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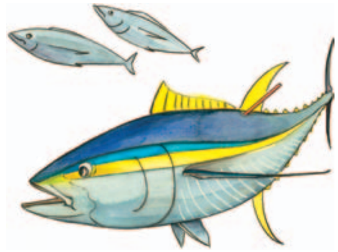

Pelagic Fisheries Research Program
university of hawai'i at mānoa

Volume 13, Number 2 May–August 2008

What If You Don't Speak "CPUE-ese"?

J. John Kaneko and Paul K. Bartram

Introduction

Seafood consumers are largely unaware of the environmental consequences they implicitly endorse when buying fish from different sources. To more effectively support responsible fisheries, consumers need to be able to easily differentiate seafood harvested in sustainable ways using more "environmentally friendly" methods from seafood from less sustainable origins.

This requires easy access by consumers to easy-to-understand information comparing the "environmental baggage" of competing suppliers of similar seafood products.

Existing scientific measures do define such distinctions—but they are often too complex or technical to be easily understood or used by the average seafood consumer. New communication tools for readily conveying such information to non-scientist seafood consumers are needed.

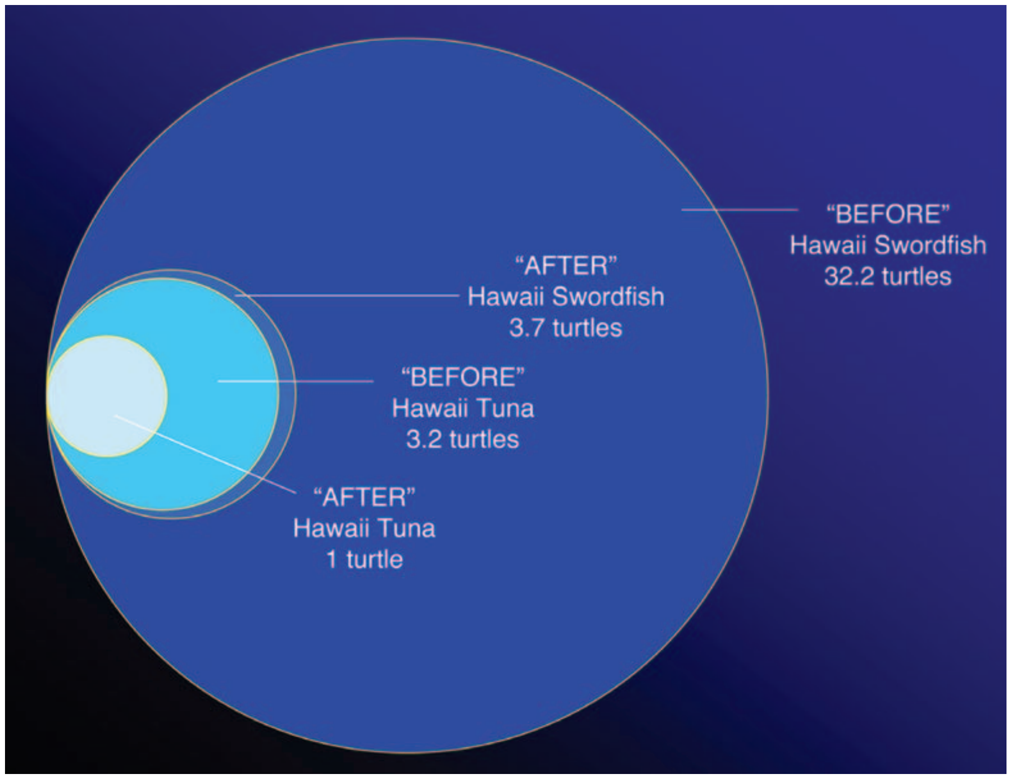

Figure 1. Computed Hawai'i longline tuna fisheries bycatch-to-catch (B/C) ratios were reduced after increased (to greater than 20 percent of the annual fishing trips) observer coverage documented a lower rate of sea-turtle interaction than had the lower previous observer coverage (of less than 5 percent of the annual fishing trips). Sea-turtle interactions were significantly reduced in the Hawai'i longline swordfish fishery as a result of revised hook-and-bait requirements required by federal regulations that took effect in mid-2004.

