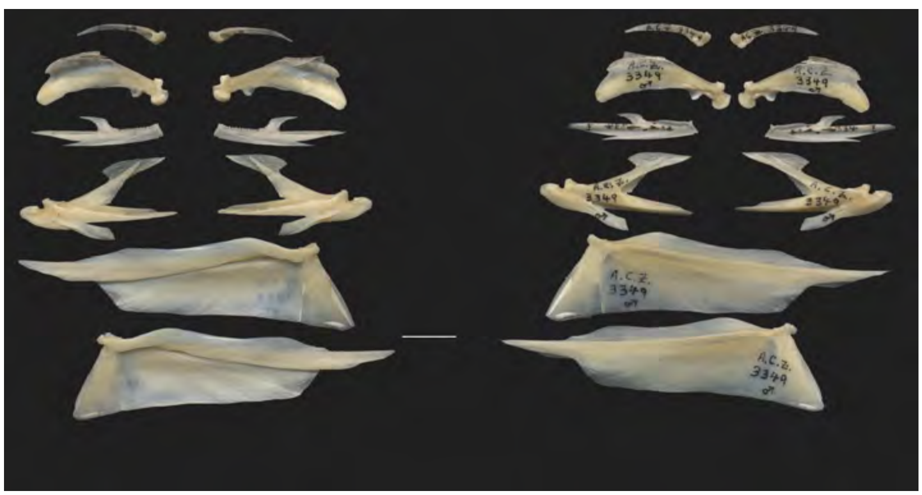

Figure 15. *Aulostomus chinensis*, the trumpetfish, or *nūnū*, ACZ-3349. Collected at Kāne‘ohe, O‘ahu. Scale bar = 1 cm.

3.3.9 Bleniidae

Entomacrodus marmoratus (fig. 20) is found along rocky coasts exposed to surf, often skipping from pool to pool in the intertidal zone (Randall 1996:153–155). It grows to a length of 15 cm on a diet of benthic algae. Known in Hawai‘i as *pāo‘o*, a general

Figure 16. *Sufflamen fraenatus*, the bridled triggerfish, or *humuhumu mimi*, ACZ-3193. Collected at Polihua, Lāna‘i. *Top to bottom*: maxilla, premaxilla, dentary, quadrate, 1st dorsal spine, 2nd dorsal spine, pterygial carina. Scale bar = 1 cm.

term for blennies, it is caught with a net, in the hands, or sometimes with a hook and line (Hosaka 1973:154). It is eaten dried or cooked with salt in *kī* leaves. It was used in sorcery to rid a person of infatuation (Titcomb 1972:126).

3.3.10 Bothidae

Bothus mancus (fig. 21) lives, like other flatfish, on sandy or sedimentary bottoms (Gosline and Brock 1960:147). It grows to about 48 cm. It is a carnivore, eating primarily fishes and some crabs and shrimp (Randall 1985:46). Known in Hawai‘i as *pāki‘i*, it is taken with a hook and line, spear, or by hand (Hosaka 1973:82). This fish is not eaten raw, but is broiled or partly dried and broiled (Titcomb 1972:137).

Figure 17. *Platybelone argalus platyura*, the needlefish, or *'aha*, ACZ-3274. Collected at North Island, Pearl and Hermes Reef. *Top to bottom*: dentary and premaxilla with maxilla, lower pharyngeal, angular, quadrate and pterygoids. Scale bar = 1 cm.

3.3.11 Carangidae

Pseudocaranx dentex[8] (fig. 22) lives in bays and coastal waters, but is not common around the main Hawaiian Islands, being more abundant in the Northwestern Hawaiian Islands (Gosline and Brock 1960:177). Like other jacks, it is a strong-swimming carnivorous fish. Known in Hawai'i as *ulua*, it is taken with a hook and line. They were eaten raw or cooked, the eyes considered a particular delicacy, and played an important role in certain traditional religious rites (see pg. 29).

Scomberoides lysan[9] (fig. 23) commonly reaches lengths of 30 cm and larger individuals can be 50 cm long (Hosaka 1973:105). It is found near the surface, where it moves constantly in search of the fish, shrimps, and crabs that are its food (Hosaka 1973:106). Known in Hawai'i as *lai*, it is most commonly caught with a hook and line

[8] Ziegler identified this specimen as *Caranx cheilio*. The name has changed since Ziegler's identification.

[9] Ziegler identified this specimen as *S. sancti-petri*; the taxonomy has changed since Ziegler's identification.

Figure 18. *Tylosurus crocodilus*, the needlefish, or *ʻaha*, ACZ-3253. Original locality unknown; purchased in Kāneʻohe, Oʻahu supermarket. *Top to bottom*: dentary and premaxilla, maxilla, angular, quadrate. Scale bar = 1 cm.

by dragging bait across the surface (Hosaka 1973:106). Titcomb (1972:95) reports that it is a "[d]elicious fish, broiled, dried, or baked in the *imu*."

Decapterus macarellus[10] (fig. 24) is commonly 25–30 cm long, but larger individuals are up to 45 cm long (Hosaka 1973:107). It is an open ocean fish that travels in large schools and feeds on plankton (Gosline and Brock 1960:172). Today, it is often taken in large nets set from a boat, but when schools run near shore they can be taken with a hook and line, as well (Hosaka 1973:107). Known in Hawaiʻi as *ʻōpelu*, it was caught in traditional Hawaiian times with a fine-mesh net called *kāʻili* (Malo 1951:209). This is a prized food fish that is eaten "raw, dried, sometimes broiled after drying, or broiled when fresh" (Titcomb 1972:133). The *ʻōpelu* is an *ʻaumakua* of the descendants of Pāʻao (Titcomb 1972:36–37), a priest from Kahiki. At the time of Contact, there was a *kapu* on fishing for *ʻōpelu* in the winter months of Hoʻoilo (Malo 1951:209). The *ʻōpelu* figured with the *aku* in yearly rites (Valeri 1985:231–232).

[10]Ziegler identified this specimen as *Decapterus pinnulatus*. The name has changed since Ziegler's iden-

Figure 19. *Beryx decadactylus*, ACZ-3311. Original locality unknown; purchased in Kāne'ohe, O'ahu supermarket. Scale bar = 1 cm.

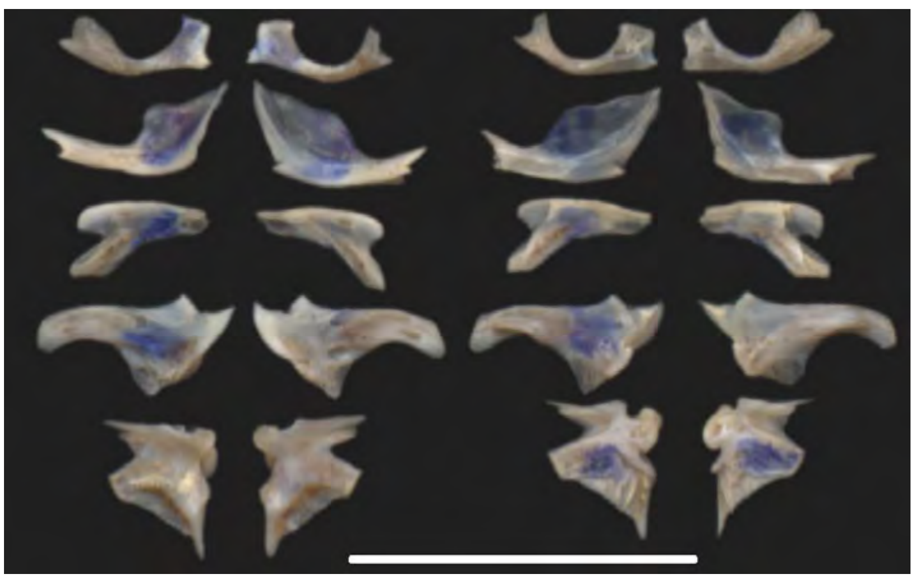

Figure 20. *Entomacrodus marmoratus*, the marbled blenny, or *pāo'o*, ACZ-3346. Original locality unknown; received from Kāne'ohe, O'ahu aquarium fish store. Scale bar = 1 cm.

tification.

