Replacing Purse Seining with Pole-and-Line Fishing in the Western Pacific:

Some Aspects of the Baitfish Requirements

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Cover photo: Pole-and-line fishing with live bait; photo courtesy of David Itano

Introduction

Recently there have been discussions on the desirability of replacing at least some of the purse seining in the Pacific Islands region[1] with pole-and-line fishing. Pole-and-line fishing, however desirable, is highly dependent on live baitfish supplies. The purpose of this short study is to estimate the quantities of baitfish to replace purse seining in the Pacific Islands region and to examine the ability of the region's baitfish resources to support that replacement.

Background

There were several waves of pole-and-line fishing in the region of the Pacific Islands. Gillett (2007) describes this activity:

- By the mid-1930 Japanese tuna fishing was well-developed in the Micronesia area with 45 pole-and-line vessels based in Palau, 52 in FSM, and 19 in the Northern Mariana Islands.
- Tuna catches in Micronesia reached the highest level of 33,000 metric tonnes in 1937. Most of the production was processed into a dried tuna product "katsuobushi" which was shipped to Japan. There were also at least two tuna canneries in operation.
- All commercial tuna fishing in the Micronesia area came to a halt during World War II.
- In the early 1950s the activities of the Japan-based pole-and-line vessels were limited to fishing close to Japan by their need to carry live bait, but later improvements in technology allowed those vessels to increase their range from their Japanese bases. By the early 1960s Japanese pole and line vessels were fishing in the areas near the Northern Marianas and Palau during their near-Japan off-season and during the next ten years were fishing well south of the equator. All this pole-and-line fishing used bait captured in Japan.
- Japanese companies had established through various arrangements substantial locally-based pole-and-line tuna fishing presence in several Pacific Island countries, including Papua New Guinea (1970), Solomon Islands (1971), and Fiji (1976).
- Van Camp Seafood Company established a transshipment base in Palau in 1964, supporting eight to 15 locally based pole-and-line vessels.

In addition to the above location, attempts were made to establish pole-and-line fishing operations in other Pacific Island Countries: the Federated States of Micronesia (Pohnpei, Chuuk), Kiribati (Gilbert Group), Tuvalu, New Caledonia, Samoa, Tonga, Cook Islands, and French Polynesia. The tuna production at each of those locations was minor compared to the four countries that had significant fisheries (Table 1).

Japan-based pole-and-line vessels have also been very active in the Pacific Islands region. Lawson (1998) indicates that the activities of that fleet in the Pacific Islands area reached a peak in 1977 when over 300 pole-and-line vessels fished the area and caught 154,296 tonnes of tuna. Those vessels were based in Japan and transported live bait from Japan for their fishing activities in the region. Matsunaga et al. (2006) state that in 2005 the entire Japanese pole-and-line tuna fleet (including the home-water fishery) consisted of 215 vessels greater that 10 GRT: 77 vessels between 10 and 50 GRT, 95 between 50 and 200 GRT, and 43 larger than 200 GRT.