The area of the circles is proportional to the number of sea-turtle takes per 418,000 lb of target fish (tuna or swordfish) caught. The Hawai'i longline tuna fishery, with the lowest B/C ratio (for the 2003–2005 period studied) in this comparison, established the baseline of one sea-turtle take per 418,000 lb of tuna.

Successful Efforts at Reducing Sea-Turtle "Bycatch"

The Hawai'i longline fishery, working with fisheries scientists and fisheries managers, has made significant progress in reducing incidental interactions with sea turtles. Under current federal regulations, Hawai'i longliners are required to employ sea-turtle-take reduction measures. These measures have resulted in an 89 percent reduction of incidental sea-turtle take ("bycatch"), from 0.174 down to 0.019 incidental captures of all sea-turtle species per 1000 hooks ("catch per unit

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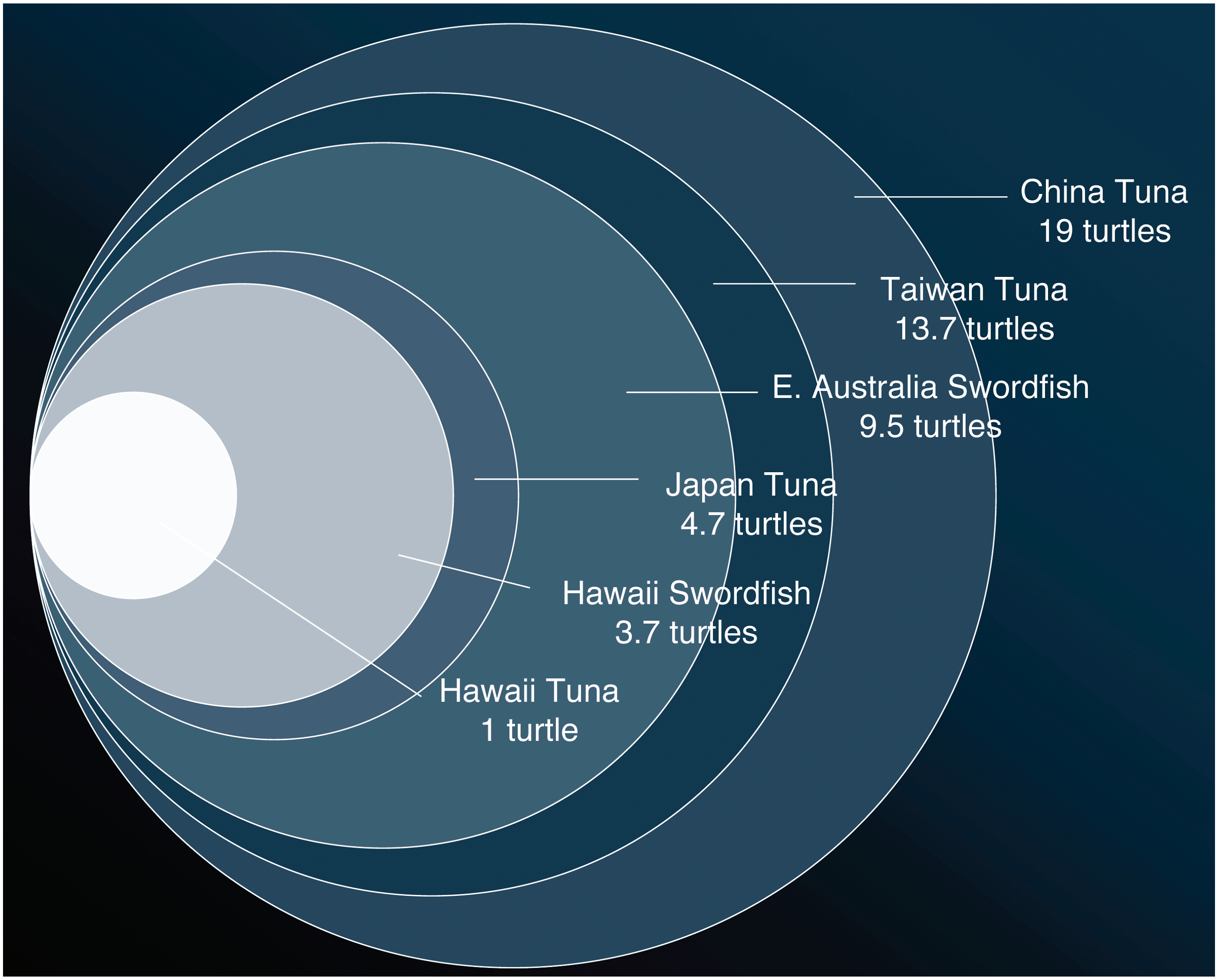

