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Fisheries for small pelagics in the Pacific Islands and their potential yields[a]

by

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ABSTRACT

A review is presented of the data currently available on small pelagic fisheries, both inshore and offshore in the South Pacific Region. Most information concerns pole-and-line tuna live bait fisheries. The biological characteristics of small pelagics are discussed with respect to exploitation. Estimates of yields and maximum sustainable yields are compared with those in Southeast Asia for the same species groupings. The lack of data on small pelagic yields in most areas of the South Pacific is discussed and ways to assess standing stock sizes and potential yields are suggested.

INTRODUCTION

Small pelagic fishes, the mackerel and herring-like species which generally attain a maximum weight of less than 500g, form an important part of the total marine fisheries production of both Southeast Asia and the island nations of the South Pacific region. In Southeast Asia, small pelagics comprise about 20% of the total annual marine landings or a catch of 1,300,000 t/year (Table 1). In much of Southeast Asia, both pelagic and demersal fisheries are exploited at or beyond the level of the maximum sustainable yield (MSY) and the maximum economic yield (MEY) (Marten and Polovina 1982; Silvestre and Pauly in press; Bailey et al. 1987; Dalzell et al. 1988). By contrast, the small pelagic fisheries resources of the South Pacific region as a whole may be only relatively lightly exploited, although in certain areas they constitute important subsistence fisheries and are also used as live bait to catch tuna. In this paper, we review current knowledge of South Pacific small pelagic fisheries resources and attempt to give some indication of potential yields for small pelagic fisheries, based largely on inferences from Southeast Asia, which is faunistically similar.

SMALL PELAGIC FISHES AND NOMINAL LANDINGS IN THE SOUTH PACIFIC REGION

Species Taken

The term 'small pelagic fishes' refers to a diverse group of planktivorous fishes that share the same common habitat, the surface layer of the water column, usually above the continental shelf and in waters not exceeding 200m in depth. In Pacific islands, there is typically little or no continental shelf, and beyond the barrier or fringing reef, the descent to 200m is rapid. Table 2 lists the small pelagic fishes of the South Pacific region.

Many of the individual species in each species grouping are used as bait-fish for pole-and-line tuna fishing and the taxonomy and distribution of these bait-fish are described by Lewis et al. (1983a). These data are summarized in Table 3 and Fig. 1. Papua New Guinea (PNG) was taken as the western boundary of the South Pacific region. A functional regression of the logarithm of the number of small pelagic bait-fish species versus distance in an easterly direction from PNG was negative and highly significant. Although not

conclusive, this analysis suggest a cline of decreasing small pelagic species diversity away from the Indo-Australian archipelago which is thought to be the evolutionary center of the Indo-Pacific fauna (Carcasson 1977). These results are consistent with those of Sale (1980) for coral reef species.

Landings with the exception of tuna bait fisheries

Data on small pelagic fish landings in the South Pacific region are rather sparse. Nominal production of small pelagic fishes for six different Pacific Island nations are given in Table 4. Information on subsistence catches, for example, is generally lacking and thus is not included. It should be clearly understood that these data are not comprehensive. No information, for example, on the volume of catches of small pelagics in French Polynesia was found in the literature, although these fishes are known to be an important component of catches in this location (Bagnis et al. 1974). The data clearly highlight the gaps in the present knowledge of small pelagic resources utilization in the region.

Fishing methods and gears

Small pelagic species, used for live bait in Fiji, PNG, the Solomon Islands and Kiribati are caught by light attraction and the use of a stick-held lift net or Bouke-ami. The deployment and operation of Bouke-ami nets has been described in detail by Dalzell (1980), Muyard (1980) and McCarthy (1985). The Bouke-ami net is mounted on the deck of the pole-and-line tuna vessel and is dismantled and stowed when not in use. Tuna vessels normally employ two or three skiffs with a generator to power 1-1.5 kW submersible lamps. These lamps and those mounted on the deck of the tuna vessel are used to aggregate the bait-fish. Similar systems are also used in the Philippines to capture small pelagics although the use of submersible lamps in this regions is not common, and surface illumination is predominant.

In PNG, various small-scale gears are used to capture small pelagic fishes. The gold spot herring *Herklotsichthys quadrimaculatus* and big-eye scad *Selar crumenophthalmus* are captured in the North Solomons by hand-held scoop nets (Hulo 1985). A group of men will carefully surround a school in knee-deep water then close in scooping the fish into baskets carried on their backs. Scoop nets are also used in the North Solomons to capture flying fishes (ibid). The fishermen attract the flying fishes on a moonless night by a kerosene pressure lamp mounted on a canoe. This type of fishing is found also in the Micronesian islands of Palau (Johannes 1983), Kiribati (Mees 1985) and most of Polynesia where it has developed to a high degree. In the Marakei Islands of Kiribati, catches of flying fishes taken in this fashion account for about 40% of the total fish landings from these islands.

Encircling seine nets originally made from bush materials, are used in the Admiralty Islands of PNG to capture half-beaks (Hemirhamphiade) and other larger pelagics such as trevallies (Carangidae) and mullet (Mugilidae) (Kubohjam 1985). Cast netting is used in Palau to capture H. quadrimaculatus when this species congregates in spawning aggregations (Johannes 1983). Palau stocks of H. quadrimaculatus may in fact be overfished, possibly due to dynamite fishing on the herring schools. Johannes also mentions that the big-eye scad, Selar boops is heavily fished by gill and seine netting in Palau, although there has not yet been any sign of a decline in the scad stocks. In Guam, its more wide-spread cogener, Selar crumenophthalmus is caught by hook-and-line and gill nets as juveniles, and offshore night jigging for adults (Amesbury et al 1986). The big-eye scad, Selar crumenophthalmus is highly prized in French Polynesia and is captured by drive-in seine netting, gill netting and jigging with feather lures on hand lines at night using light attraction (Bagnis et al. 1974). In Hawaii, a rather more sophisticated fishery using spotter planes and surround nets has developed (Shiota 1986).

In Tahiti, the roundscad Decapterus macarellus is caught by hook-and-line, using coconut pulp as bait (Bagnis et al. 1974). These authors also report the capture of D. macarellus by netting (presumably gill netting) in the reef passes of the Leeward Islands, and successful bottom gill netting trials have more recently been carried out in the Cook Islands. Gillett (1987) reports on the success of the Hawaiian hoop net for Decapterus spp. in Niue. In Fiji, gill nets are used both passively and to actively surround schools of Rastrelliger brachysoma and R. kanagurta in inshore waters. Landings of over 500t/yr. have been recorded (Lewis 1985) and are seasonal.

In French Polynesia, structures similar in construction and design to Philippine fish corrals are used to capture both pelagic and demersal species. In the Philippines, such corrals are composed primarily of cane whilst according to Grand (1985) Polynesian fish corrals or 'parcs' are made from netting suspended from steel posts. The catches and economics of Polynesian parcs have been studied by both Grand (1985) and Morize (1985).

DISTRIBUTION AND BIOLOGY OF SMALL PELAGIC FISHES

Distribution

In much of the South Pacific many of the small pelagic catches are associated with coralline areas. The exceptions are the larger islands such as Fiji, PNG and the Solomon Islands which possess extensive river systems and estuarine areas. The prawn trawl fishery in the Gulf of Papua is in shallow

(<30m) waters and as a consequence, about 15% of the catch of finfish are small pelagics, consisting mostly of anchovies (Stolephorus spp., Thryssa spp.) and clupeoids (Sardinella spp.). The magnitudes of the mean annual catches are indicated separately in Table 5. Clearly the estuarine anchovy and sardine components far outrank those catches from the coralline environments even with a gear designed for demersal operations. Unfortunately, very little of this fish catch is destined for human consumption and most, in fact, is thrown back in the sea.

The general distribution of small pelagic fishes on both coralline and non-coralline shelf areas is shown in Fig. 2, adapted from Dalzell and Ganaden (1987). Within the coastal zone are found the big-eye scads, anchovies, clupeoids and half beaks. The exception amongst the anchovies is Stolephorus punctifer, a stenohaline species which prefers neritic and oceanic waters (Hida 1973). Dalzell (1984a) has shown that the catch per effort of S. punctifer in PNG is inversely correlated with annual rainfall (Fig. 7). The fusiliers may also be included with the small pelagics of the coastal zone since their distribution is determined largely by the extent of coral cover which is generally associated with shallow (30 m depth) coastal water. Studies of reef fish populations on the Australian Barrier Reef (Williams and Hatcher 1983) and a small island fringing reef in the Philippines (Alcala 1985) have shown that fusiliers formed the largest component of the fish biomass. Further, fusiliers form 75% of all fish captured by Muro-ami or drive-in nets on Philippine coral reefs and account for 99% of the small pelagic fishes caught by this method (Corpuz and Dalzell, unpub. data).

Further offshore are found the mackerels (Rastrelliger spp.), although according to Druzhinin (1970), there appears to be a differential distribution between R. brachysoma and R. kanagurta, the latter being more common in offshore neritic waters. Ranging between the neritic and truly oceanic areas are the roundscads (Decapterus spp.). Although these species are generally caught around shelf areas, they have been caught around fish aggregating devices in the Celebes Sea above 5,000m of water, well away from the shelf zone (K.L. Yamanaka, University of British Columbia, pers. comm) and are often caught by purse seiners in the South Pacific operating at large distances from land (Gillett 1987). Similarly, flying fishes inhabit both inshore coastal waters and the open ocean.