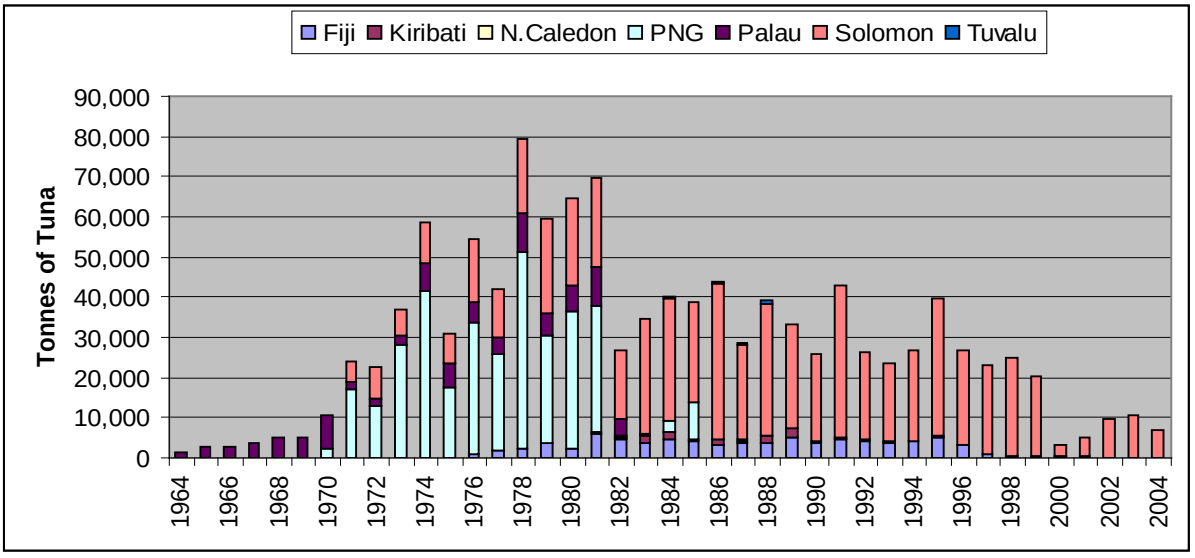
[1] The Pacific Islands region, as used in this paper, is taken to be equivalent to the 200-mile zones of the 24 countries and territories that are members of the Secretariat of the Pacific Community, plus adjacent international water. Prior to the late 1990s the SPC fishery statistics were for the SPC area but then were expanded to include the larger western and central Pacific Ocean, including the waters of several Asian countries.

Table 1: Tuna Catches by Pacific Island Pole-and-Line Fleets (tonnes)

	Fiji	Kiribati	N.Caledon	PNG	Palau	Solomon	Tuvalu	Total
1964					1,178			1,178
1965					2,742			2,742
1966					2,936			2,936
1967					3,529			3,529
1968					5,099			5,099
1969					5,259			5,259
1970				2,428	8,082			10,510
1971				16,974	2,143	4,711		23,828
1972				13,130	1,519	7,905		22,554
1973				28,216	2,350	6,513		37,079
1974	12			41,630	6,808	10,332		58,782
1975	11			17,369	6,269	7,094		30,743
1976	742			32,921	5,323	15,586		54,572
1977	1,711			24,115	4,012	11,961		41,799
1978	2,524			48,859	9,694	18,101		79,178
1979	3,494			26,857	5,688	23,689		59,728
1980	2,496			33,994	6,576	21,608		64,674
1981	5,835	564	229	31,412	9,411	22,172		69,623
1982	4,428	457	868		4,053	16,802	216	26,824
1983	3,738	1,594	439			28,651	337	34,759
1984	4,572	2,031		2,744		30,381	540	40,268
1985	3,943	719		9,300	97	24,774	4	38,837
1986	3,111	1,414			131	38,644	390	43,690
1987	3,862	434			161	23,609	632	28,698
1988	3,870	1,472			157	32,671	1,090	39,260
1989	5,121	2,282			77	25,760	149	33,389
1990	3,674	595			88	21,474	90	25,921
1991	4,826	224				37,907	29	42,986
1992	4,100	551			75	21,687	8	26,421
1993	3,806	293				19,495		23,594
1994	4,122	192				22,531		26,845
1995	4,877	482				34,315		39,674
1996	3,288					23,543		26,831
1997	1,033					22,206		23,239
1998	466					24,251		24,717
1999	508					19,578		20,086
2000	351					2,692		3,043
2001	475					4,710		5,185
2002						9,652		9,652
2003						10,797		10,797
2004						6,882		6,882

Source: Lawson (1989)

Figure 1: Tuna Catches by Pacific Island Pole-and-Line Fleets



Source: Table 1

As can be seen from Table 1, the pole-and line catches from vessels based in the Pacific Islands area reached a maximum about 30 years ago. At that time the number of locally-based pole-and-line vessels operating in the region was about 100 to 120 vessels. Gillett (2008) indicates that the number of pole-and-line vessels had declined to 14 in 2002 (based in Solomon Islands, Palau, Fiji), and to 12 in 2006, with only 2 vessels based in the Solomon Islands operating in 2008.