Figure 2. Comparison of current estimates of bycatch-to-catch (B/C) ratios in selected longline tuna and swordfish fisheries. The area of the circles is proportional to the number of sea-turtle takes per 418,000 lb of target fish (tuna or swordfish) caught. The Hawai'i longline tuna fishery, with the lowest B/C ratio (for the 2003–2005 period studied) in this comparison, established the baseline of one sea-turtle take per 418,000 lb of tuna.

of effort"—CPUE—measured as number of sea turtles caught per 1000 hooks) set in the swordfish fishery (Gilman et al. 2006). Using this standard scientific terminology, the "good news" is readily conveyed to fishers, fisheries managers, and fisheries scientists.

But what about the seafood consumer who doesn't speak "CPUE-ese"?

"Catch-to-Bycatch" (C/B) Ratios Used for Scientific Measurement of the Environmental Impacts of Pelagic Longline Fisheries

A study funded by the Pelagic Fisheries Research Program (PFRP) of the University of Hawai'i is exploring simple methods for representing and comparing the amount of bycatch associated with Hawai'i and other competing pelagic longline fisheries in relation to their target catches of tuna and swordfish.

John Kaneko and Paul K. Bartram are the principal investigators of this "Catch-to-Bycatch Ratios" (C/B ratios) comparative study of Hawai'i and other longline fisheries competing with Hawai'i fishers in the fresh-fish marketplace. Dr. Martin Hall of the Inter-American Tropical Tuna Commission first used "catch-to-bycatch" ratios to compare the bycatch impacts of different purse-seine-setting methods in the eastern Pacific tuna fisheries (Hall 1996). In 2004 C/B ratios were further described in a PFRP-published report.

Circle Diagrams Display C/B Ratios in Pictorial Format

Phase Two of the current PacMar, Inc., study for PFRP examined long-range Asian longline freezer fleets. C/B ratios for the various longline fisheries were determined and compared to those of the Hawai‘i fleets.

Circle diagrams displaying these C/B ratios in pictorial format were presented at the November 2007 meeting of PFRP project investigators. Later these early representations were improved following consultations with Dr. John Sibert and others.

C/B Ratios Converted to B/C Ratios and Displayed in Pictorial Format

C/B ratios were converted to bycatch-to-catch (B/C) ratios to represent how many sea-turtle interactions were associated with a common weight of target fish catch.

Circle diagrams (Figure 1) expressing B/C ratios were identified as an easy-to-understand method to represent the significant progress by the Hawai‘i fishery in reducing sea-turtle interactions. Following the increased shipboard-observer coverage (over 20 percent of fishing trips starting in 2001) in the Hawai‘i longline tuna fishery, the level of sea-turtle interactions in this fishery was more accurately quantified than previously. For the 2003–2005 period the Hawai‘i longline tuna fishery established a baseline of one sea-turtle take per four-hundred-eighteen thousand pounds of tuna. The areas of the circles shown in the diagrams represent the number of sea-turtle interactions associated with this baseline weight of fish catch.

Circle diagrams (Figure 2) were also used to compare the sea-turtle B/C ratios of Hawai‘i tuna and swordfish with those of tuna and swordfish from the other longline fisheries evaluated in the study. The B/C ratios of the other fisheries were adjusted to the baseline Hawai‘i tuna longline fish-catch weight (four-hundred-eighteen thousand pounds) for direct comparison. The larger the area of the circle, the more sea-turtle takes associated with every pound of fish from that source.