Figure 21. *Bothus mancus*, the flowery flounder, or *pāki‘i*, ACZ-3331. Collected at Waikīkī, O‘ahu. Scale bar = 1 cm.

Selar crumenopthalmus[11] (fig. 25) is a schooling fish of coastal waters throughout Hawai‘i. It feeds on plankton and grows to a length of about 38 cm (Gosline and Brock 1960:173). Known in Hawai‘i as *akule*, or *halalū* when young, it is caught with a hook and line, frequently at night with a light, and with surround nets (Hosaka 1973:108). It is eaten raw, broiled, or cooked in *ti* leaf bundles (Titcomb 1972:62).

Caranx ignobilis (fig. 26) is a common fish within the reef and close to shore. It grows to a length of about 90 cm on a carnivorous diet of crustaceans and fish (Gosline and Brock 1960:176, 177). Known in Hawai‘i as *pā‘ū‘ū* or *ulua*, it is caught day or night with a hook and line (Hosaka 1973:112). It is eaten raw, baked, or broiled; the eyeballs are a particular delicacy (Titcomb 1972:152 ff.). *Ulua* were offered during rites at sacrificial *heiau luakini*; if an *ulua* could not be caught for the rites, then a human was sacrificed instead (Valeri 1985:312–314). It was associated with the Hawaiian god, Kū (Valeri 1985:45).

Seriola dumerili (fig. 27) is an open-water, carnivorous fish that grows to a length of 1.9 m (Randall 1996:85). It is taken near the bottom in deeper coastal waters, from 75–185 m, with a hook and line (Gosline and Brock 1960:171). Known in Hawai‘i as *kāhala*, this once important commercial fish is now avoided because it frequently causes ciguatera (Randall 1996:85). Traditionally, it was cooked in the earth oven

[11] Ziegler identified this specimen as *Trachurops crumenopthalmus*. The name has changed since Ziegler's identification.

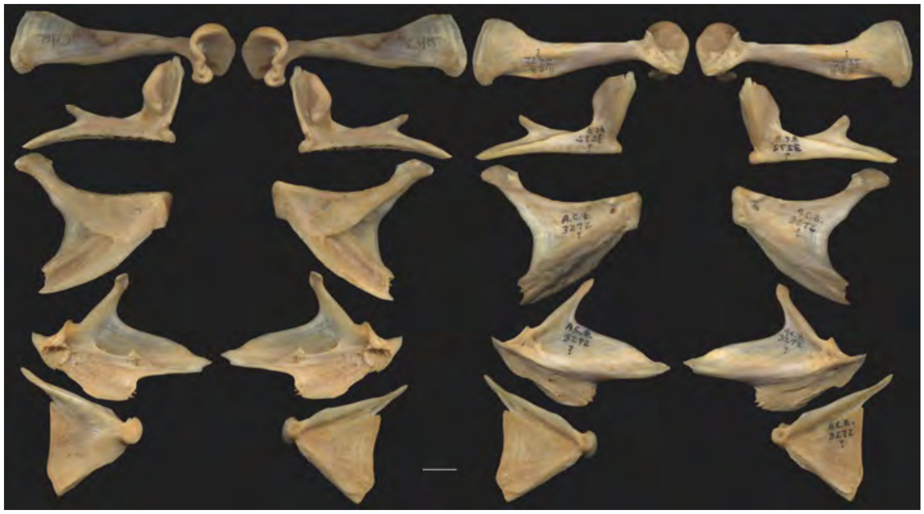

Figure 22. *Pseudocaranx dentex*, the thicklipped jack, or *ulua*, ACZ-3272. Collected off Southeast Island, Pearl and Hermes Reef. Scale bar = 1 cm.

Figure 23. *Scomberoides lysan*, the leatherback, or *lai*, ACZ-3356. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

whole or sliced into steaks. It was also salted and eaten raw or wrapped in *kī* leaves and baked (Titcomb 1972:83).

3.3.12 Cichlidae

Fishes in Hawaii commonly referred to as tilapia (fig. 28) are in the genera *Oreochromis*, *Sarotherodon*, and *Tilapia*. They were introduced to Hawaiʻi in 1957 to control the growth of weeds and algae in freshwater systems and for *aku* bait.

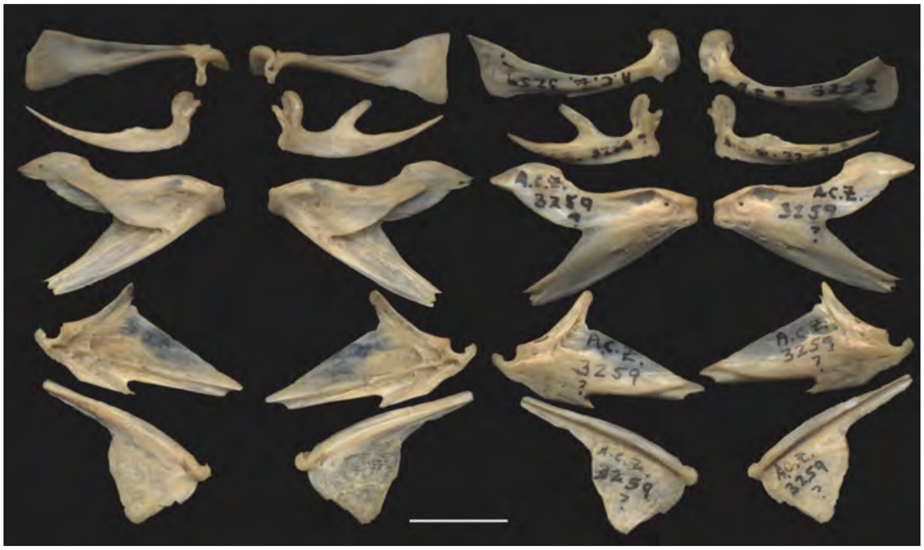

Figure 24. *Decapterus macarellus*, the mackerel scad, or *ʻōpelu*, ACZ-3259. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

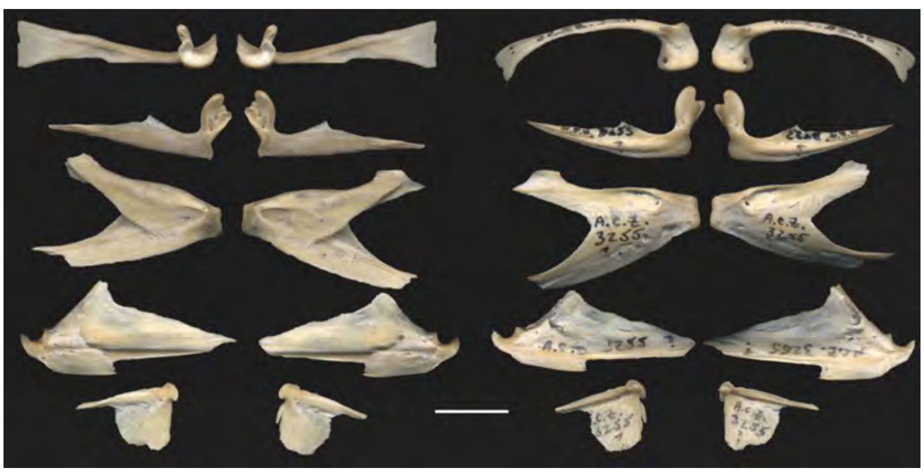

Figure 25. *Selar crumenopthalmus*, the bigeye scad, or *akule*, ACZ-3255. Original locality unknown; purchased in Kāneʻohe, Oʻahu supermarket. Scale bar = 1 cm.