There are several reasons for the decline in the number of pole-and-line vessels in the region. One of the most important is the inability to compete economically with the more efficient purse seining – the early 1980s corresponded to a period when the number of purse seine vessels operating in the Pacific Islands increased rapidly. Also to be considered is that several of the Pacific Island pole-and-line fleets were actually operated by government fishing companies, an arrangement that is rarely profitable in any fishery. The immediate cause of the PNG fleet collapse was the fuel taxes levied by the PNG government.

There are also pole-and-line vessels operating in northeast Indonesia (i.e. that portion of Indonesia lying within FAO area 71). An investigation of the number of longline and pole-and-line vessels operating in northeast Indonesia and in the Philippines in 2005 was carried out by Gillett and McCoy (2006). They concluded that that there were 132 pole-and-line vessels greater than 30 GRT operating in northeast Indonesia in 2005.

Baitfishing in Support of Pole-and-Line Fishing

Pole and line fishing is highly dependent on a supply of live baitfish. Some features of baitfishing in the Pacific Islands region are:

- The amount of bait available to a fishing operation often determines the amount of tuna captured in a day's fishing operation.
- The bait is captured in a separate fishing operation which is characteristically carried out (a) by the tuna fishing vessel to use the bait, (b) at night, and (c) with lights and lift net gear ("boke ami").
- The techniques commonly used are described in Hallier et al. (1982).
- The bait species captured in the tropics are generally more fragile than temperate baitfish species, and the mortality experience after captured before use in tuna fishing is often high.

The amount of tuna captured in pole-and-line fishing normally is much greater than the amount of baitfish used. The amount of tuna captured per amount of bait used is known as the tuna-baitfish ratio. This ratio can vary due to the baitfish species used, fishing style, and other factors. Various studies provide information on the tuna-baitfish ratios of pole-and-line fisheries that formerly operated in Pacific Island countries and adjacent areas (Table 2).

Table 2: Information on Tuna to Bait Ratios Obtained by Various Pole-and-Line Fishing Operations

Area	Information on Tuna to Bait Ratio	Source
PNG	In a study which analysed 13,000 daily catch forms submitted by live-bait pole and line boats operating in Papua New Guinea in 1972 and 1973 it was determined that 41,393,000 kg of skipjack was caught and the total quantity of bait taken was 1,373,046 kg, giving a tuna-to-bait ratio of 30 to 1.	Kearney (1977)
Solomon Is.	Pole-and-line catches peaked in 1979 with 23,807 tonnes of skipjack. In 1979 a total of about 607.4 tonnes of bait was used, or about 39 kg of skipjack per kg or bait.	Argue and Kearney (1982)
Fiji	In February and March 1978, the Ika Corporation fleet averaged 31.1 kg of skipjack per kg of bait	Ellway and Kearney (1981)
SPC Area	On the SPC Skipjack Programme research vessel (1997-1980): • The corrected tuna-to-bait ratio of anchovies throughout the SPC area was 32.3 • The corrected tuna-to-bait ratio of sprats throughout the SPC area was 34.7 • The corrected tuna-to-bait ratio of sardines throughout the SPC area was 27.4	Skipjack Programme (1981a)
Palau	The annual bait catch in Palau in the period 1964 to 1972 varied from 21,776 kg to 222, 206 kg; averaging about 140,000 kg. The tuna catch in those years averaged 3,713 tonnes. The tuna to bait ratio was therefore 26.5	Muller (1977), Lawson (1998)
Hawaii	The ratio of skipjack tuna to baitfish (*Stolephorus purpureus*) in the Hawaiian pole-and-line fishery averaged 23.1 over the period 1950 to 1972.	Yoshida et al. (1977)
Japan	The ratio of skipjack tuna to baitfish (mostly *Engraulis japonicus*) in the Japanese pole-and-line fishery averaged 9.7 over the period 1957 to 1971.	Yoshida et al. (1977)