Conclusion

As consumer attention to sustainable seafood increases, suppliers will need effective ways to communicate and compare the environmental impacts associated with their fishery products. With over 80 percent of the seafood consumed in the US now being imported, US suppliers face a growing challenge to differentiate seafood by country of origin, production method, processing methods, sustainable fishery practices, and effective fishery management.

All that consumers really want to know is “Which source of fish is least destructive to sea-turtle populations?” Bycatch-to-catch ratios, especially when expressed as circle diagrams, offer one way to answer this basic question.

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UPCOMING EVENT

Advances in Marine Ecosystem Modelling Research

June 23–26, 2008, Plymouth, UK

http://www.amemr.info/default.asp?page=2008Symposium

PUBLICATIONS OF NOTE

Watters, G.M., R.J. Olson, J.C. Field, and T.E. Essington. 2008. “Range Expansion of the Humboldt Squid Was Not Caused by Tuna Fishing.” *Proceedings of the National Academy of Sciences USA* 105 (3): E5.

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Pelagic Fishing in Prehistoric Guam, Mariana Islands

Judith R. Amesbury

Introduction

Mahimahi and marlin were on the menu in prehistoric Guam. Fish bones from archaeological sites are evidence of the extraordinary fishing skills and good meals enjoyed by the pre-contact fishermen.

Micronesian Archaeological Research Services (MARS) has conducted an analysis of long-term fishery data for pelagic species in the Marianas. As part of that research, MARS sent fish bones from two archaeological sites on the east coast of Guam to Foss Leach and Janet Davidson, Honorary Research Associates of the Museum of New Zealand Te Papa Tongarewa. The two sites are at Mangilao Golf Course and Ylig Bay (Figure 1).

Leach and Davidson's analyses reveal that a high proportion of the fish caught and eaten by the people from these sites was *mahimahi* and marlin with some wahoo or *ono* and tuna as well.

People have lived in the Mariana Islands for at least 3,500 years or about 3,000 years prior to European contact. Spoehr (1957) divided the long Prehistoric Period into the Pre-Latte Phase and the Latte Phase. Other authors, including Moore and Hunter-Anderson (1999), have proposed subdivisions of the Pre-Latte Phase (Table 1). The Mangilao Golf Course and Ylig Bay sites yielded fish bones of pelagic species from both Pre-Latte and Latte Phases.