3.3.13 Chaetodontidae

Chaetodon miliaris (figs. 29 and 30) grows to a length of about 16 cm and feeds mainly on zooplankton (Randall 1985:26). It is diurnal and usually found on shallow water

Figure 26. *Caranx ignobilis*, the crevally, or *pā‘ū‘ū*, ACZ-3149. Original locality unknown; received from Waikīkī Aquarium, Honolulu, O‘ahu. Scale bar = 1 cm.

Figure 27. *Seriola* cf. *dumerili*, the greater amberjack, or *kāhala*, ACZ-3270. Scale bar = 1 cm.

reefs (Randall 1985:25). Known in Hawai‘i as *lau wiliwili*, it has relatively little value

Figure 28. Cf. *Tilapia* sp., the tilapia, ACZ-3321. Original locality unknown; purchased in Honolulu, O‘ahu fish market. Scale bar = 1 cm.

as a food fish and is “[e]aten when better cannot be had” (Titcomb 1972:98).

Forcipiger sp. (fig. 31) is a reef fish that grows to a length of 18–22 cm on a primarily carnivorous diet of worms, small crustaceans, sea urchins, and fish eggs (Randall 1996:105–106). It has limited value as a food fish.

3.3.14 Chanidae

Chanos chanos (fig. 32) is found in bays, inlets, and the mouths of harbors, usually near the surface but occasionally deeper. It grows to a length of about 1.5 m on a vegetarian diet primarily of seaweed (Hosaka 1973:74). Known in Hawai‘i as *awa*, it was a favorite food fish, grown in fishponds. Chiefs would reserve the fish for themselves if they were in short supply (Titcomb 1972:70).

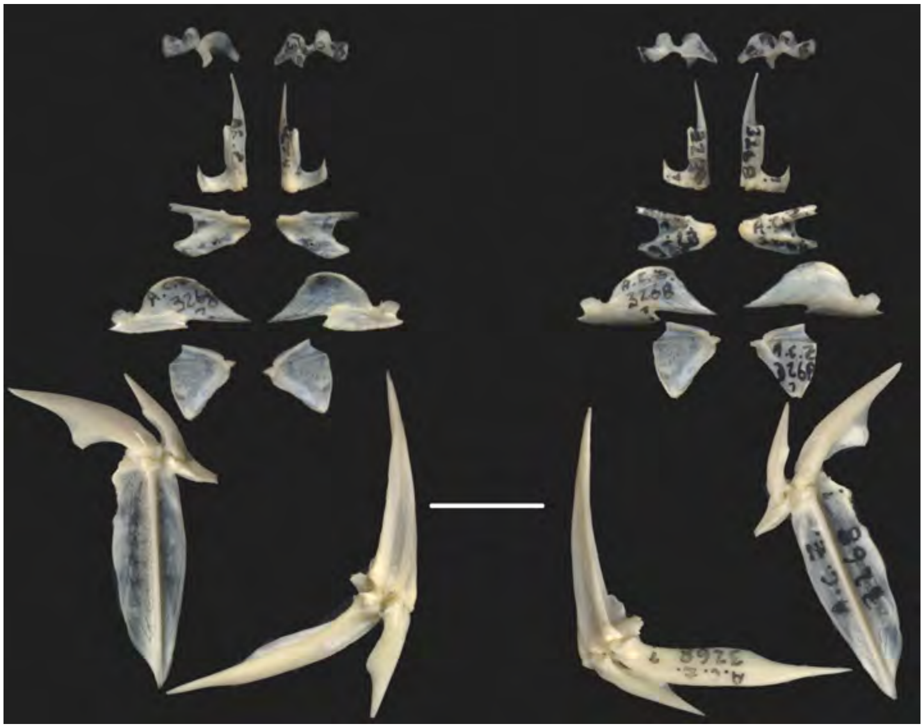

Figure 29. *Chaetodon miliaris*, the milletseed butterflyfish, or *lau wiliwili*, ACZ-3268. Original locality unknown; purchased in Honolulu, Oʻahu fish market. *Bottom*, dorsal and anal fin pterygiophores and spines. Scale bar = 1 cm.

3.3.15 Cheilodactylidae

Goniistius vittatus[12] (fig. 33) is a relatively deep water fish, not usually seen at depths less than about 20 m. It has a carnivorous diet of small invertebrates (Randall 1985:19). It grows to a length of about 40 cm. In Hawaiʻi it is known as *kikākapu*, a name also given to several of the butterflyfishes, with which it appears to have been classified. *Kikākapu* in general were not regarded as good eating because they have so little flesh (Titcomb 1972:88-90).

3.3.16 Cirrhitidae

Cirrhitus pinnulatus (fig. 34) is a bottom-dweller found on hard substrates in the surge zone (Randall 1985:19). It grows to a length of about 28 cm on a carnivorous diet primarily of crabs. Known in Hawaiʻi as *poʻopaʻa*, it is easily caught with a hook and

[12] Ziegler identified this specimen as *Cheilodactylus vittatus*. The name has changed since Ziegler's identification.

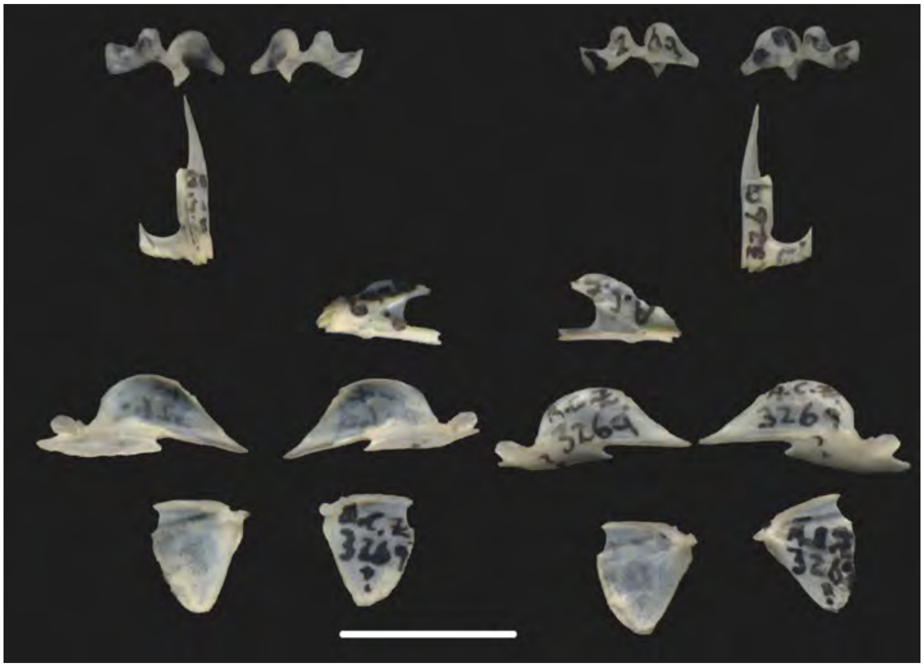

Figure 30. *Chaetodon miliaris*, the milletseed butterflyfish, or *lau wiliwili*, ACZ-3269. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

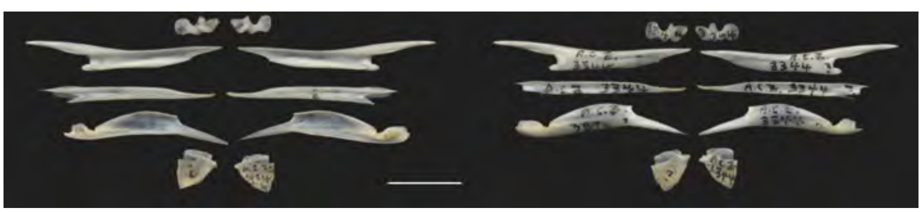

Figure 31. *Forcipiger* sp., a butterflyfish, or *lau wiliwili nukunuku ʻoiʻoi*, ACZ-3344. Original locality unknown; received from Kāneʻohe, Oʻahu aquarium fish store. Scale bar = 1 cm.

line (Hosaka 1973:133). Although its reputation as a food fish is mixed, it is eaten raw, broiled, or salted and dried (Titcomb 1972:142).