From the above it can be seen that the tuna-baitfish ratios in the height of the Pacific Islands pole-and-line fisheries were around 32:1. That ratio, in conjunction with tuna catch information in Table 1, can be used to estimate bait usage in the former Pacific Island pole-and-line fishery (Table 3).

Table 3:
Tuna Caught by Pacific Island Pole-and-line Fisheries and Bait Used

Year	Amount Tuna Catch	Amount Bait Used		Year	Amount Tuna Catch	Amount Bait Used
1964	1,178	37		1985	38,837	1,214
1965	2,742	86		1986	43,690	1,365
1966	2,936	92		1987	28,698	897
1967	3,529	110		1988	39,260	1,227
1968	5,099	159		1989	33,389	1,043
1969	5,259	164		1990	25,921	810
1970	10,510	328		1991	42,986	1,343
1971	23,828	745		1992	26,421	826
1972	22,554	705		1993	23,594	737
1973	37,079	1,159		1994	26,845	839
1974	58,782	1,837		1995	39,674	1,240
1975	30,743	961		1996	26,831	838
1976	54,572	1,705		1997	23,239	726
1977	41,799	1,306		1998	24,717	772
1978	79,178	2,474		1999	20,086	628
1979	59,728	1,867		2000	3,043	95
1980	64,674	2,021		2001	5,185	162
1981	69,623	2,176		2002	9,652	302
1982	26,824	838		2003	10,797	337
1983	34,759	1,086		2004	6,882	215
1984	40,268	1,258				

Units: metric tonnes

At the height of the Pacific Islands pole-and-line fishery in 1978 about 79,178 tonnes of tuna were caught by using about 2,474 tonnes of baitfish.

The Purse Seine Fishery in the Pacific Islands Area

The characteristically clear water and deep thermocline in the equatorial western Pacific create conditions unfavourable for purse seining – the tuna schools tended to be smaller, faster-moving, and dive deeper than in the eastern Pacific or off Japan. Several decades ago the governments of Japan and subsequently, of the United States sponsored many experimental purse seining expeditions to the equatorial Pacific area. The Japanese persisted and were the first to have success. The main innovation was the pre-dawn setting of deep nets around logs in the area between Micronesia and Papua New Guinea.

By the late 1970s there were several fully commercial Japanese and American purse seine operations in the western equatorial area of the Pacific Islands. The number of purse seine vessels operating in the Pacific Islands increased rapidly during the early 1980s. The US purse seine fleet moved in quickly from the eastern Pacific due to the very strong El Niño event of 1982-83 and pressure to reduce dolphin mortality in their traditional fishing grounds. In 1983, 62 US seiners caught 179,000 tonnes of tuna in the Pacific Islands area.

The purse seine fishery in the region expanded during the following two decades, as the pole-and-line catches declined. In the past ten years the purse seine fishery in the Pacific Islands region has ranged from about 750,000 tonnes per year to well over a million tonnes

per year[2]. For simplicity, this report uses a Pacific Islands tuna purse seine catch of one million tonnes.

Some Thoughts on the Baitfish Requirements for Expanding the Pole-and-Line Fishery

Using information in the above sections, it is estimated that to catch a million tonnes of tuna annually in the region would require about 31,250 tonnes of baitfish per year. This assumes:

- A tuna-baitfish ratio of 32 to 1; i.e. that the tuna baitfish ratios obtained by former pole-and-line fisheries in the region remain valid.
- The species composition of the 31,250 tonnes of baitfishing is similar to that of the former pole-and-line fisheries.
- The condition of the baitfish is similar to that of the former pole-and-line fisheries. Baitfish that is stressed by, for example, rough capture and transfer techniques, tends to suffer higher mortality aboard pole-and-line vessels, decreasing the tuna-baitfish ratio.