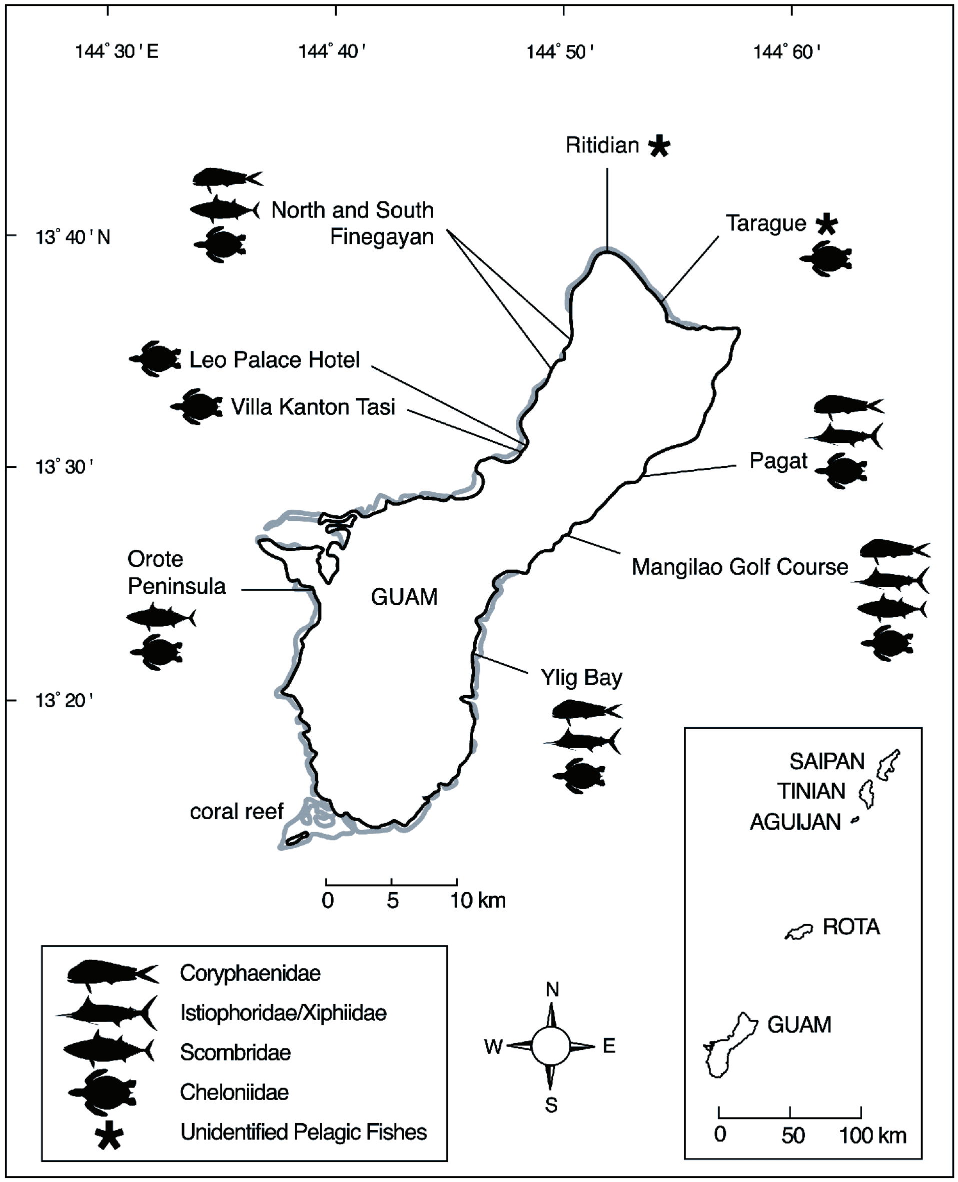

Figure 1. Guam, showing archaeological sites with pelagic fish and turtle remains. Figure by Robert Amesbury.

Mangilao Golf Course

A large archaeological site complex occupied an area on the northeast coast of Guam where the Mangilao Golf Course is now located. Paul H. Rosendahl, Ph.D., Inc., conducted archaeological fieldwork at Mangilao Golf Course from 1989 to 1992 under the overall guidance of Alan Haun, Senior Archaeologist (Dilli et al. 1998). In 2005 MARS sent 8,000 fish bones from the excavations to Leach and Davidson. Of those bones, nearly 400 were identified to the lowest possible taxonomic level, usually family, genus, or species (Leach and Davidson 2006a).

Minimum number of individuals (MNI) was determined for each fish group identified; total MNI equals 267 (Table 2). While 267 fish is a very low number for a large site occupied for many centuries, only a portion of the fish bones discarded at the site were preserved in the ground and recovered by the archaeologists and only a portion of those could be identified by the faunal analysts. So the MNI is a small sample of the fish caught and eaten at the site.

The most abundant family in the identified remains is Scaridae (parrotfishes), as is the case in most archaeological fishbone assemblages from Pacific islands (Table 2). Coryphaenidae (*mahimahi*) is the second most abundant family, and the fifth most abundant family group is Istiophoridae/Xiphiidae (marlins, sailfishes, and swordfishes). Also present are wahoo or *ono* (Subfamily

Table 1. Spoehr's (1957) broad phases of Marianas prehistory as subdivided by Moore and Hunter-Anderson (1999).

Phase	Subdivisions	Years Before Present	Approximate Calendar Dates
Pre-Latte Phase	Early Pre-Latte	3500 to 2500 years BP	1550 to 550 BC
	Intermediate Pre-Latte	2500 to 1600 years BP	550 BC to AD 350
	Transitional	1600 to 1000 years BP	AD 350 to 950
Latte Phase		1000 years BP to AD 1521	AD 950 to 1521

Table 2. Families of fishes, minimum number of individuals (MNI), and percent MNI from Mangilao Golf Course, Guam (based on Leach and Davidson 2006a).