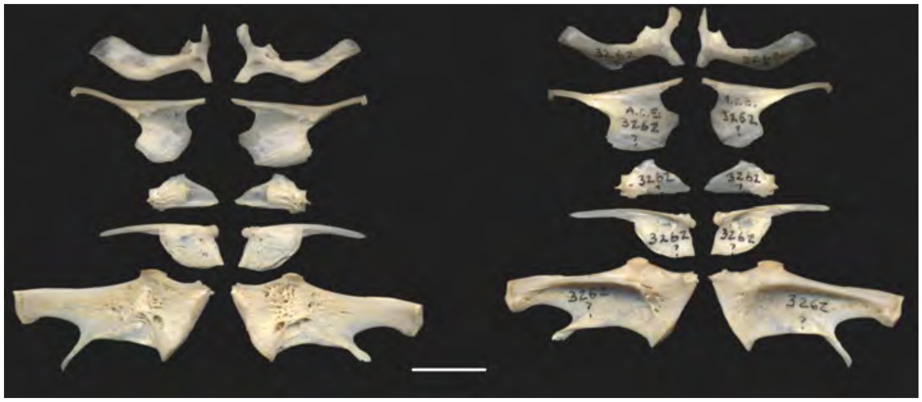

Figure 32. *Chanos chanos*, the milkfish, or *awa*, ACZ-3262. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

Figure 33. *Goniistius vittatus*, the Hawaiian morwong, or *kīkākapu*, ACZ-3264. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

Figure 34. *Cirrhitus pinnulatus*, the stocky hawkfish, or *po'opa'a*, ACZ-3145. Original locality unknown; received from Waikikī Aquarium, Honolulu, O'ahu. Scale bar = 1 cm.

3.3.17 Congridae

Conger cinereus marginatus[13] (fig. 35) is a nocturnal reef-dweller that grows to a length of 1.15 m on a carnivorous diet of fish, shrimps, and crabs (Randall 1985:6). Known as *puhi ūhā* in Hawai'i, it is caught with a hook and line, or with a hand net or a spear while torch fishing at night (Hosaka 1973:77). It is considered a good food fish.

3.3.18 Coryphaenidae

There are two Hawaiian species of the genus *Coryphaena* (fig. 36) in Hawai'i. Both are open-water fish that have a carnivorous diet of smaller fishes. The more common of the two species is *C. hippurus*, which grows to a length of at least 1.5–2 m; *C. equisetis* reaches a length of about 75 cm. They are taken by hook and line, typically while trolling (Gosline and Brock 1960:181). *Mahimahi* are not eaten raw; slices are broiled over coals or the fish is dried and then cooked (Titcomb 1972:100).

3.3.19 Diodontidae

Diodon holocanthus (fig. 37) grows to a length of about 38 cm on a carnivorous diet of gastropods, echinoids, and crabs, which it crushes with its strong beak-like jaws (Randall 1985:65–66). It is found primarily around coral reefs. Known in Hawai'i

[13] Ziegler identified this specimen only to species; the Hawaiian representative is an endemic subspecies.

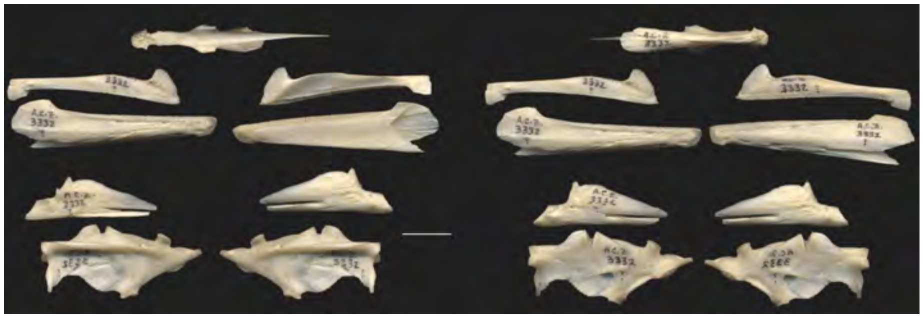

Figure 35. *Conger cinereus marginatus*, the mustache conger, or *puhi ūhā*, ACZ-3332. Hilo, Hawai‘i harbor. *Top*, premaxillo-ethmo-vomer; *bottom*, articulated quadrate and hyomandibular. Scale bar = 1 cm.

Figure 36. *Coryphaena* sp., the dolphin, or *mahimahi*, ACZ-3308. Original locality unknown; purchased at Honolulu, O‘ahu fish market. Scale bar = 1 cm.

as *‘o‘opu okala* or *kōkala* it is often regarded as poisonous. The fish is an *‘aumakua* associated with the sea god, Kāne ko kala (Titcomb 1972:91).

3.3.20 Elopidae

Elops hawaiensis (fig. 38) is found in small schools along sandy shores and in brackish areas and fishponds. It grows to a length of up to 1.05 m on a carnivorous diet of small fish and crustaceans (Randall 1996:26). Known in Hawai‘i as *awa‘aua*, the fish is caught with a hook and line (Hosaka 1973:72) or in nets (Titcomb 1972:70). Its soft flesh can be dry and bony, but when raised in a fishpond it takes on better eating qualities. It is eaten raw (Titcomb 1972:70).

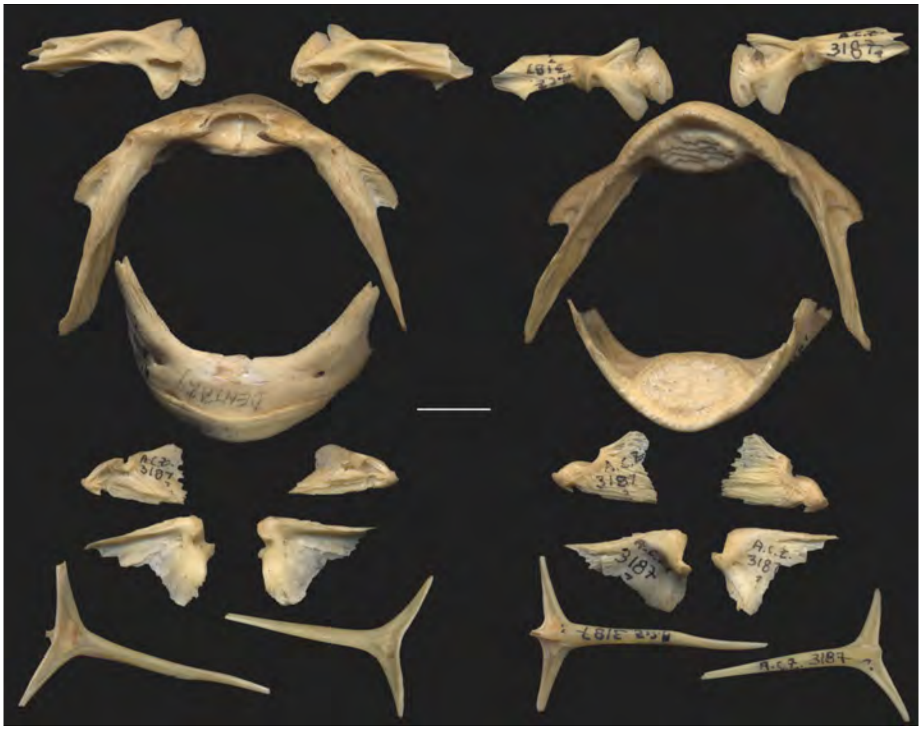

Figure 37. *Diodon* cf. *holocanthus*, the spiny puffer, or *ʻoʻopu okala*, ACZ-3187. Original locality unknown; discarded by Bishop Museum, Honolulu. Scale bar = 1 cm.