None of the assumptions above appear to be unreasonable.

Would it be possible to capture this amount of baitfish? Several factors should be considered, including:

- During the height of the pole-and-line era, a maximum of about 2,474 tonnes of baitfish was captured. The amount of baitfish required to catch a million tonnes of tuna would therefore be almost 13 times the baitfish catch during the height of the Pacific Islands pole-and-line fishery.
- PNG and the Solomon Islands are well-endowed with baitfish resources, and to a lesser extent Palau and Fiji. In general, in progressing from west to east in the region, the amount of habitat for baitfish production decreases. The number of species considered to be desirable baitfish also decreases.
- Fish aggregation devices could improve somewhat the tuna-baitfish ratio (they were not used extensively during the height of the pole-and-line era) but a remarkable improvement in the ratio would be unlikely.

It would appear that any new and large pole-an-line fishery in the region would be based largely on the baitfish resources of PNG and the Solomon Islands, and to a much lesser extent, Palau and Fiji. There are numerous baitfishing grounds in PNG and the Solomons – many more than were actually used regularly by the former pole-and-line fleets. But the following should be considered when contemplating whether baitfish catches 13 times larger than at the height of the pole-and-line fishery would be possible:

- During the height of the fishery the fleets normally captured baitfish in the most desirable locations - certain baitfish grounds that had characteristics, such as high catches or proximity to tuna fishing grounds. In a greatly expanded baitfishery those baitfishing grounds with low yields and or those that are situated in logistically disadvantaged positions would, out of necessity, need to be used.
- There is some evidence that during the height of the pole and line fishing era, the baitfish resources at popular baiting areas were under heavy fishing pressure. Skipjack Programme (1984b) discusses PNG and states: “After indications of overexploitation of baitfish at the two locations [Ysabel Pass and Cape Lambert] on several occasions between 1978 and 1980, restrictions were placed on effort, leading to a recovery of the stocks within a few months. This suggests that yields from the Ysabel Pass and Cape Lambert grounds may have been near the maximum sustainable.”
- It is unlikely that in the entire country of PNG there are the equivalent of 12 Ysabels/Lamberts located within convenient distance to favourable fishing grounds.

[2] Note that this amount is smaller than catches in the entire western Pacific – which includes the domestic fisheries of some Asian countries.

Skipjack Programme (1984) states that in PNG "there are few large areas like Ysabel Pass and Cape Lambert capable of supporting the concentration of baitfishing effort involved in a mothership-type operation."

- Muller (1977) concluded that the baitfishery in Palau in the late 1960s and early 1970s was near its optimum level. The decline of CPUE in 1971 shows that there is an optimum fishing intensity for baitfish, after which the catch drops sharply.

The above suggests that it would be quite difficult to expand baitfish catches in the region by a factor of 13 from the levels at the height of the pole-and-line fishery three decades ago. Given the available information on baitfishing in the region, it is not possible to make a more definitive statement on the subject.

Issues of Practicality and Desirability

Apart from the issue of the ability of the region to produce 31,250 tonnes of baitfish, there are also the issues of practicality and desirability.

The EEZs of the Marshall Islands, Nauru, Kiribati, and Tuvalu are where a substantial amount of the purse seining in the region occurs, but those countries have very limited baitfish resources. The countries in the east of the region generally do not have substantial baitfish resources. Baitfish resources would dictate that a replacement of purse seining by pole-and-line fishing would mean a large displacement of surface tuna fishing activities towards the western part of the region - something that may not be equitable or acceptable to many Pacific Island countries. This may have negative implications for regional solidarity in the fisheries sector – something that is vitally important to Pacific Island countries.