Family or Other Group	Common Name	MNI	Percent MNI
Scaridae	Parrotfishes	97	36.33
Coryphaenidae	*Mahimahi*	41	15.36
Labridae	Wrasses	23	8.61
Lethrinidae	Emperors	20	7.49
Istiophoridae/ Xiphiidae	Marlins, Sailfishes, and Swordfishes	14	5.24
Epinephelinae	Groupers	11	4.12
Elasmobranchii	Sharks and Rays	10	3.75
Diodontidae	Porcupinefishes	9	3.37
Balistidae	Triggerfishes	8	3.00
Acanthuridae	Surgeonfishes	7	2.62
Nemipteridae	Monocle breams	6	2.25
Lutjanidae	Snappers	5	1.87
Scombrinae, Tribe Scomberomorini	Wahoo or *ono*	4	1.50
Teleostomi	Includes bony fishes	4	1.50
Carangidae	Jacks	2	0.75
Scombrinae, Tribe Thunnini	Tunas, including Skipjack and Yellowfin	2	0.75
Echeneidae	Remoras	2	0.75
Holocentridae	Squirrelfishes	1	0.37
Kyphosidae	Sea chubs	1	0.37
Total		**267**	**100.00**

Scombrinae, Tribe Scomberomorini) and tuna, probably skipjack and/or yellowfin (Subfamily Scombrinae, Tribe Thunnini). Nearly 23 percent of the MNI belong to the pelagic families Coryphaenidae, Istiophoridae/Xiphiidae, and Scombridae, which means that more than 23 percent of the pounds of fish eaten were pelagic fishes.

In order to determine if there were changes in the catch over time, Leach and Davidson grouped the assemblages into time periods based on the site stratigraphy and forty-one radiocarbon dates. The majority of fishes were from the Intermediate/Transitional Pre-Latte Phase and the Latte Phase with *mahimahi* and marlin identified in both the Pre-Latte and Latte Phases. Confidence limits for the percentages of MNI from each time period were calculated. No catch changes over time could be confirmed.

The fishermen from Mangilao not only caught pelagic fishes, they caught some very large reef fishes as well. Both *Cheilinus undulatus* (humphead wrasse) and *Bolbometopon muricatum* (humphead parrotfish) are present throughout the Pre-Latte Phase. *Bolbometopon* is also present in the Latte Phase.

Numerous artifacts identified as fishing gear were recovered from the Mangilao Golf Course excavations. They include sixty-four one-piece fishhooks and fifty-five gorges, seventeen composite hook components, nine bone harpoon points, and five stone net sinkers (Holstrum et al.1998). The composite fishhook components include fourteen bone points, two shell points, and one possible unfinished shell shank. Eight of the nine barbed harpoon points were manufactured from human bone and one from non-human bone. As there were no large land mammals in the Marianas during the pre-contact period, human bone was commonly used in making compound fishhook points and spear points.

Ylig Bay

The Ylig Bay archaeological fieldwork under the direction of Sandra Lee Yee, Project Director for International Archaeological Research Institute, Inc. (IARII), was conducted from 2003 to 2005. In 2005 MARS sent 2,000 fish bones from this site to Leach and Davidson. They identified 170 bones; MNI equals 95 (Table 3).

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Pelagic Fishing (continued from page 5)

Table 3. Families of fishes, minimum number of individuals (MNI), and percent MNI from Ylig Bay, Guam (based on Leach and Davidson 2006b).