3.3.21 Exocoetidae

Exocoetus volitans (fig. 39) is one of the smaller species of flyingfish in the waters around Hawaiʻi, reaching a length of about 25 cm (Gosline and Brock 1960:131). Known as *mālolo* in Hawaiʻi, the flyingfish was caught with surround nets. It was sought after for food and eaten raw or cooked in *ti* leaves (Titcomb 1972:104).

The exocoetid specimen (fig. 40) represents an unknown member of a family that is poorly classified (Gosline and Brock 1960:130).

3.3.22 Fistulariidae

Fistularia sp. (fig. 41) grows to a length of 1.2 m on a diet that includes shrimps. It is caught with a hook and line (Gosline and Brock 1960:133). The inshore species of this genus is known in Hawaiʻi as *nūnū peke* (Randall 1996:56).

Figure 38. *Elops hawaiensis*, the Hawaiian tenpounder, or *awa‘aua*, ACZ-3341. Original locality unknown; purchased at Honolulu, O‘ahu fish market. Scale bar = 1 cm.

3.3.23 Gadidae

Theragra chalcogramma (fig. 42) is a fish of the northern ocean commercially harvested off the west coast of Canada and Alaska. It is a popular fish for fish and chips and is used to make imitation crab meat. It is not found in Hawaiian waters.

3.3.24 Holocentridae

Myripristis kuntee (fig. 43) is a small soldierfish that grows to a length of about 19 cm. Like other fish in this family, it hides in caves and holes during the day and forages for food, mainly crustaceans, at night (Randall 1985:11, 12). Known in Hawai‘i as *‘ū‘ū*, it is taken with hook and line, net, or spear (Hosaka 1973:85). It is considered an excellent food fish and is eaten raw or broiled (Titcomb 1972:158). Some *‘ū‘ū* were considered *‘aumakua* (Pukui and Elbert 1986).

The Ziegler collection contains another specimen of *Myripristis* (fig. 44) that was not identified to species.

Pristilepis oligolepis (fig. 45) is a deep-water fish (Randall 1996:49). The Hawaiian name for this fish is not known; it was likely a rare catch while fishing with a hook and line in traditional Hawaiian times.

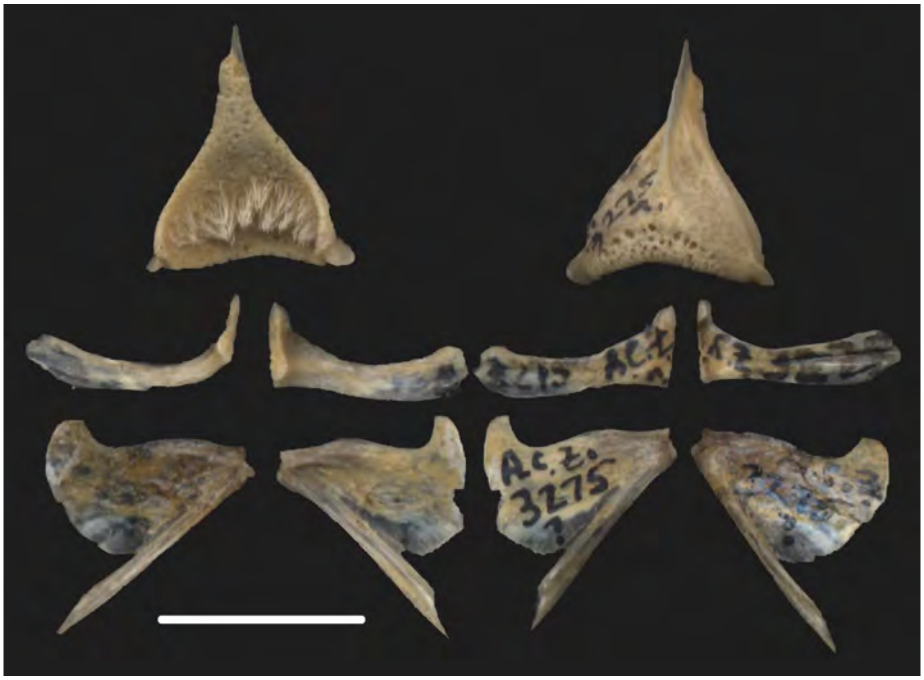

Figure 39. *Exocoetus volitans*, a flyingfish, or *mālolo*, ACZ-3275. Found dead on deck of Townsend Cromwell. *Top to bottom*: Lower pharyngeal, premaxilla, dentary. Scale bar = 1 cm.

3.3.25 Kuhliidae

Kuhlia sp.[14] (figs. 46 and 47) is a primarily nocturnal omnivore that is found in schools in marine, brackish, and freshwater environments. It grows to about 30 cm in length (Randall 1985:16). Known in Hawai‘i as *āholehole*, it is taken by hook and line and throw net (Hosaka 1973:121). It is also raised in fishponds. Considered a fine eating fish, it is eaten "raw, dried, or broiled on hot coals, also salted or *ho‘omelumelu*" (Titcomb 1972:59). The *āholehole* was considered a "sea pig" associated with the demigod Kamapua‘a (Valeri 1985:11). It was traditionally used in birth rites and is associated with the Hawaiian god, Lono (Valeri 1985:45).

3.3.26 Kyphosidae

Kyphosus sp. (fig. 48) is a shore fish that lives on rocky bottoms and coral reefs, where it grows to a length of about 60 cm on an herbivorous diet of primarily benthic algae. There are three species of *Kyphosus* in Hawai‘i (Randall 1985:22), all known as

[14] Ziegler identified these specimens as *K. sandvicensis*; the taxonomy of the genus has been revised since Ziegler's identification.

Figure 40. Exocoetid, a flyingfish, or *mālolo*, ACZ-3286. Found dead on Lisianski Island. Scale bar = 1 cm.

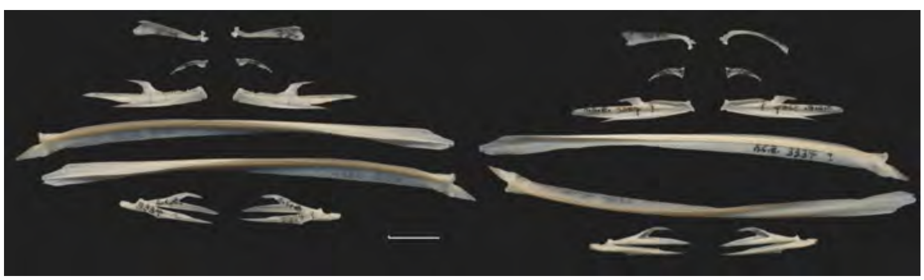

Figure 41. *Fistularia* sp., cornetfish, ACZ-3334. Collected at ‘Anini Beach, Kaua‘i. Scale bar = 1 cm.

nenue. It is occasionally caught by hook and line (Hosaka 1973:126) or in nets (Titcomb 1972:113). It has a strong odor, but is considered a delicious fish raw, or wrapped in *ti* leaves and broiled (Titcomb 1972:114).