In addition to the above large-scale spatial distribution of pole-and-line catches in the WCPO, there would also be uneven distribution at the country level. Pole-and-line fisheries would be restricted to at most a few days distance from baitgrounds, and probably less. Consequently, the fishery would be concentrated in coastal areas and quite patchy. This may lead local depletion issues that would impact catch rates and hence the economics of the operation. (J.Hampton, SPC, personal communication, December 2009)

The production of 31,250 tonnes of baitfish in Pacific Island inshore areas would likely have substantial interaction with the multitude of small-scale subsistence and commercial fishing activities that produce food for the villages and towns of the region. This could easily have negative food security implications for the areas that produce large quantities of baitfish for industrial fishing operations. In relation to this issue, the following observations are relevant:

- There is a growing recognition in the region that protection of the flow of marine foods to villages should be a paramount objective in fisheries management.
- One of the organizations now encouraging pole-line fishing, has in the past contemplated a campaign to stop pole-and-line fishing in the region due to its negative impacts on village food supplies[3].
- In the late 1990s the World Bank carried out a survey of management of small-scale fisheries in 31 villages in 5 Pacific Island countries. The study came across a situation in which a village's fishing grounds had been subjected to substantial baitfishing for industrial tuna fishing. At that location, Susui Village in Fiji, the local council was successful in eventually banning baitfishing operations. The report of the World Bank survey stated: "The community considered the reduction of a threat largely dismissed by the Government (baitfishing by tuna vessels) a major management success". (World Bank 1999).
- There is at least some speculation that the lights used in night-time baitfishing can negatively affect turtle nesting activities[4].

[3] M.Hagler, Greenpeace (personal communication, circa 1990)
[4] J.Moody, Namena Resort (personal comm., 2005)

Management of Baitfisheries

The ability of Pacific Island countries to manage a large baitfishery also relevant to the issues practicality and desirability of a Pacific Island country having such a fishery. During the height of the pole-and-line fishery there was apparently minimal management of baitfishing activities with regards to sustainability of the resource. A review of the readily-available fisheries literature of the region reveals only one case: restrictions were placed on baiting effort in the two major baitfishing grounds of PNG in the late 1970s and early 1980s in response to overexploitation of baitfish (Skipjack Programme,1984b). In another sense, there were government interventions in the baitfisheries of some countries (including those in PNG and Solomon Islands) to generate cash for villages adjacent to the baitfishing grounds.

Of greater relevance to the present study would be the effectiveness of any future regimes to manage baitfisheries. An important aspect of this topic is that management of a baitfishery is not extremely difficult (e.g. controls on total catches and/or boat-nights). Another key point is that there are great differences between Pacific Island countries in the ability to carry out basic fisheries management and related activities. Overall, the management ability of a government fishery agency in a Pacific Island country is part of the larger issue of fisheries governance.

In recent years much has been written about the general problems of governance in the fisheries sectors of Pacific Island countries in general. This includes Clark (2006), Barclay and Cartwright (2007), FFA (2007), AusAID (2007), Gillett and van Santen (2008), and Hanich and Tsamenyi (2009). Common features that emerge from these analyses are:

- Low capacity of national fisheries agencies brought about by lack of qualified personnel at all levels, faced with increasing complex issues.
- Poor decision making: inconsistent, lacking policy objectives
- Poor leadership/organizational skills by department heads
- Structures of government fisheries agencies that are not conducive to transparency and stakeholder input.
- Low levels of government funding of government fisheries agencies
- Few staff incentives for performance in support of good governance

A recent SPC/FFA[5] study was focussed on the long-term future of Pacific Island fisheries and their management. The report of that study (Gillett and Cartwright, 2010) identifies the major challenges of the future. These include:

- A lack of highly competent and appropriately skilled fisheries managers.
- A lack of clear policy directions and planning in all fisheries; continued optimism (or inertia) that somehow “it will all be fine” in respect of pressure on resources.