Biology

The identities of different small pelagic fish stocks within the South Pacific region is generally unknown. However, this has important implications for fisheries management since adjacent states and territories may be exploiting shared small pelagic resources. In neighboring Southeast Asia, there is evidence to suggest that certain small pelagic stocks may be contiguous along the coastal waters of neighboring countries. A useful summary of the present state of knowledge about Southeast Asian small pelagic stock interaction is given by FAO (1985). The data suggest, for example, that common sardine, roundscad and mackerel stocks may extend between the Philippines and the coastal waters of Borneo. Within the Philipines, Tiews et al (1970) examined the nematode infestation rates of D. russelli and D. macrosoma caught around Manila Bay and northern Palawan. The difference in infestation rates were thought to indicate some degree of stock separation.

Tagging of R. brachysoma in the Gulf of Thailand (Somjaiwong and Chullosorn 1974) and the Malacca Strait (Hongskul 1980) has shown that this species can move over considerable distances when making feeding and spawning migration. The majority of fishes, however, remained in the general vicinity of the tagging site. Similarly, tagging of R. kanagurta on the west coast of India showed that this species was capable of at least a limited migration in a northern or southern direction, parallel to the coast (Bal and Rao 1984). Hardenberg (1934) suggested that populations of Stolephorus anchovies make periodic migrations along the coast of Sumatra and the anchovies in the vicinity of the Thai and Malaysian border in the Malacca Strait are currently considered to form a transboundary shared stock (FAO 1985).

In this context, our only south Pacific example of stock identification is of interest. Daly and Richarson (1980) used electrophoretic techniques to determine the degree of separation of three stocks of S. heterolobus and S. devisi from northern PNG. These stocks were caught at three bait grounds, separated by up to 400 km. of deep open sea. Daly and Richardson concluded from their analysis that the different anchovy stocks were semi-isolated.

A summary of growth and mortality parameters for selected stocks of small pelagic fishes from the tropical Indo-Pacific region including the South Pacific is given in Table 6. Tropical small pelagic fishes can be characterized as having short life spans, (on average 1-2 years), fast growth rates and concomittant high natural mortalities. Where life spans are short, the ratio of the natural mortality (M) to the growth constant (K) is high and conventional yield-per-recruit analyses suggests it pays to fish these species hard with a small size at first capture (Murphy 1977; Gulland 1983). This assessment is based on Beverton and Holt's (1957) yield-per-recruit analysis where knife edge selection is assumed. However, Pauly and Soriano (1986) have shown that this can lead to over estimates of yield per recruit which in turn has led to the false conclusion that it is difficult to overfish these stocks.

Little is known of the relationship between the magnitude of recruitment in relation to parental stock sizes for tropical small pelagic species. Cushing (1971) has suggested that clupeoids may have stock-recruitment relationships which tend towards linearity, with little density dependence. Muller (1976), however, was able to fit a modified Ricker (1954) function that incorporated a term for rainfall to data on stock and recruitment of S. heterolobus from Palau. Similarly, Csirke (1978) showed that a Ricker function which accounted for the concentration of the stock biomass gave a good description of the stock-recruitment relationship of the Peruvian anchoveta, Engraulis ringens. A classical Ricker function was used by Hara (1977) to describe the stock-recruitment relationship of the tropical and sub tropical round herring Etrumeus teres. Dalzell (1984b) has suggested that for stolephorid anchovies and Spratelloides gracilis from PNG, the stock-recruitment relationship may tend towards linearity. However, the methodology used, based on Pauly (1982), has been criticized by Garcia (1983) for possibly generating a strong positive correlation, purely as a statistical artefact.

SEASONALITY

Small pelagic fishes are generally planktivorous feeders that are relatively low in the food chain, and hence, can reach high biomass levels, especially in areas of extensive upwelling such as eastern boundary currents, e.g., Chile-Peru, Benguela and Canary Current systems. Small pelagics also live at the boundary of the air-water interface and in the same manner as their planktonic food supply are likely to be strongly influenced by environmental conditions in comparison to demersal species (Csirke, in press). In the tropical zones, the major environmental influences are the monsoon winds which blow, according to season, from the north or south. It is not surprising, therefore, that production of small pelagics can be highly seasonal, and this has important consequences for such fisheries.

Excellent examples of small pelagic fisheries seasonality can be found in the Philippines. Fig. 3 shows the seasonal indexes of the monthly landings of roundscads (Decapterus spp.), anchovies (Stolephorus spp.), and sardines (Sardinella spp.) at Navotas fish port complex near Manila. About 35% all commercial fish in the Philippines are landed at Navotas. Fishing effort is generally constant throughout the year and the seasonal indexes, based on monthly time series of landings between 1980 and 1986 reflect the seasonality of production.

The production peak for roundscads in the Philippines occurs between March and June which corresponds to the period following the end of the northeast monsoon and the beginning of the southwest monsoon in June. Sardines have a production peak during the southwest monsoon which normally lasts between June to October. The production peak of stolephorid anchovies occurs between September to November, towards the end of the southwest monsoon and the transition to the northeast monsoon. The marked seasonality of Philippine small pelagics can have pronounced economic effects. The monthly price of roundscads is inversely correlated with the quantity landed such that the increasing scarcity of these species after May leads to a steady increase in price (Dalzell and Corpuz, unpub. data). Philippine fish canners are sometimes obliged to import sardines, usually from Japan, to compensate for the decline in landings of sardines in the Philippines after August (J. Wu, Permex Producer and Exporter Corp., pers. comm.).

Similar seasonality indexes were computed with monthly catch per effort data between 1976 and 1981 for bait catches at Ysabel Passage and Cape Lambert, two bait grounds in northern PNG (Fig. 4). There is evidence of a seasonal influence on catch rates, particularly at the Ysabel Passage where peak production occurred between June to September. A similar seasonality was reported for catches of baitfish and other small pelagics in New Caledonia with a peak between March to July (Conand 1985) and in the Fiji baitfishery, with peak catches during March-June (Lewis et al 1983). During this period of the year, the winds blow predominantly from the southeast.

Distinct seasonal trends in individual species catch-per-effort data are also apparent (Fig. 5) in PNG . Both Stolephorus heterolobus and S. devisi show clear production peaks in June-August and during October. Interestingly, these peaks are contemporary with the average peak spawning intensity of these two species (Dalzell, 1988) and peaks in zooplankton biomass (Chapau 1983). The pattern with S. gracilis is less clear with a pronounced peak in September and a possible peak during the closed season for the fishery between January and February.

PRODUCTION AND YIELDS OF SMALL PELAGICS IN THE SOUTH PACIFIC

Production trends

As with many fisheries in the South Pacific region, there is little information on catch and fishing effort for small pelagics. The most consistent sources of data concern the pole-and-line tuna fishery bait catches in PNG, the Solomon Islands, Palau and Fiji (Fig. 6). In each instance, the total annual bait catch in tonnes has been plotted against annual fishing effort. For the PNG, Fijian and Solomon Islands bait fisheries, there was little evidence of curvature in the scatters of catch versus effort. Apart from the Fijian fishery, catches of live bait from these fisheries consist primarily of stolephorid anchovies. Similar 'linear' catch-fishing effort relationships have also been found for small pelagic fisheries which catch mainly stolephorid anchovies, in parts of the Philippines (SCS 1976, 1977, 1978). Rather than fit a simple linear regression to the points, a line forced through the mean and origin was used as the most realistic interpretation of the relationship. Attempts to fit surplus production models to baitfish catch and effort data from Fiji have been made (JICA 1987) but the fit of the model was poor and the results spurious.

The lack of pronounced curvature in the catch-effort relationship for the PNG, Solomons and Fijian bait catches may be due to the dynamics of the pole-and-line fishery. These fisheries comprise essentially two fisheries, one for bait and for the target species, skipjack tuna (Katsuwonus pelamis). Since sufficient quantities of bait are essential to capture tuna, the fishermen will quickly leave a bait ground when catches decline and will try other locations for bait supply. Whilst options on other bait grounds declined gradually in PNG during the now-defunct fishery (1971-1981, 1985), there were always options for fleets operating at the two principal sites, Ysabel Passage and Cape Lambert. Similarly, both the Solomon Islands and Fijian bait fisheries contain many different sites at which to capture live bait. Thus,there are plenty of options for relocation should bait catches at a specific location decline.

Muller (1976) fitted surplus yield curves (Schaeffer 1954; Fox 1970) to catch-and-effort data from the Palau bait fishery and obtained estimates of the maximum sustainable yield (MSY) and optimal fishing effort (f_{opt}). Muller's analysis used the average monthly catch and fishing effort between February to July for the years 1965-1974. When the annual values are plotted (Fig. 6), the scatter of points still suggests a possible curvi-linear relationship but the fit of a curve is entirely dependent on the 1971 data point. Whether the decline in catch per effort at Palau during 1971 was due in fact to overfishing or some environmental parameter(s) is unknown.

Unlike the PNG, Solomon Islands and Palau bait fisheries, where catches tend to be dominated by Stolephorus spp., the Fijian bait fish catches are composed of about 7 species or species groupings including relatively high concentrations of demersal species such as the cardinal fish Rhabdamia gracilis (Lewis et al 1983b). This is a consequence of using large (>20m) bouke-ami nets which hang deep enough to catch demersal fishes. The catch per effort of baitfish in Fijian waters was much reduced during 1979 which prompted a special investigation by the South Pacific Commission (Ellway and Kearney 1979). The conclusions of the study were that there indeed appeared to have been a decline in the catch per effort of baitfish during 1979 but this figure may have been depressed further by deliberate under-reporting of the catch by the fishermen. The logic for this was to discourage competition between boats if good catches were encountered.