Family or Other Group	Common Name	MNI	Percent MNI
Coryphaenidae	*Mahimahi*	37	38.9
Scaridae	Parrotfishes	18	18.9
Acanthuridae	Surgeonfishes	8	8.4
Epinephelinae	Groupers	6	6.3
Lethrinidae	Emperors	5	5.3
Istiophoridae/Xiphiidae	Marlins, Sailfishes, and Swordfishes	4	4.2
Lutjanidae	Snappers	4	4.2
Carangidae	Jacks	3	3.2
Labridae	Wrasses	2	2.1
Elamobranchii	Sharks and Rays	2	2.1
Teleostomi	Includes bony fishes	2	2.1
Sphyraenidae	Barracudas	1	1.1
Balistidae	Triggerfishes	1	1.1
Diodontidae	Porcupinefishes	1	1.1
Holocentridae	Squirrelfishes	1	1.1
Total		**95**	**100.0**

Most abundant family is Coryphaenidae. The sixth most abundant group is Istiophoridae/Xiphiidae. Slightly more than 43 percent of MNI belong to these three families. No identifiable tuna bones are present but tuna is not as common as *mahimahi* and marlin in pre-contact assemblages from the Marianas.

With Pelagic Fisheries Research Program funding, MARS paid for three of the six radiocarbon dates obtained by IARII. The six dates fall into two groups. Three earlier dates range from AD 370–890 (Transitional Pre-Latte Phase), and three later dates range from AD 1270–1660 (Latte Phase and Historic Period). It is likely that if more dates were obtained, they would fill the gap between the two groups. The later dates are from a deposit that is essentially prehistoric, but the two-sigma ranges of the dates extend into the Historic Period.

European contact with Guam occurred with Magellan's arrival in 1521 but the Spanish did not colonize Guam until 1668. During the period between contact and colonization, the people of Guam continued in many of their pre-contact lifeways but with the addition of certain imports, notably iron for fishhooks. While we cannot say that all the materials in the later deposits are pre-contact, we can say that they are pre-colonization, and no metal was found in the deposits dating to 1270–1660.

To look for changes in the fish catch over time, Leach and Davidson (2006b) divided the fish bones into three groups based on the deposits from which they derived—Transitional Pre-Latte Phase, Latte Phase/Historic Period, and mixed deposits. Percentages by MNI and confidence limits were calculated. There were no significant changes in abundance from the Pre-Latte Phase to the Latte Phase/Historic Period.

The Ylig site has a high percentage MNI of *mahimahi*. It is possible that the large vertebrae were preferentially collected at the start of the excavation. However Leach and Davidson (2006b) found consistently high percentages of *mahimahi* in the three sub-collections. The percentage MNI in the Transitional Pre-Latte deposits is the same as the percentage MNI in the Latte Phase/Historic Period deposits, so preferential collection from the upper levels of the excavation does not explain the abundance of *mahimahi*.

The analysis of fishing gear from Ylig Bay has not been completed but a human bone hook from a compound fishhook was found (Photo 1). This item is nearly identical to points found at two other sites on the east coast of Guam, Pagat (Craib 1986) and Targue (Ray 1981) (Figure 1). Shanks from compound fishhooks are rarely found, possibly because they were made of non-durable materials.

Significance of the Findings

Prior to the analyses of fish bones from these two sites in Guam, it appeared that most of the pelagic fishing in the Marianas during the Prehistoric Period occurred around Rota, the next island north of Guam (Figure 1, Table 4). This made sense because Rota is smaller than Guam, Saipan, or Tinian and has less reef area. Rota also lacks the large protected west-coast bays and lagoons of Guam and Saipan where extensive reef fishing occurs.

The analyses from these two sites on Guam have changed the picture of pelagic fishing in the Marianas during the Prehistoric Period. It is now clear that there were simply more fish-bone analyses for sites on Rota. Pelagic fishing was important on Guam as well as on Rota.

Mahimahi was identified at eight of the ten Marianas sites that have pelagic remains with MNI analysis (Table 4). Marlin was also identified at eight of the ten sites. This is unusual for Pacific islands. The database of fish remains from archaeological sites at Museum of New Zealand Te Papa Tongarewa contains information on more than 75 tropical Pacific island sites and more than 125 sites in New Zealand, but none of the sites outside the Marianas have *mahimahi* remains and only one site outside the Marianas has marlin remains (Leach and Davidson 2006b). Marlin accounted for less than 1 percent of MNI at Motupore, Port Moresby, Papua New Guinea.