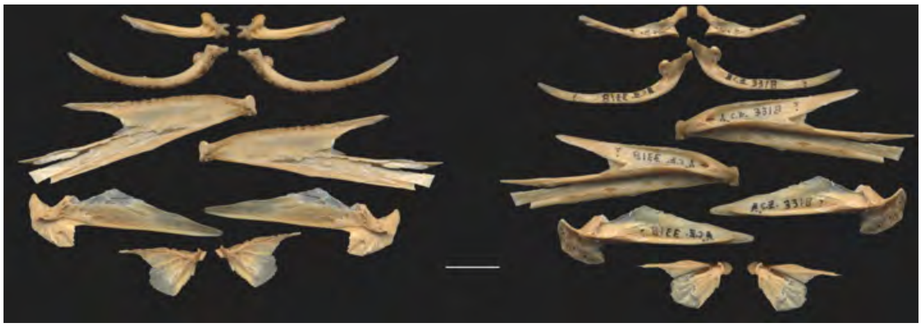

Figure 42. *Theragra chalcogramma*, Alaskan pollack, ACZ-3318. Original locality unknown; purchased in Honolulu, O‘ahu. Scale bar = 1 cm.

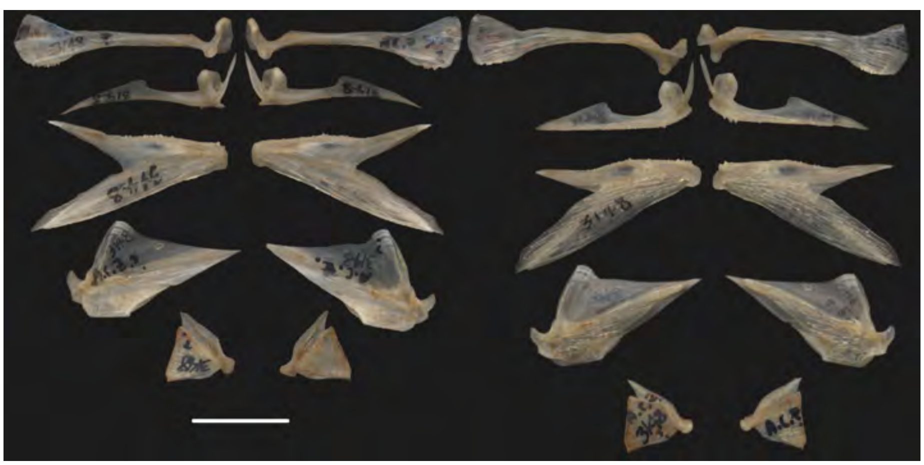

Figure 43. *Myripristis kuntee*, the shoulderbar soldierfish, or *‘ū‘ū*, ACZ-3148. Original locality unknown; received from Waikiki Aquarium, Honolulu, O‘ahu. Scale bar = 1 cm.

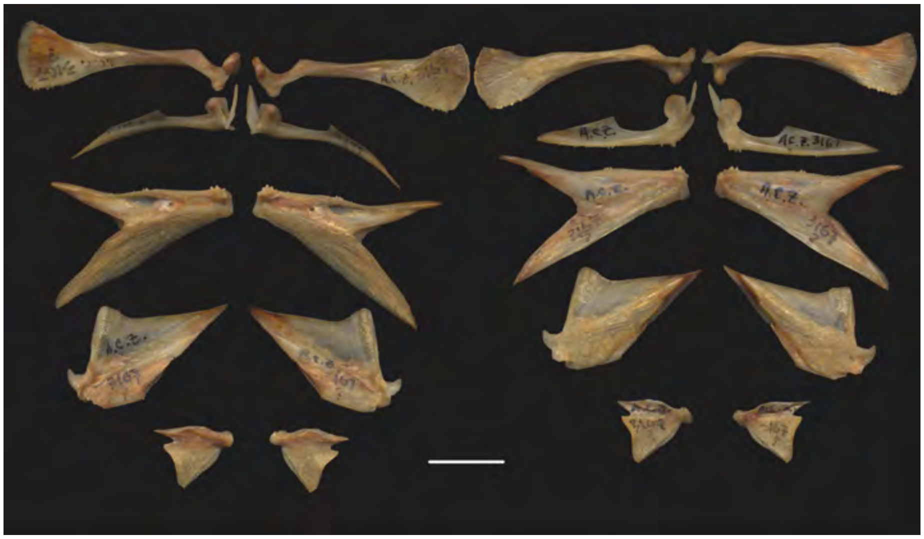

Figure 44. *Myripristis* sp., a squirrelfish, or *‘ū‘ū*, ACZ-3167. Collected in the vicinity of Ka‘ena Point, O‘ahu. Scale bar = 1 cm.

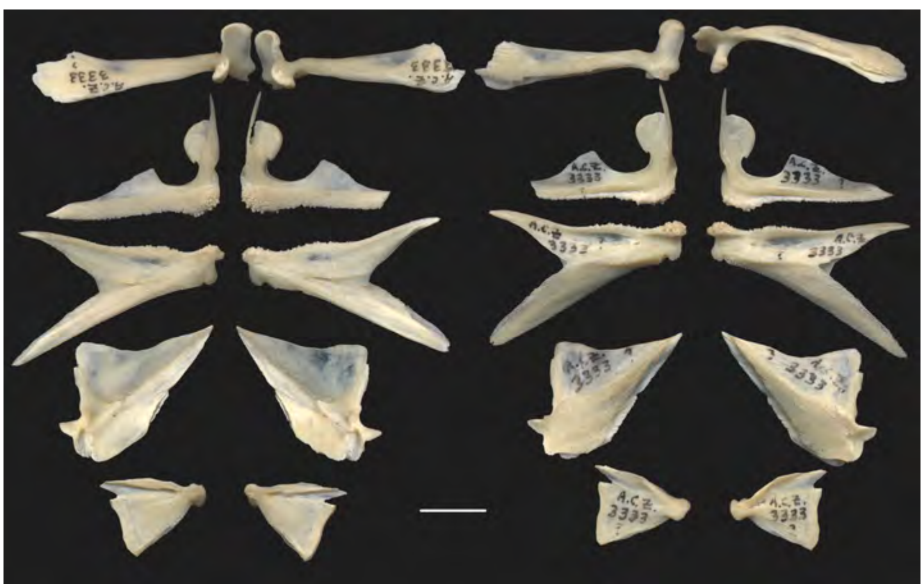

Figure 45. Cf. *Pristilepis oligolepis*, a squirrelfish, ACZ-3333. Hawai‘i Island; purchased at Honolulu, O‘ahu fish market. Scale bar = 1 cm.

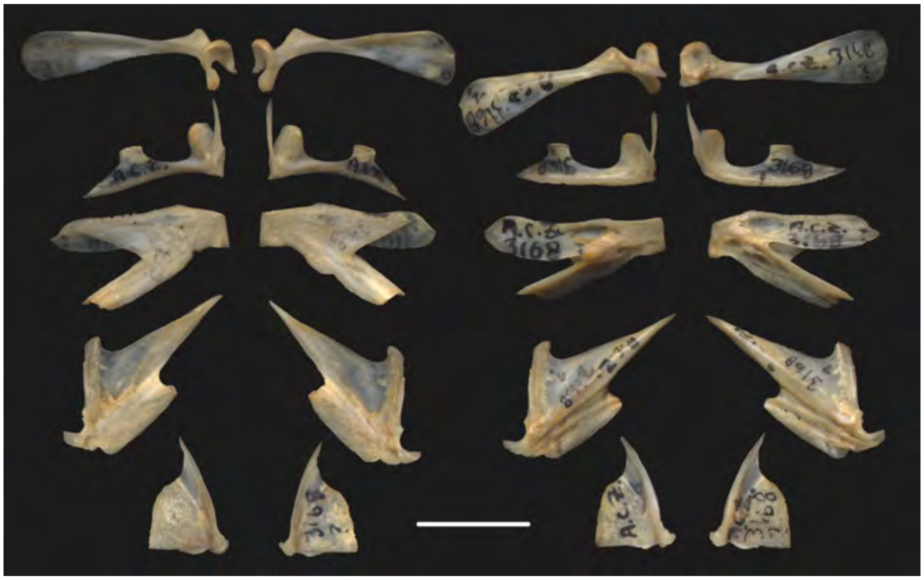

Figure 46. *Kuhlia sp.*, the Hawaiian flagtail, or *āholehole*, ACZ-3168. Collected in the vicinity of Ka‘ena Point, O‘ahu. Scale bar = 1 cm.