Dalzell (1984b), based on an analysis of catch (C) and effort (f) data from Ysabel Passage and Cape Lambert, suggested that the combined MSY of exploited stocks of S. heterolobus and S. devisi was about $0.6t/km^2$ of fishing ground. However,the generally poor fit of Schaefer and Fox type models to catch and effort data of stolephorid anchovy catches in PNG prompted the investigation of the effects of other variables on anchovy production. Dalzell (1984a) showed that rainfall significantly influenced the production of Stolephorus punctifer, S. devisi and S. heterolobus at Cape Lambert and Ysabel Passage (Fig. 7). Dalzell (1984a) proposed that catches of S. heterolobus and S. devisi could be modelled with respect to rainfall by a simple parabolic function of the form $y = a + bX + cX^2$ where $y = C/f/km^2$ and X = annual rainfall in mm. In both species, the optimum rainfall for maximum catch per effort is about 3,000 mm per year. Note that the additional points for 1985 for Ysabel Passage, which fit rather well, were added without recalculating the curves (See Fig. 7). The catch per effort of *S. gracilis* and other species in the bait catch did not appear to be influenced by rainfall.

Potential yields

The analyses of bait catches presented here are concerned mainly with *Stolephorus* spp. and *Spratelloides* spp. and only in catches from Fijian waters do these species groupings comprise less than half the catch. Of interest to the South Pacific Islands are the potential yields of these and other species such as roundscads, sardines and mackerels. Unfortunately, the data for making these assessments are presently not available for most locations. The standing stock biomass per km^2 of small pelagics has been estimated by Petit and Philippes (1983) for bays and lagoons around New Caledonia to be between 0.04 and 1.84 t/km^2 with a weighted mean of 0.465t/km^2, consisting primarily of sardines, anchovies and sprats. Estimates of mean standing stocks of small pelagics, primarily anchovies and sprats, for the Ysabel Passage and Cape Lambert baitgrounds of PNG (Dalzell 1984b, 1986) were 0.59 t/km^2 and 0.29 t/km^2, respectively (Tables 7 & 8) with a weighted mean of 0.42 t/km^2. These limited data suggest that at least around major high lands in the South Pacific the biomass densities of small pelagic fishes may be relatively similar.

A summary of the yields and maximum sustainable yields of selected small pelagic species from the South Pacific region and Southeast Asia are given in Table 9. The majority of observations are for Southeast Asia; thus, the usefulness of these data are somewhat limited. However, the data for yield of anchovies, either *Stolephorus* spp. or a mixture of stolephorids and other engraulids are remarkably similar and these figures may be useful as a first approximation of yields for South Pacific Islands where *Stolephorus* spp. exist. The estimates are expressed in terms of t/km^2 based either on the known area of fishing ground or as with Philippines on the total shelf area, since the catch data used by Dalzell and Ganaden (1987) were compiled on a national basis.

Marten and Polovina (1982) showed that there was an empirical relationship between estimated potential yield (P_y) (in t/km^2/year) for tropical pelagic fisheries and primary productivity (in gC/m^2/year). Dalzell and Pauly (1987) updated this information with respect to the Philippines and derived the empirical equation:

$$\log_{10} P_y = 0.0046 \text{ Prime Prod.} - 0.233 \quad (r = 0.661;\ n = 13;\ p<0.02;\ d.f=11)$$

All the examples used by Marten and Polovina (1982) are adjacent to major land masses or extensive large archipelagos such as Indonesia and the Philippines. The relationship may not hold throughout the smaller South Pacific islands. However, the usefulness of such approaches can be demonstrated with data from PNG which is about 40% larger than the Philippines in land area (Anon. 1980). The continental shelf area for different parts of PNG was estimated by

Dalzell and Wright (1986). Estimates of mean daily primary productivity in the waters around PNG were given by FAO (1971). For the Gulf of Papua region, this amounts to about 135 g C/m^2/year. Substituting this into the above formula gives an estimated P_y of 2.443 t/km^2/year or for a continental shelf area of 45,780 km^2 or a total yield of 111,860 t/year. For the remaining coralline areas of the country, the estimated annual primary productivity is 46g C/m^2/year which gives a predicted P_y of 0.951t/km^2 or 89,480t/year for a total remaining shelf area of 94,000 km^2. The shelf area of Torres Strait was not considered in this analysis since virtually all of it is in Australian waters. This would give a total pelagic P_y in PNG of about 201,000 tonnes/year. Assuming ecological similarity with the Philippine and the Indonesian archipelagos, then about 60-70% of this or about 130,000t would consist of small pelagic fishes (FAO 1984).

Estimates of primary productivity for South Pacific waters range from 18 to 46g C/m^2/year (FAO 1972). Assuming that the small pelagic resources are concentrated largely above the shelf and adjacent to the coast, then applying the relationship derived by Martin and Polovina (1982), the estimated potential yield of pelagic fishes is 0.71 to 0.95 t/km^2/year. The total size of the pelagic resource depends on the shelf area of the different islands. By comparison, this is about one fifth of the yield of 3 to 5 t/km^2/yr. that Munro and Williams (1985) state as a generalized figure for total neritic fish production from coralline shelf. Such approaches as outlined above have been labelled 'quick and dirty' assessments and as stated previously, the relationship between productivity and MSY may not hold for the small island land massess and shelves of the South Pacific. However, given the absence of data on fish resources in general in much of the region, we conclude that such an approach is justified, if only to obtain an impression of the scale involved.

A possible alternative, however, is the use of catch rates expressed in t/n.mi of 200m isobath. Polovina et al (1985) used this technique to make an empirical estimate of the potential yield of S. crumenophthalmus in the Mariana Islands. These authors quoted catch rates of 0.4 to 0.9 t/n.mi of 200 m contour from the Hawaiian islands and used there in conjunction with the length of the 200 m contour in the Marianas (490 n.mi) to suggest harvests of 200 to 440 t/yr for these islands.

ASSESSING SOUTH PACIFIC SMALL PELAGIC RESOURCES

It is clear from the foregoing that the major problem assessing South Pacific small pelagic resources is the general lack of data about these species. The only published regional assessment carried out with a standard gear was the bait surveys made by the SPC tuna program. Even in this instance, there are problems with the data since a slightly larger net was used on the last of the three cruises. A summary of the results is shown in Table 10, adapted from Gillet and Kearney (1983). The catch rates ranged from 33 to 291 kg/haul with a mean of 98.2 kg/haul using a bouke-ami of approximately 700m^2. These catches refer essentially to strongly phototactic species such as the clupeoids.

An analysis of catch, effort and species composition data was made for hauls at bait sites adjacent to both high islands and atoll lagoons in Micronesia (Skipjack Survey and Assessment Program, 1984). The results suggested that the catch per effort at high island sites (X = 104 kg/haul) was significantly higher than at the bait sites in atoll lagoons (X = 54 kg/haul). Further, the species composition of the bait catches from high island sites was more varied and contained species of stolephorid anchovies which are one of the most effective baitfishes. Muller (1976) has suggested that the presence of Stolephorus heterolobus at a given location is dependent on the primary productivity being greater than 2 mg $C/m^3/hr$. Other analyses by the SPC Skipjack Program in the same report indicate that there is a greater degree of variability of catch per effort at atoll bait sites than at high island bait sites. It was concluded that atolls in general offer much less potential for commercial baitfish operations than high islands and that this may also be the case for small pelagic production in total.

Unlike the bait fisheries, the small pelagic catches in the South Pacific are made by small-scale fishermen. Monitoring such fisheries, particularly where resources are limited, is difficult. By comparison, monitoring and collecting data from commercial bait catches is relatively straightforward. Further, small pelagic fisheries, apart from being multispecies fisheries with the attendant problems that this entails, are also multigear fisheries. The review of fishing methods for small pelagics in the South Pacific, given earlier, is not exhaustive, but still includes a diverse array of gears. An initial step of any assessment program should be to complete an inventory of the different gears in the region that catch small pelagic fishes.

Further, if South Pacific small pelagic resources are seriously investigated, there has to be some standardization of effort between different gears. Dalzell et al. (1987) have shown how this might be done in intensive commercial and small-scale pelagic fisheries in the Philippines. There, fishing effort was expressed as annual adjusted fleet horsepower with all fishing vessels adjusted to the equivalent in purse seine horsepower. Such an approach may not be appropriate for South Pacific small pelagic fisheries, but something analogous is necessary. Otherwise direct comparison of geographic and temporal trends will not be possible.

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Table 1. Small pelagic fish production in Southeast Asia from 1977 to 1983.

Year	Total Marine[a] Catch (tonnes)	Total Small[b,c] Pelagic Catch (tonnes)	Percentage of Marine Catch
1977	6,057,635	1,294,052	21.4
1978	6,095,462	1,321,386	21.7
1979	5,860,976	1,224,110	20.9
1980	6,007,045	1,289,910	21.5
1981	6,851,452	1,347,158	19.7
1982	6,789,834	1,368,975	20.2
1983	7,148,723	1,264,237	17.7

[a,b] Total marine and small pelagic catch obtained from FAO Yearbook of Fisheries Statistics (FAO, 1981, 1984) for HongKong, Malaysia, Singapore, Philippines, Indonesia and Thailand.

[c] Includes roundscads, big eye scads, anchovies, sardines, round herrings, mackerels and fusiliers.