Considering the above, what can be concluded on the ability of a Pacific Island country to manage a large baitfisheries? On this issue, considerable speculation is required and there are large differences between countries of the region. In general, it could be stated that any country in the region could manage such a fishery, if given high enough priority by the senior leadership in the country. However, if the present trends in fisheries management are projected into the future, it is likely that many countries would have considerable difficulty in establishing and maintaining an effective management regime for baitfisheries.

Alternatives to Baitfishing

The main alternatives to the wild capture of baitfish for pole-and-line fishing are the culture of baitfish and transportation of baitfish into the region from other areas.

[5] SPC = Secretariat of the Pacific Community; FFA = Forum Fisheries Agency. These are the two regional organizations that assist Pacific Island countries in fisheries development and management.

The cultivation of baitfish for pole-and-line fishing has been undertaken at several locations in the Pacific Islands, including the Gilbert Group of Kiribati, Fiji, Samoa, American Samoa, and the Tuamotu Islands of French Polynesia. This has involved mainly milkfish and mollies, but also several other species. Kearney and Rivkin (1981) explored the economics of baitfish culture in the Pacific Islands and one of the conclusions is "the tendency of fishermen not to want to pay for bait under any circumstances cannot be quantified but should not be overlooked."

Baitfish has been transported into the region for pole-and-line fishing for many decades by Japan-based pole-and-line vessels. In recent years that fleet has used such technology as refrigerated bait wells to reduce the mortality of temperate bait species in warm seas. It is conceivable that baitfish supplies could also be transported into the region from Australia, New Zealand, or Indonesia.

The main difficulty with the above culture and transport schemes is that they add substantial costs to pole-and- line fishing – which (even without those extra expenses) has tremendous difficulty with high production costs relative to purse seining.

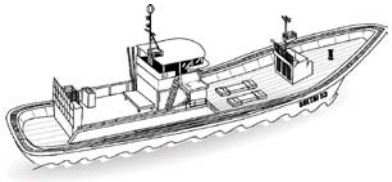
Bait transport schemes also suffer from problems related to species and disease introductions. A new baitfish species (Marquesan sardine) was intentionally introduced into Hawaiian waters after being transported on a pole-and-line vessel some 3,600 km (Murphy 1960). A new species (goldspot herring, also a baitfish species) was apparently non-intentionally introduced to Hawaii (Eldredge 1994). Ponia et al. (2003) discuss the impacts of aquatic species introductions in the Pacific Islands: "The potentially adverse impacts of such introductions stem from not only the species that are intentionally introduced but also unintended 'hitch-hikers'. These include both macro-organisms (e.g. snails, worms, larvae) and micro-organisms (parasites, bacteria and viruses). The impacts of introduced organisms may be severe. Native species and the ecosystem as a whole can be affected. Rural livelihoods, food security, poverty alleviation and public health may be at risk. Significant economic losses in international trade can occur." Eldredge (1994) examines the disease implications for aquatic species introductions to the Pacific Islands and concludes that disease interactions with exotic organisms fall into four categories

- Effects of exotic diseases on local organisms,
- Effects of local diseases on exotic organisms,
- Increased susceptibility to diseases of exotic organisms cultured in unsuitable or
- Marginal environmental conditions, and
- Predisposition of the environment to pathogen problems.

Conclusions

The three major conclusions of the present study are:

- It is estimated that to catch a million tonnes of tuna annually in the Pacific Islands region (i.e. replace the purse seine fishery) would require about 31,250 tonnes of baitfish per year.
- Although it is unlikely that the region could support a fishery capable of catching 31,250 tonnes of baitfish, there is not enough information available to make a definitive statement to that effect.
- Apart from the issue of whether the region could produce a large amount of baitfish for industrial fishing, there may be considerable negative implications of a large increase in baitfishing on small-scale food fisheries.



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