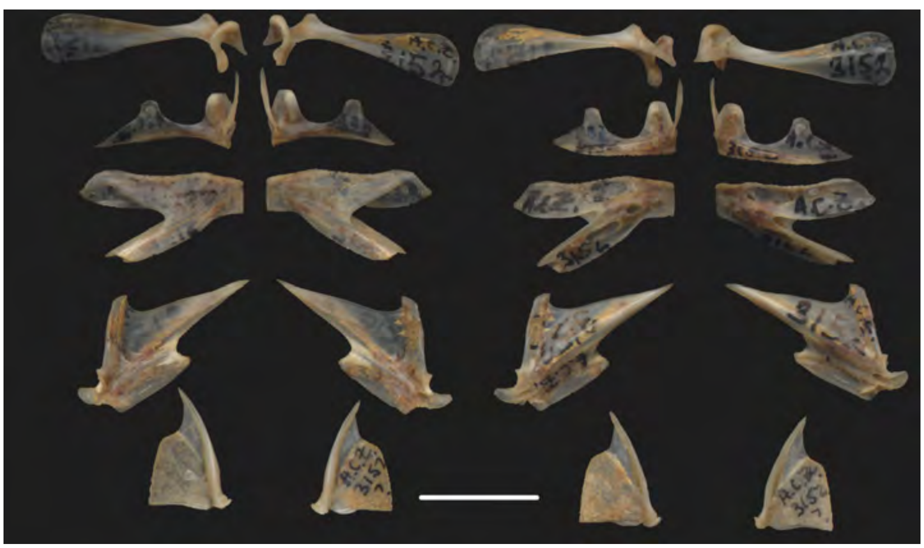

Figure 47. *Kuhlia sp.*, the Hawaiian flagtail, or *āholehole*, ACZ-3152. Original locality unknown; received from Waikiki Aquarium, Honolulu, O‘ahu. Scale bar = 1 cm.

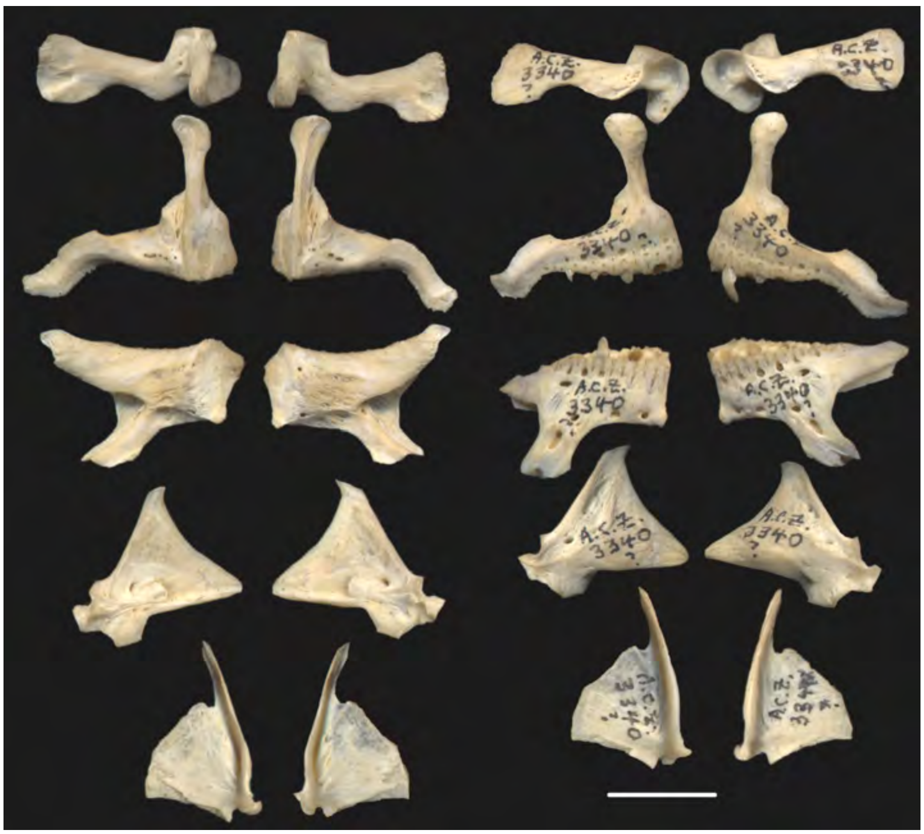

Figure 48. *Kyphosus* sp., the rudderfish, or *nenue*, ACZ-3340. Original locality unknown; purchased at Honolulu, O‘ahu fish market. Scale bar = 1 cm.

3.3.27 Labridae

Oxycheilinus unifasciatus[15] (fig. 49) grows to a length of 46 cm on a carnivorous diet of fish, crabs, brittle stars, and urchins (Randall 1985:36). It ranges in depth from 9–161 m. Known in Hawai‘i as *po‘ou*, it is eaten raw or broiled, among other ways (Titcomb 1972:143).

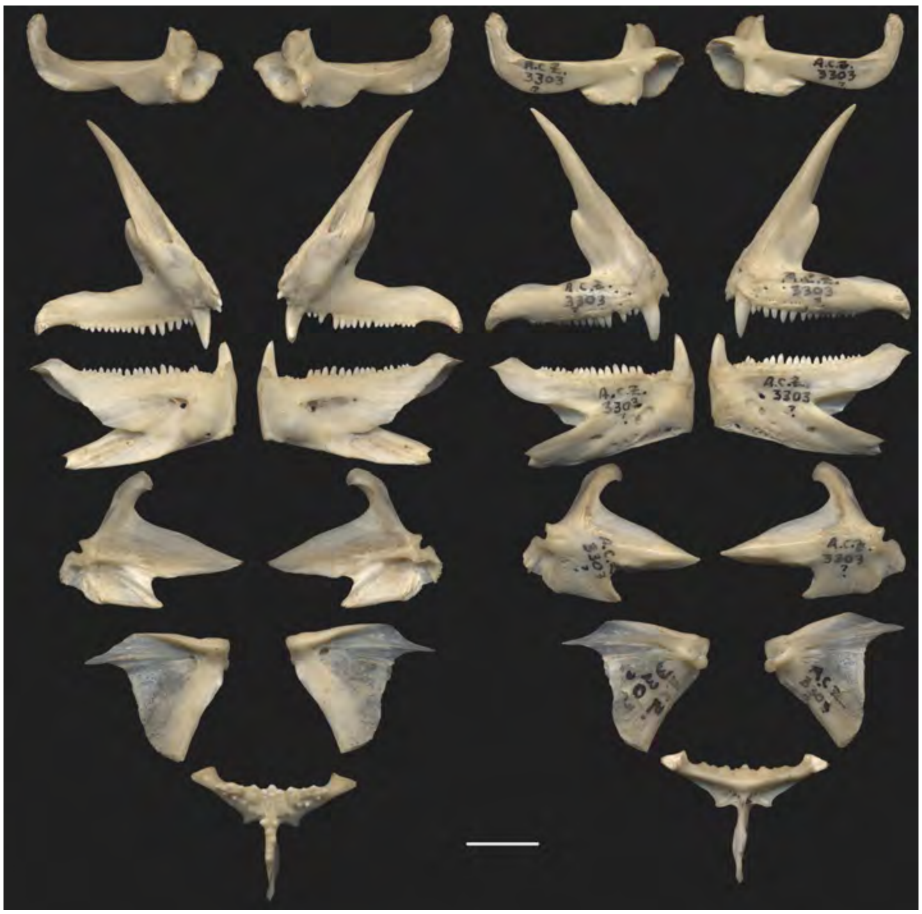

Figure 49. *Oxycheilinus unifasciatus*, the ringtail wrasse, or *po‘ou*, ACZ-3303. Original locality unknown; purchased in Kāne‘ohe, O‘ahu supermarket. *Bottom*, lower pharyngeal. Scale bar = 1 cm.