Table 2. Definition of small pelagics in context of South Pacific Region

Common Name	Genus
Anchovies	*Stolephorus*[a] spp., *Thryssa* spp., *Setipinna* spp.
Sardines	*Sardinella* spp., *Amblygaster* spp.
Round herrings	*Dussumieria* spp.
Herrings	*Herklotsichthys* spp., *Pelona* spp.
Sprats	*Spratelloides* spp.
Mackerels	*Rastrelliger* spp.
Scads	*Decapterus* spp., *Selar* spp. *Selaroides* spp., *Atule* spp.
Fusiliers	*Pterocaesio* spp., *Caesio* spp. *Gymnocaesio* spp.
Flying fish	Exocoetidae
Half beaks	*Hemiramphus* spp., *Hyporhamphus* spp.

[a]Nelson (1983) has placed the smaller stolephorids such as *Stolephorus heterolobus*, *S. devisi*, *S. punctifer* and *S. purpureus* in a separate genus, *Encrasicholina*. We have maintained the previous classification to avoid confusion.

Table 3. Number of principal small pelagic bait-fishes at different locations within the South Pacific region. Source: Lewis et al. (1983)

Country/ Territory	Engraulidae	Clupeidae	Atherinidae	Carangidae	Caesionidae	Scombridae	Total	Distance from PNG (km)	Log_e N
PNG	10	15	7	7	6	4	49	0	3.9
Solomon Islands	5	9	6	6	6	3	35	1333	3.6
Vanuatu	3	6	2	4	2		17	2716	2.8
New Caledonia	5	8	4	5	6	1	29	2962	3.4
Fiji	7	10	5	5	7	3	37	3704	3.6
Tonga	2	6	2	4	0	1	15	4691	2.7
Wallis/Futuna	1	4	3	2	1	1	12	3704	2.5
W. Samoa	6	7	2	2	2	2	21	4691	3.0
A. Samoa	7	5	1	0	0	1	14	4691	2.6
Palau	5	6	3	3	3		20	2123	3.0
Yap	3	2	2	0	1		8	2123	2.1
Truk	0	4	2	1	0		7	1728	1.9
Ponape	4	5	5	4	2	1	21	1975	3.0
Kosrae	5	3	4	2	0		14	2222	2.6
Marshall Is.	0	3	2	1	0	1	7	2963	1.9
Kiribati	0	5	2	3	4	1	15	3210	2.7
Tuvalu	0	1	2	3	1		7	3605	1.9
Tokelau	1	1	1	0			1	4691	1.1
Cook Is.	0	1	3	2			6	6175	1.8
Society Is.	3	2		3			8	7160	2.1
Marquesa Is.	0	1		4			5	8296	1.6
Tuamotu Is.	0	1		2			3	7901	1.1
N.E. Qld. (Aust.)	6	5		1			12	1235	2.5

Table 4. Nominal small pelagic catches for various countries within the South Pacific Region

Country	Small pelagics (Family)	Mean annual catch (1980-1983) (tonnes)
Fiji[a]	Half-beak (Hemiramphidae)	124
"	Silversides (Atherinidae)	3
"	Jacks and Scads (Carangidae)	1325
"	Sardines (Clupeidae)	16
"	Sprats (Clupeidae)	10
"	Herrings (Clupeidae)	13
"	Anchovies (Engraulidae)	15
"	Mackerels (Scombridae)	543
Cook Is.[a]	Flying Fish (Exocoetidae)	270
"	Jacks & Scads (Carangidae)	44
Kiribati[a]	Flying fish (Exocoetidae)	32
"	Jacks & Scads (Carangidae)	555
"	Clupeoids (Clupeidae & Engraulidae)	392[b]
New Caledonia[a]	Mackerel like spp. (Scombridae) and Carangidae)	82
Papua New Guinea[c]	Anchovies (Engraulidae)	1393[d]
"	Sardines (Clupeidae)	539[e]
"	Sprats (Clupeidae)	297[f]
"	Herrings (Clupeidae)	20[f]
"	Silversides	9[f]
"	Scads (Carangidae)	6[f]
"	Mackerels	2[f]
Solomon Is.[g]	Anchovies (Engraulidae)	1254
"	Sardines (Clupeidae)	17
"	Herrings (Clupeidae)	21
"	Clupeids (Clupeidae)	28
"	Sprats (Clupeidae)	192
"	Mackerels (Scombridae)	5
"	Silversides (Atherinidae)	7
"	Fusiliers (Caesionidae)	9

[a] From FAO Yearbook of Fisheries Statistics, 1983.
[b] 1983 only.
[c] 1980 and 1981 bait catches plus average small pelagic catch for those years from Gulf of of Papua trawl fishery.
[d] 252 tonnes from live tuna bait catch, 1141 tonnes from Gulf of Papua shrimp trawl fishery.
[e] 7 tonnes from live tuna bait catch, 532 tonnes from Gulf of Papua shrimp trawl fishery.
[f] In live tuna bait catch only.
[g] 1982 and 1983 in Evans and Nichols (1985)

Table 5. Estimated anchovy and sardine catch from Gulf of Papua shrimp trawl fishery.

Year	Shrimp catch[ab] (t)	Finfish by[c] catch (t)	Anchovy[d] catch (t)	Sardine[e] catch (t)
1977	889	6,579	11	276
1978	1,694	12,536	1,354	527
1979	2,003	14,822	1,601	623
1980	2,001	14,807	1,599	622
1981	1,744	12,906	1,394	542
1982	2,603	19,262	2,080	809
1983	1,940	14,252	1,539	599

[a] From Anon. (1985)

[b] Original catch figures of tails multiplied by 1.7 to give whole shrimp weight (Anon. 1979).

[c] Average by catch ratio of finfish to shrimp of 7.4:1 computed from Anon. (1979) and Watson (1984).

[d] Percentage of anchovies and sardines in by-catch estimated as 10.8% and 4.2% respectively, from Kailola and Wilson (1978), and Watson (1984).

1

Table 6. Growth and mortality parameters for different stocks of small pelagic fish from Southeast Asian, Indian, East African and Pacific coastal waters.

Family & Species	Location	L_{∞} [a]	K [b]	Lmax (cm)	tmax (yrs)	Ø' [c]	M [d]	References
CLUPEIDAE								
Amblygaster sirm	Philippines, Palawan	27.3	0.86	25	2.96	2.81	1.66	Ingles and Pauly (1984)
" "	Java Sea	24.3	0.59	20	3.22	2.54	1.34	Burhanuddin et al. (1974)
" "	Red Sea	22.6	0.65			2.52	1.45	Rafail (1972)
" "	Mozambique	22.0	2.5		1.04	3.8	3.41	Gjosaeter et al. (1984)
" "	"	22.0	3.74		1.04	3.26	4.44	" " " "
" "	"	23.5	3.5		1.04	3.29	4.17	" " " "
" "	Indonesia	25.2	1.175				2.08	Sadhotomo and Atmadja (1985)
" "	New Caledonia	18.03	2.633	23	1.141	2.93	3.68	Conand (1984)
Sardinella melanura	Phils., Palawan	22.5	0.70	21	4.1	2.55	1.53	Ingles and Pauly (1984)
Sardinella longiceps	Phils., Manila	21.0	1.10	18	1.93	2.69	2.10	Ingles and Pauly (1984)
" "	Indonesia	23.8	0.51			2.46	1.22	Dwiponggo (1972)
" "	India	21.0	0.60	19	3.0	2.42	1.39	Antony-Raja (1972)
" "	"	20.7	0.53			2.36	1.29	Bannerji (1973)
" "	"	27.0	0.46			2.53	1.09	Nair (1960)
" "	"	20.7	.050			2.33	1.24	Hornell and Naidu (1924)
" "	India, Calicut	21.0	0.6	20.0	4	2.43	1.39	Bennet (1973)

[a,b] Parameters of the von Bertalanffy growth function (VBGF)

[c] The parameter Ø' is computed from: $Ø' = \log_{10}K + 2.\log_{10}L_{\infty}$ (Pauly and Munro, 1984) and also direct comparison of VBGF growth parameters.

[d] From Pauly's (1980) growth-temperature formulation

2

Family & Species	Location	L_{∞}	K	Lmax	tmax	ø'	M	References
Sardinella longiceps	India, Karwar	21.0	0.6	19.5	4	2.42	1.39	Annigeri (1960)
Sardinella fimbriata	Manila	18.0	0.70	17	3.15	2.36	1.63	Ingles and Pauly (1984)
" "	Palawan	22.0	1.15	19	1.88	2.75	2.13	Ingles and Pauly (1984)
" "	India	18.4	1.32			2.65	2.42	Radhakrishnan (1964)
" "	Philippines	14.0	1.60			2.50	3.00	Ronquillo (1960)
Sardinella albella	India	13.0	1.65			2.45	3.08	Bennet (1961)
" "	"	13.3	1.30			2.36	2.62	" "
" "	"	17.0	1.10			2.50	2.19	Nair (1960)
" "	Mozambique	12.4	2.16			2.52	3.64	Gjosaeter et al. (1984)
" "	"	13.8	2.03			2.59	3.39	" " " "
" "	India	13.6	1.22			2.35	2.50	Sekharan (1968)
Sardinella gibbosa	India	14.6	1.38			2.47	2.66	" "
" "	Mozambique	13.3	3.90			2.84	5.25	Gjosaeter et al. (1984)
" "	"	14.1	3.50			2.84	4.81	" " " "
Spratelloides gracilis	Papua New Guinea	7.6	4.30	7.0	0.5	2.40	11.3	Dalzell (1984b)
S. lewisi	" " "	5.5	5.37	4.9	0.4	2.21	8.9	Dalzell (1987)
" "	" " "	7.0	5.44	6.2	0.4	2.43	8.4	" "
S. delicatulus	Fiji	7.3	4.58	6.2	0.4	2.39	6.9	Dalzell et al. (in press)
Herklotsichthys quadrimaculatus	Fiji	12.6	2.00	12.2	1.6	2.50	3.53	Dalzell et al. (in press)
"	New Caledonia	12.5	3.61	15.7	0.83	2.75	5.01	Conand (1984)
"	Kiribati	13.5	1.83	10.1	0.8	2.52	3.31	Based on data in McCarthy (1985)