Table 4. Percent of pelagic fishes in the total MNI of identified fishes from ten sites in the Mariana Islands that have pelagic fish remains with MNI analysis.

Site or Area	Coryphaenidae Percent MNI	Istiophoridae/Xiphiidae Percent MNI	Scombridae Percent MNI	All Pelagics Percent MNI
Pagat, Guam	4.0	1.0		5.0
Mangilao, Guam	15.4	5.2	2.3	22.9
Ylig Bay, Guam	38.9	4.2		43.1
Afetña, Saipan			2.6	2.6
Central Tinian	2.2			2.2
Tachogna, Tinian	0.7	1.3	1.3	3.3
Mochong, Rota	11.8	3.2	1.9	16.9
Airport Road, Rota	16.3	9.2	8.1	33.6
Vista Del Mar, Rota		7.7	11.5	19.2
Songsong, Rota	4.7	3.5	1.2	9.4
Average of 10 Sites	**9.4**	**3.5**	**2.9**	**15.8**

However there is another part of the Pacific with evidence of pre-contact fishing for *mahimahi* and marlin. This is the area on either side of the Luzon Strait, which includes southern Taiwan and the northern Philippines. Coryphaenidae and Istiophoridae are among the most common taxa identified from archaeological sites at O-luan-pi (or Eluanbi) on the southernmost tip of Taiwan, which date to approximately the same time period as the Early Pre-Latte Phase in the Marianas or somewhat earlier (Li 2002, 1997).

Across the Luzon Strait from Taiwan in the Batanes Islands of the Philippines, *mahimahi* bones have been recovered from a site on the island of Sabtang (Campos pers. comm. 2008). Also the Yami of Botel Tobago, an island off the southeast coast of Taiwan, traditionally fished for *mahimahi* (Hsu 1982; Kano and Segawa 1956).

Leach and Davidson (2006a) noted that pre-contact people in both southern Taiwan and the Marianas possessed highly specialized fishing skills not seen in other parts of Oceania. Pelagic fishing skills may be one of the pieces of the puzzle that will help to answer the question of where the people of the Marianas came from.

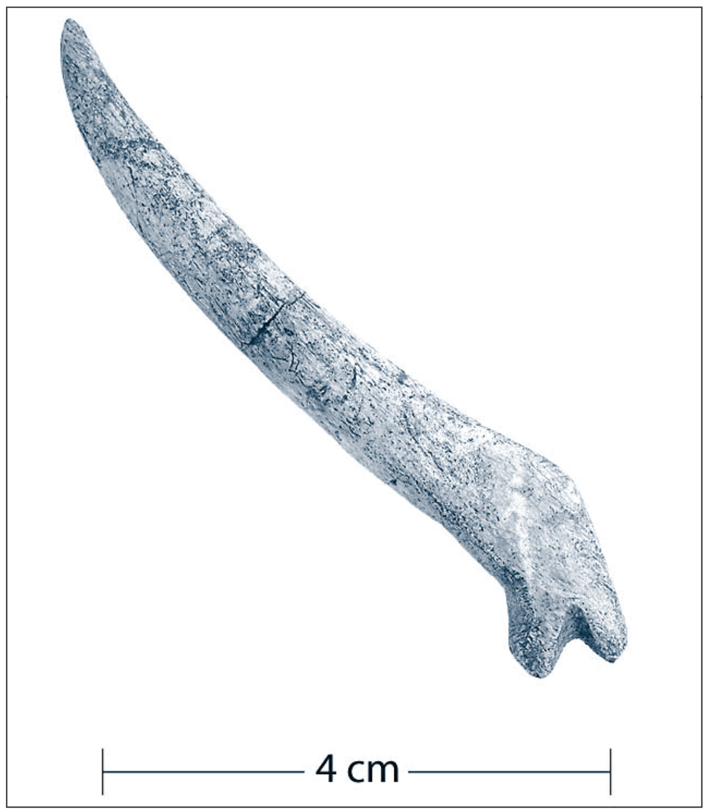

Photo 1. Human bone point of compound fishhook from Ylig Bay, Guam. Photo by Rick Schaefer.

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