Bodianus bilunulatus (fig. 50) is found on shallow-water reefs into deeper water up to 110 m (Randall 1985:38). It grows to a length of 50 cm on a carnivorous diet of mollusks, sea urchins, and crabs. Known in Hawai‘i as *‘a‘awa*, it is usually caught on

[15] Ziegler identified this specimen as *Cheilinus unifasciatus*. The name has changed since Ziegler’s identification.

a hook and line (Hosaka 1973:147). Its white flesh is eaten broiled or dried (Titcomb 1972:57).

Figure 50. *Bodianus bilunulatus*, the Hawaiian hogfish, or *‘a‘awa*, ACZ-3258. Original locality unknown; purchased in Honolulu, O‘ahu fish market. *Bottom*, lower pharyngeal. Scale bar = 1 cm.

Coris flavovittata (fig. 51) reaches 45 cm in length (Gosline and Brock 1960:229). It is found “in crevices of the reef, under large projecting *limu*-covered rocks, or asleep in the sandy bottom, completely hidden” (Titcomb 1972:75) where it feeds on sea urchins, pelecypods, gastropods, brittle stars, crabs, hermit crabs, and polychaetes (Randall 1985:39). Known in Hawai‘i as *hilu*, it is caught in nets and eaten “raw, dried and salted, baked or broiled” (Titcomb 1972:75).

Cheilio inermis (fig. 52) is found commonly on open bottoms with rich plant growth (Randall 1985:39) and may sleep on the sand at night (Titcomb 1972:94). It reaches a length of 50 cm (Randall 1985:39). It is a carnivore, feeding on gastropods, pelecypods, crabs, sea urchins, and shrimps (Randall 1985:39). In Hawai‘i it is known as *kuūpoupou*, and is considered “a good food fish, eaten raw or cooked in *ti* leaves” (Titcomb 1972:94).

Anampses cuvier (fig. 53) is found inshore on rocky bottoms to a depth of about 80 ft. (Randall 1985:40). A carnivore, it feeds on a variety of small invertebrates and reaches a length of about 35 cm (Randall 1985:40). Known in Hawai‘i as *‘ōpule*, it is a “greedy feeder easily caught with a hook and line” (Hosaka 1973:148). This fish is not eaten raw, but is good for broiling and baking (Titcomb 1972:135).

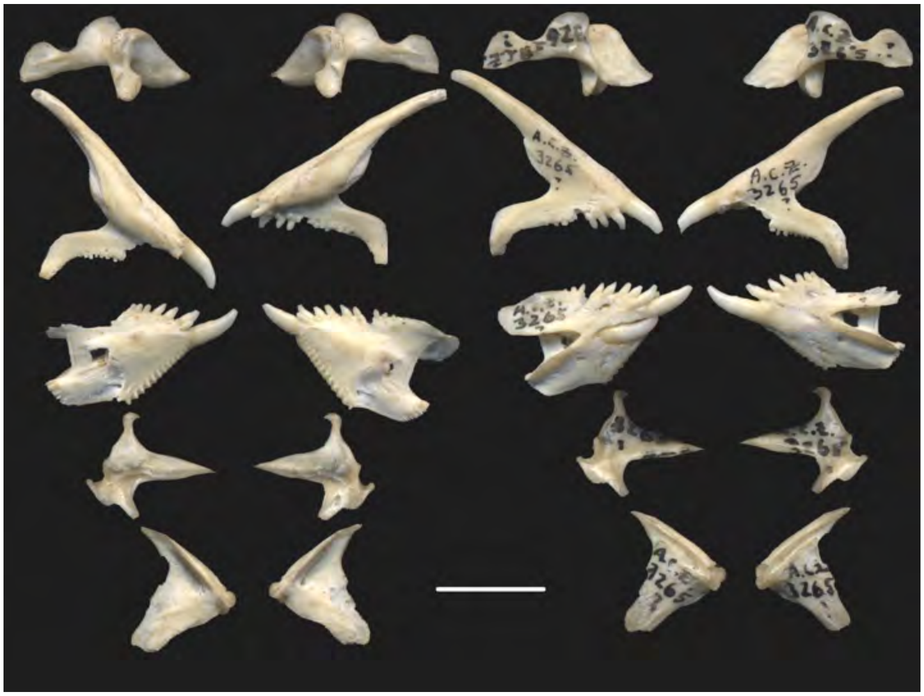

Figure 51. *Coris flavovittata*, the yellowstripe coris, or *hilu*, ACZ-3265. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

Figure 52. *Cheilio inermis*, the cigar wrasse, or *kūpoupou*, ACZ-3261. Original locality unknown; purchased in Honolulu, Oʻahu fish market. Scale bar = 1 cm.

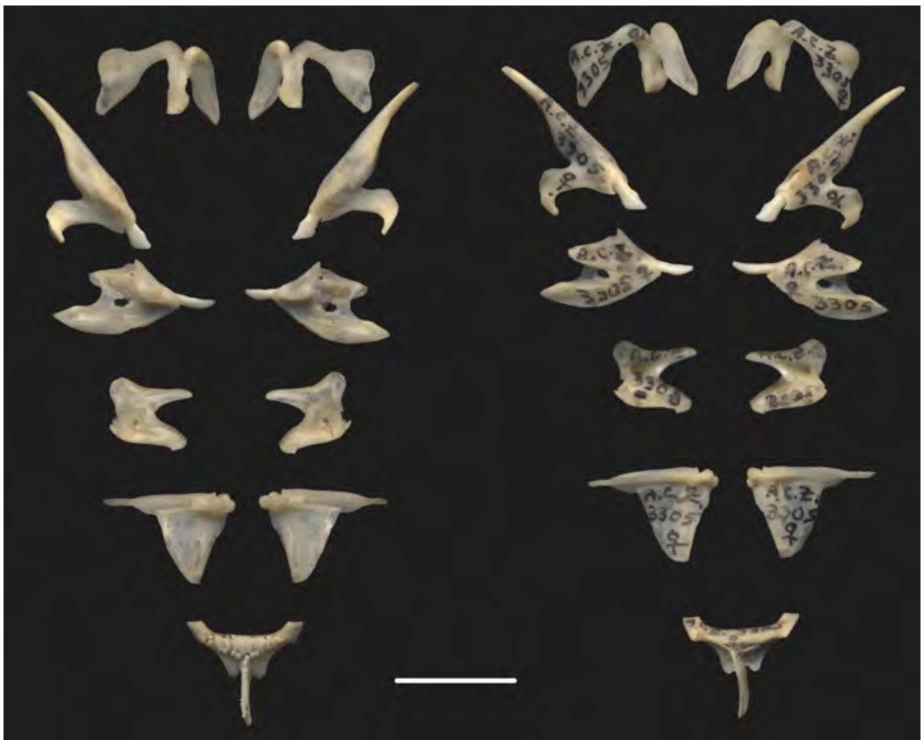

Figure 53. *Anampses cuvier*, the pearl wrasse, *‘ōpule*, ACZ-3305. Original locality unknown; purchased in Honolulu, O‘ahu fish market. *Bottom*, lower pharyngeal. Scale bar = 1 cm.