Family & Species	Location	L_{∞}	K	Lmax	tmax	Ø'	M	References
"	Seychelles	13.3	2.56	12.8	1.20	2.66	4.10	Moussao and Poupon (1986)
"	Hawaii	12.6	2.91	12.0	0.82	2.67	4.50	Recalculated from Williams and Clark (1983)
"	Philippines	16.2	1.50	15.5	2.00	2.60	2.79	Jabat and Dalzell (unpub. data)
Dussumieria acuta	Ragay Gulf	21.0	1.05	18	1.0	2.67	1.97	Corpuz et al. (1985)
CAESIONIDAE								
Pterocaesio pisang	Philippines	17.6	1.14	15	1.82	2.55	2.15	Cabanban (1984)
" "	"	17.5	0.97	15	2.20	2.47	2.15	" "
CARANGIDAE								
Decapterus macrosoma	Manila	31.5	0.65	28	3.63	2.81	1.33	Ingles and Pauly (1984)
" "	"	31.5	0.71	28	3.32	2.85	1.41	" " " "
" "	Palawan	27.0	0.90	25	3.10	2.82	1.72	" " " "
" "	"	26.8	0.71	25	4.04	2.71	1.47	" " " "
" "	"	26.5	1.00	25	2.5	2.85	1.85	" " " "
" "	"	27.8	0.83	25	2.5	2.81	1.61	" " " "
" "	"	33.0	0.5	31	5.92	2.74	1.10	" " " "
" "	"	27.5	1.25	21	1.3	2.88	2.12	" " " "
" "	"	25.0	1.20	20	1.5	2.88	2.12	" " " "
" "	"	25.5	0.85	22	2.2	2.74	1.68	" " " "

4

Family & Species		Location	L_{∞}	K	Lmax	tmax	Ø'	M	Referenes
"	"	Palawan	25.5	0.80	22	2.2	2.72	1.62	" " " "
"	"	"	33.0	0.65	30	3.9	2.85	1.31	" " " "
"	"	"	30.0	0.74	27	3.3	2.82	1.47	" " " "
"	"	Thailand	23.2	1.00	19.0	1.9	2.73	1.92	Anon. (1985)
<u>Decapterus</u>	<u>macrosoma</u>	Sumatra	27.7	1.20			2.96	2.05	" "
"	"	"	25.7	0.90			2.77	1.74	" "
"	"	"	24.0	1.00	20	2.0	2.76	1.90	" "
"	"	Indonesia	25.6	1.05				1.92	Sadhotomo and Atmadja (1985)
<u>Decapterus</u>	<u>russelli</u>	Manila	27.0	0.80	23	2.6	2.77	1.59	Ingles and Pauly (1984)
"	"	"	30.0	0.54	26	4.0	2.69	1.19	" " " "
"	"	"	26.9	0.69	24	3.4	2.70	1.44	" " " "
"	"	"	26.0	0.73	24	3.8	2.9	1.51	" " " "
"	"	"	33.0	0.45	28	4.54	2.69	1.03	" " " "
"	"	Mozambique	24.8	0.43	22.5	5.6	2.42	1.04	Gjosaeter and Sousa (1983)
"	"	"	24.4	0.42	22.5	5.6	2.42	1.04	" " "
"	"	"	26.0	0.46	22.5	5.3	2.49	1.08	" " " "
"	"	"	24.8	0.56	22.5	4.3	2.54	1.24	" " " "
"	"	Thailand	23.5	0.89	21.0	2.5	2.69	1.78	Anon. (1985)
"	"	Sumatra	26.0	0.80	23.0	2.9	2.73	1.60	" "
"	"	India	26.0	0.743	21.0	2.4	2.70	1.51	Sreenivasan (1982)
<u>D.</u>	<u>macrosoma</u>	Samar Sea	23.0	1.25	22.0		2.82	2.19	Corpuz et al. (1985)
"	"	Ragay Gulf	25.5	1.26	23.0		2.91	2.12	" " " "
<u>D.</u>	<u>mruadsi</u>	Burias Dam	27.70	0.82	22.0		2.63	1.67	" " " "
"	"	Samar Sea	23.55	0.81	23.0		2.65	1.64	" " " "

5

Family & Species	Location	L_{∞}	K	Lmax	tmax	Ø'	M	References
" "	Ragay Gulf	23.50	0.52	22.0		2.46	1.22	" " " "
Selar crumenopthalmus	Manila	36.5	0.89	34	32.	3.07	1.57	Ingles and Pauly (1984)
" "	Kavieng	24.5	1.1	21.5	2.1	2.82	2.07	Wright and Dalzell (unpub. data)
" "	Indonesia	26.9	1.35	25	2.1	2.73	2.24	Sadhotomo and Atmadja (1985)
ENGRAULIDAE								
Stolephorus punctifer	Manila	10.1	1.10	9.0	2.2	2.05	2.55	Ingles and Pauly (1984)
" "	"	10.6	1.85	9.2	1.2	2.32	3.53	" " " "
Stolephorus punctifer	Manila	1.15	8.0	2.0	1.99	2.69	" "	" "
Stolephorus devisi	Indonesia	7.6	1.8	7.2	1.6	2.02	3.84	Burhanuddin et al.(1975)
" "	Papua New Guinea	7.4	2.1	7.2	1.7	2.06	4.42	Dalzell (1984b)
" "	" " "	7.5	2.4	7.2	1.3	1.86	4.80	" "
" "	" " "	7.8	2.0	7.2	1.3	2.09	4.21	" "
Stolephorus indicus	Manila Bay	16.3	1.42	15	1.8	2.58	2.67	Ingles and Pauly (1984)
" "	Singapore	19.0	0.71	15	2.5	2.41	1.62	Tham (1967)
Stolephorus heterolobus	Manila Bay	12.1	1.60	11.0	1.6	2.37	3.10	Ingles and Pauly (1984)
"	" "	11.4	0.95	11.0	2.4	2.09	2.29	" " " "
"	Singapore	8.9	2.10	7.3	0.9	2.22	4.07	Tham (1967)
"	Palau	9.1	2.10	9.0	2.2	2.24	4.04	Muller (1976)
"	Indonesia	7.6	2.10	6.8	1.2	2.08	4.25	Burhanuddin et al. (1975)
"	Papua New Guinea	7.9	2.60	7.2	1.0	2.21	4.99	Dalzell (1984a)
"	" " "	8.7	2.40	8.2	1.2	2.26	4.61	" "
S. commersoni	Manila	11.3	0.96	10.0	2.3	2.09	2.28	Ingles and Pauly (1984)

6

Family & Species	Location	L_∞	K	Lmax	tmax	Ø'	M	References
S. bataviensis	Singapore	9.9	2.1	9.0	1.2	2.31	3.95	Tham (1967)
" "	Jakarta	7.8	1.6	7.3	1.9	1.9	3.53	Burhanuddin et al. (1975)
" "	Papua New Guinea	10.9	1.7	9.9	1.5	2.31	3.35	Dalzell (unpub. data)
SCOMBRIDAE								
Rastrelliger								
brachysoma	Gulf of Thailand	20.0	3.53	23.0	1.1	3.15	4.56	Sucondharman et al (1970)
"	" " "	19.6	4.14	21.0	0.9	3.20	5.09	" " " "
"	Borneo	22.9	2.28	22.0	1.4	3.08	3.30	Sudjastani (1974)
"	Gulf of Thailand	20.9	3.38			3.17	4.38	Hongskul (1972)
"	" " "	20.9	4.20			3.26	5.05	Somjaiwong et al. (1970)
"	" " "	23.0	3.60	22.0	0.9	3.28	4.44	Kurogane et al. (1970)
"	" " "	18.2	1.56			2.71	2.74	Somjaiwong et al. (1970)
"	Samar Sea	24.5	1.28	22.0	1.7	2.89	2.17	Corpuz et al. (1985)
"	" "	25.0	1.30	23.0	2.1	2.91	2.32	" " " "
"	" "	25.5	1.45	23.0	1.7	2.97	2.19	" " " "
"	Manila	34.0	1.10	30.0	2.1	3.10	1.84	Ingles and Pauly (1984)
"	Samar Sea	25.0	1.60	22.0	1.4	3.00	2.56	" " " "
"	West Thailand	26.3	1.30	20.5	1.3	2.95	2.20	Anon. (1985)
"	" "	22.4	2.00	17.5	0.8	3.00	3.05	" "
"	" "	24.5	1.40	17.5	1.0	2.92	2.35	" "
"	Malaysia	23.5	1.5	22.0	2.0	2.92	2.49	" "
"	Sumatra	26.5	1.05	22.0	1.8	2.87	1.91	" "
Rastrelliger								
kanagurta	India, Cochin	21.8	5.16	22.0	1.0	3.39	5.63	George and Banerji (1964)

7

Family & Species	Location	L_{oo}	K	Lmax	tmax	ø'	M	References
Rastrelliger								
kanagurta	India, Calicut	23.3	3.12	22.0	1.0	3.23	3.98	George and Banerji (1964)
"	India, Karwar	22.4	4.32	22.0	1.0	3.20	4.97	" " " "
	Java Sea	23.9	2.76	23.5	1.6	3.20	3.64	Sudjastani (1974)
"	India	23.9	4.92	22.0	0.7	3.45	5.32	Banerji (193)
"	Egypt, Red Sea	42.0	0.288			2.71	0.72	Rafail (1972)
"	India	31.3	0.64	29.0	4.1	2.80	1.29	Pauly (1978)
"	India	31.6	0.60	29.0	4.2	2.78	1.24	Seshappa (1958)
"	Mozambique	27.8	0.753	25.0	3.2	2.76	1.46	Sousa and Gislason (1985)
"	India	39.0	0.74	33.5	2.8	3.05	1.34	Luther (1973)
"	"	26.6	0.83	26.2	5.2	2.77	1.61	Udupa et al. (1984)
"	"	30.5	0.8	29.0	4.0	2.87	1.51	Pauly (1978)
"	Samar Sea	27.5	1.30	25.0	2.0	2.99	2.11	Corpuz et al. (1985)
"	" "	28.0	1.31	26.0	2.0	3.01	2.13	" " ". "
"	Palawan	28.0	1.55	25.0	1.5	3.08	2.43	Ingles and Pauly (1984)
"	W. Thailand	26.0	1.90	23.0	1.2	3.11	2.83	Anon. (1985)
"	" "	26.3	1.50	21.0	1.2	3.02	2.41	" "
"	" "	25.0	1.60	210	1.2	3.00	2.55	" "
"	Malaysia	27.0	0.70	26.0	4.9	2.71	2.75	" "
"	Sumatra	29.5	0.60	26.0	3.8	2.72	1.28	" "
"	"	26.5	0.80	26.0	5.1	2.75	1.60	" "
"	Indonesia	25.7	1.625				2.56	Sadhotomo and Atmatja (1985)
ATHERINIDAE								
Atherinomorus								
lacunosus	New Caledonia	11.4	2.53	14	1.2	2.52	4.07	Conand (1984)

Table 7. Annual standing stock biomass estimates (in tonnes) for exploited baitfish stocks at Cape Lambert, Papua New Guinea. Source: Dalzell (1984b)

Year	*S. heterolobus*	*S. devisi*	Others[a]
1972	61.1	37.2	23.2
1973	67.7	32.9	53.3
1981	28.7	16.7	33.4
$\bar{X}$	52.5	28.9	36.6

[a] Other species standing stock estimated using mean F values for three bait species. 89% of other species composed of Caesionidae (65.2%), Clupeidae (13.6%) and Scombridae (10.2%) (Anon. 1984).

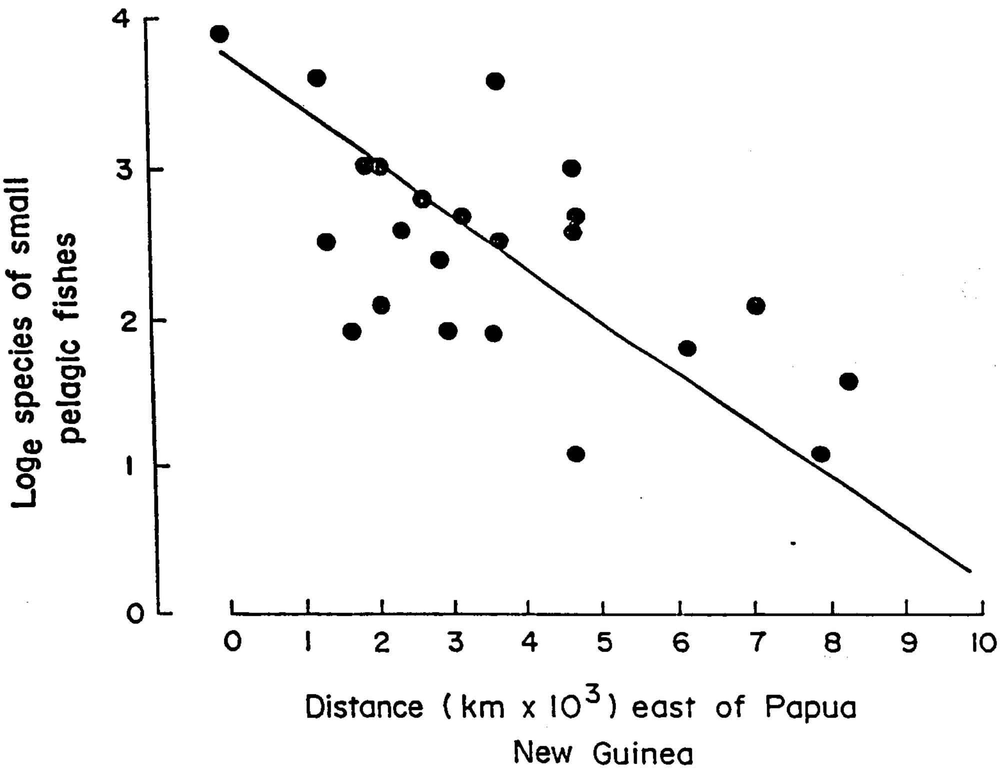

Fig. 1 Logarithm of number of small pelagic bait-fish species versus distance east of Papua New Guinea for different localities in the South Pacific region (source: Lewis et al. 1985). Equation of line:

$$y = 3.78 - 3.53 \cdot 10^{-4} X, \quad r = 0.61$$

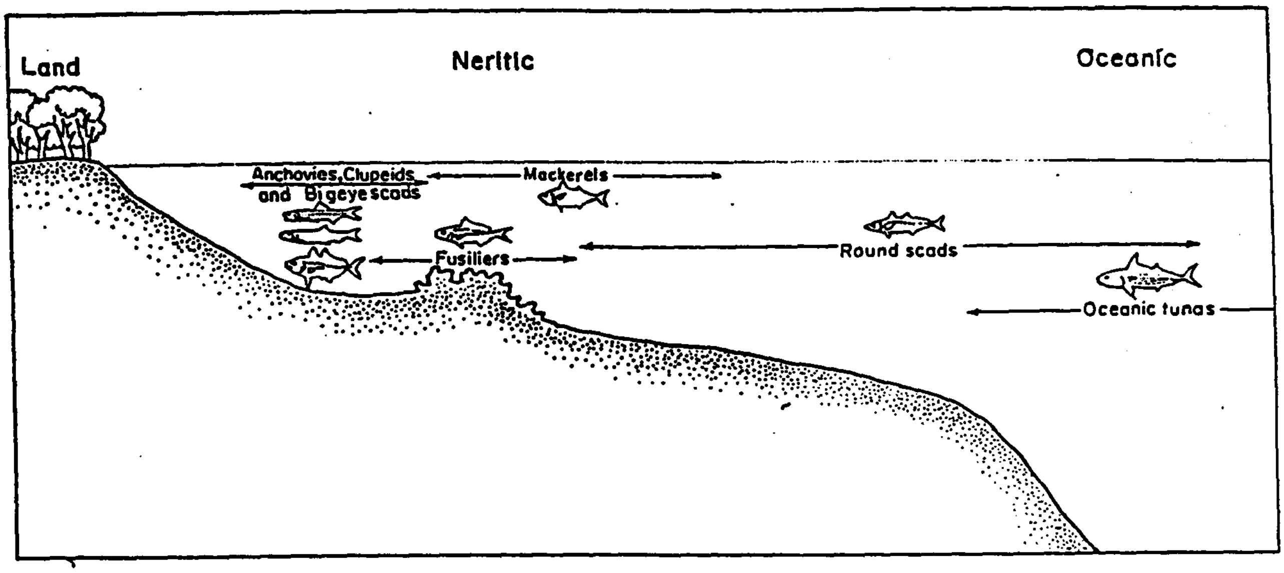

Fig. 2 Schematic representation of the distribution of principal small pelagic species groups with respect to inshore, neritic and oceanic zones.

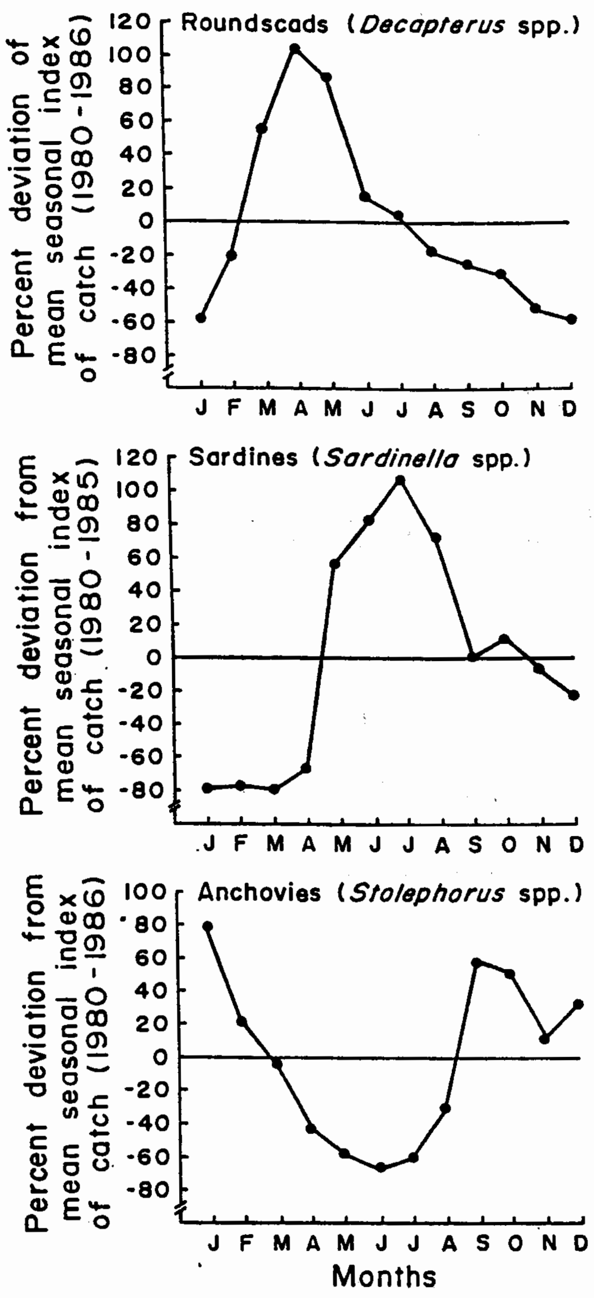

Fig. 3 Seasonality of Philippine stocks of roundscads, sardines and anchovies.

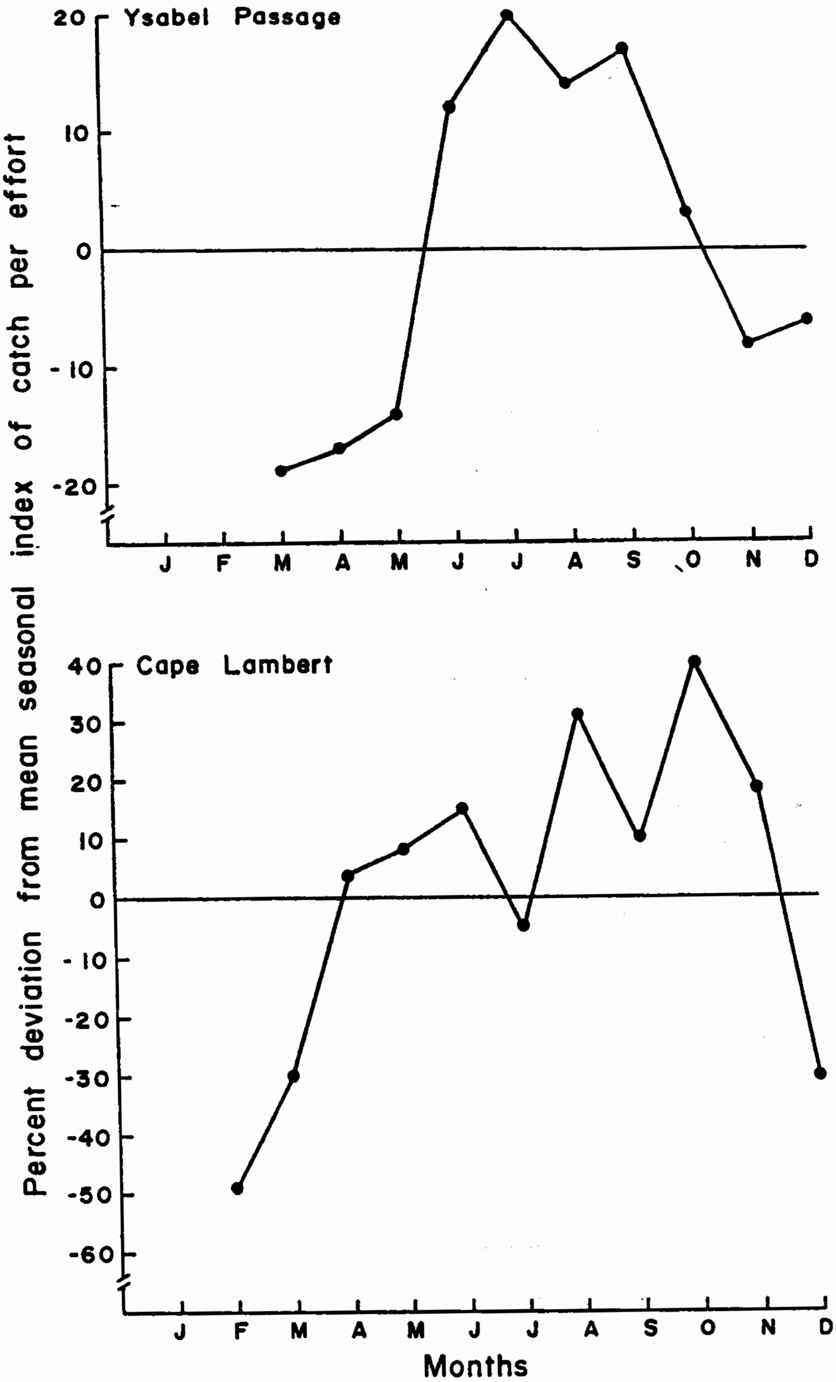

Fig. 4 Seasonality of baitfish catches at Ysabel Passage and Cape Lambert, Papua New Guinea.

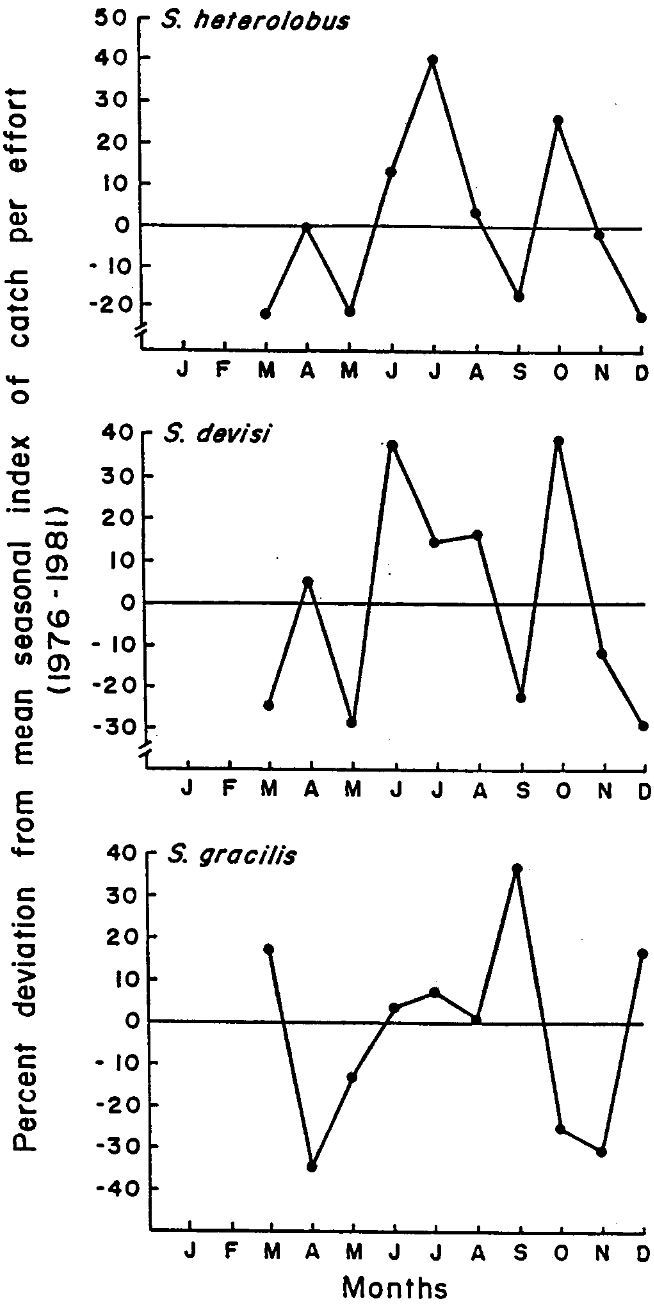

Fig. 5 Seasonality of catches of <u>Stolephorus heterolobus</u>, <u>S</u>. <u>devisi</u> and <u>S</u>. <u>gracilis</u> at the Ysabel Passage, Papua new Guinea.

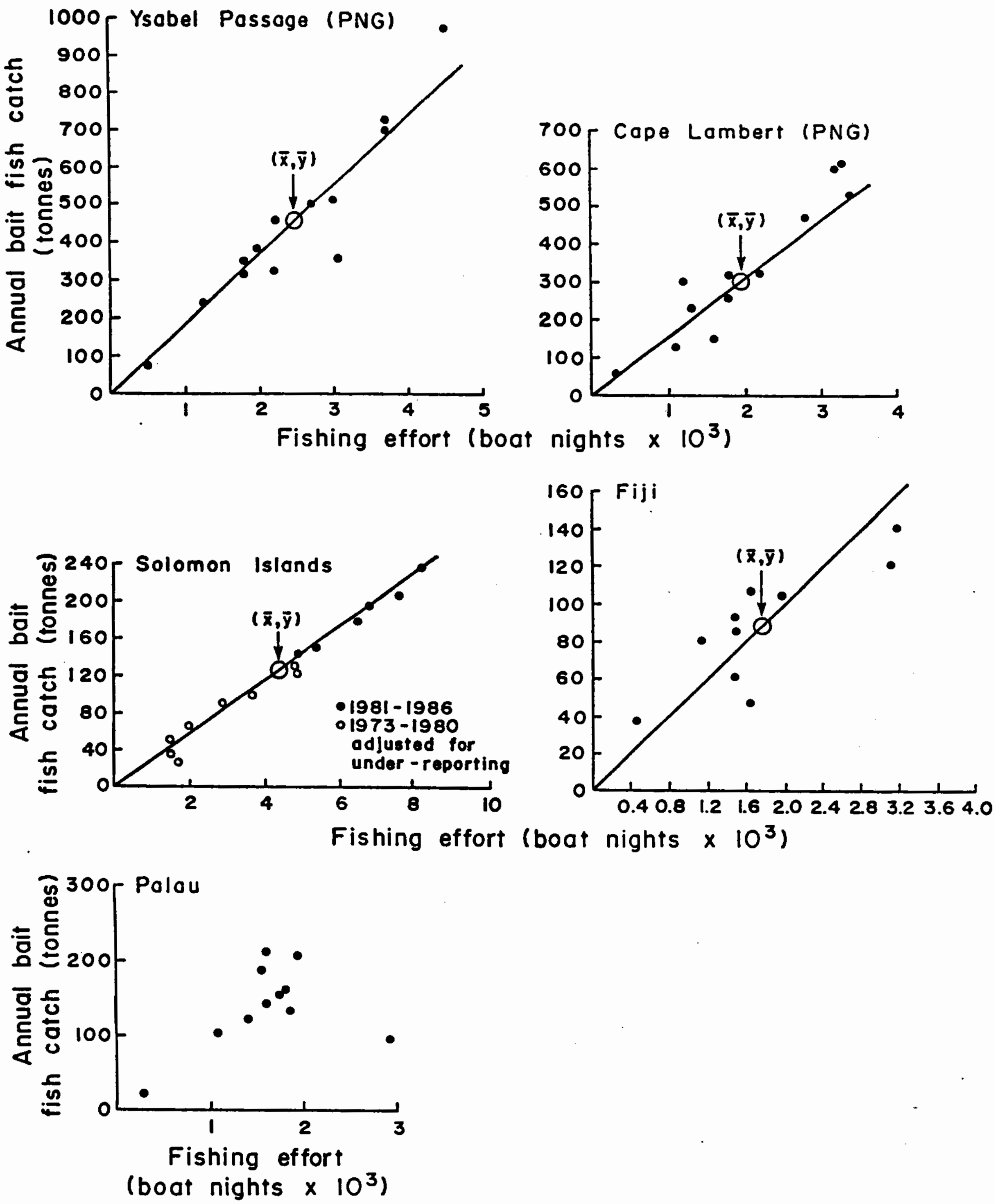

Fig. 6 Catch versus fishing effort for five South Pacific island bait-fisheries.

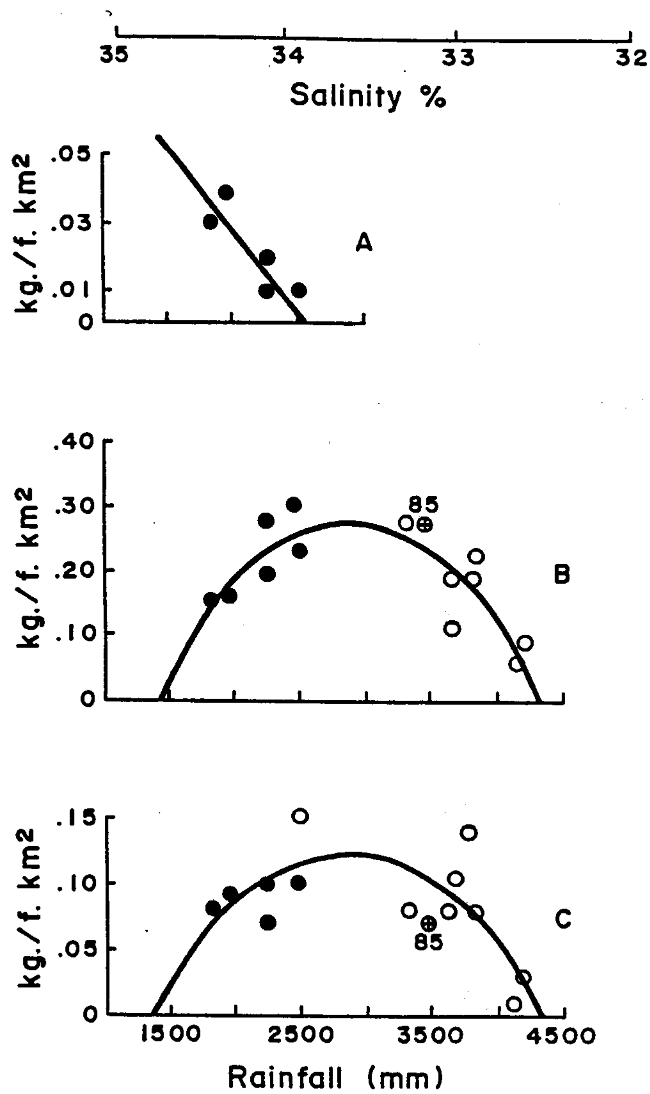

Fig. 7 A. Mean annual yield of S. punctifer versus annual rainfall at Cape Lambert. Equation for the line :

$$y = 0.1358 - 5.4\ .10^{-5}X,\ r^2 = 0.74.$$

B. Mean annual yield of S. heterolobus versus annual rainfall for combined data from Ysabel Passage (o) and Cape Lambert (•). Equation of the curve:

$$y = -0.752 + 0.689.10^{-3}X - 1.241.10^{-7}X^2,\ R^2 = 0.79.$$

C. Mean annual yield of S. devisi versus annual rainfall for combined data from Ysabel Passage (o) and Cape Lambert (•). Equation for the curve:

$$y = -0.311 + 3.032X - 5.201.10^{-8}X^2,\ R^2 = 0.513.$$

Table 8. Annual standing stock biomass estimates (in tonnes) for exploited baitfish stocks at Ysabel Passage, Papua New Guinea. Source: Dalzell (1984b)

Year	*S. heterolobus*	*S. devisi*	*S. gracilis*	Others[a]
1972	81.1	34.8	151.7	10.2
1973	48.5	28.8	128.0	6.2
1976	31.4	22.6	10.4	8.5
1977	31.3	28.5	197.6	22.3
1978	68.5	35.2	83.4	12.5
1979	50.5	105.6	39.3	25.9
1980	8.8	4.0	132.0	32.2
1981	15.0	28.3	82.5	42.3
1985	64.7	38.9	33.8	47.1
$\overline{X}$	44.4	36.3	95.4	23.0

[a]Other species standing stock estimated using mean F values for three bait species. 86% of other species composed of Clupeidae (41.8%), Apogonidae (15.5%), Caesionidae (13.7%), Atherinidae (8.9%), Carangidae (6.4%) (Anon 1984).

Table 9. **Estimates of actual yield and maximum sustainable yield for small pelagic fishes in the South Pacific region and Southeast Asia.**

Species or species grouping	Location	Average yield ($t/km^2/year$)	MSY ($t/km^2/year$)	Source of MSY
S. heterolobus and S. devisi	Northern Papua New Guinea	0.41	0.6	Dalzell (1984b)
S. heterolobus	Palau	0.47	0.5	Muller (1976)
Stolephorus spp.	Philippines	0.34	0.37	Dalzell and Ganaden (1987) Dalzell (unpub. data)
Stolephorus spp.	Thailand	0.43	–	From Chullasorn and Shindo (1983)
Anchovies, Setipinna spp. Stolephorus spp. Thryssa spp.	Gulf of Papua Papua New Guinea Papua New Guinea	0.43	–	Based on Dalzell (1986) and Watson (1984)
Rastrelliger spp.	Philippines	0.24	0.29	Dalzell and Ganaden (1987)
Rastrelliger spp.	Gulf of Thailand	0.76		Dalzell (unpub. data)
Decapterus spp.	Philippines	0.72	0.82	Dalzell and Ganaden (1987) Dalzell (unpub. data)
Decapterus spp.	Gulf of Thailand	0.47	–	Based on data in Chullasorn and Shindo (1983)
Decapterus spp.	W. Coast of Thailand	0.21	0.21	Anon. (1986)
Sardinella spp.	Philippines	0.55	0.60	Dalzell and Ganaden (1987)
Sardinella spp.	Gulf of Thailand	0.96	–	Based on data in Chullasorn and Shindo (1983)
Sardinella spp.	Gulf of Papua	0.17	–	Based on Dalzell (1986), Watson (19
Selar spp.	Philippines	0.18	0.16–0.23	Dalzell and Ganaden (1987) Dalzell (unpub. data)

Table 10. Catch and fishing effort at different locations in the South Pacific by the Skipjack Survey and Assessment Programme. Source: Gillet and Kearney (1983)

Location	No. of hauls	Catch (kg)	Average catch/ haul(kg)
Papua New Guinea	57	6,840	120
Solomon Islands	60	8,695	148
New Caledonia	40	5,207	130
Fiji	71	12,821	180
Vanuatu	5	177	35
W. Samoa	14	1,130	80
Society Is.	27	893	33
Marquesas Is.	44	5,601	127
Tuamotu Is.	27	1,196	44
Kiribati	21	1,198	57
Tonga	32	1,097	34
Palau	34	3,310	97
Ponape	36	5,056	140
Cook Is.	15	585	39
A. Samoa	5	180	36
Marshall Is.	8	609	76
Yap Is.	2	258	129
Wallis and Futuna	36	10,501	291
Truk Is.	8	690	86
Kosrae Is.	10	807	80
Tuvalu	15	1,508	100
$\bar{X}$			98.2