19

Final results: Had the programme achieved its objectives?

The fieldwork for the Skipjack Programme had begun on October 6, 1977, when the *Hatsutori Maru No. 1* departed Kavieng Harbour in New Ireland, Papua New Guinea. It concluded on August 22, 1980, when the *Hatsutori Maru No. 5* departed the Federated States of Micronesia bound for its home port in Japan. In the intervening three years, Skipjack Programme staff tagged 140,443 skipjack and 9,596 yellowfin tuna and captured 71,986 kilograms of baitfish in 26 countries and territories throughout the central and western Pacific. Full details of all baitfish and skipjack sampling and analyses are given in the many Skipjack Programme publications and reports, including a preliminary and a final country report for every country and territory and one for the region as a whole.

The fisheries officers of the island countries and territories reported that they found the individual country reports, both preliminary and final, of great value. The fact that these reports were produced quickly after the visit of the research vessel to each country or territory was greatly appreciated, thus playing an important role in the popularity of the programme and the excellent cooperation we received from all the region's fisheries officers. This cooperation was pivotal to the encouragement for the return of tags with the necessary information on the time and location of recapture of tagged fish. Return of tags with accurate information was the foundation of the scientific data that underpinned the analyses that fulfilled one of the

programme's primary purposes, which was to provide the first assessment of the total skipjack and baitfish resources for all countries and territories in the 30 million square kilometres of the area of the SPC.

One of the many reports, 'Assessment of the Skipjack and Baitfish Resources in the Central and Western Tropical Pacific Ocean' (Kearney 1983), provides a succinct precis of the performance of the programme against the three primary objectives set for it in the original program proposal (SPC 1975) and modified and expanded later that same year (Kearney 1975c).

The following comments on the achievements of the Skipjack Programme against its three specified objectives are modified from those provided in the official concluding summary of the programme.

The three defined objectives of the programme are considered in turn throughout this chapter.

A. To provide a better understanding of the migrations and stock structure of skipjack, thus determining the degree to which fisheries in different areas exploit the same stock, and hence interact with each other.

Tag recapture results provided the only comprehensive assessment of skipjack movements, including migrations, within the whole of the study area up to the time of completion of the Programme in September 1981.

There was clearly a great deal of movement of skipjack that were tagged in all parts of the study area (Figure 9). An outstanding feature of this movement was that it was obviously far more random in direction than would be consistent with the species being truly migratory. In tropical regions, there was little evidence of predetermined routes that all, or even the majority of, individuals in an area observed. At the southern extreme of the study area, around Aotearoa New Zealand, skipjack were seasonally clearly migratory: they arrived in late spring, and at the onset of winter, they moved north to warmer water rather quickly. Clearly true migration.

Blood genetics and parasite analyses confirmed the existence of structuring within the total population of skipjack. As recommended in 1976 by the 'Ad Hoc Meeting of Scientists to Discuss Skipjack Fisheries Developments and Research Requirements', during the Skipjack Programme, large numbers of blood samples were taken from skipjack from the same schools from which large numbers (more than 100) of skipjack were tagged

and released. This enabled investigation of the suggestion by Dr Barry Richardson (The Australian National University scientist contracted to do the genetic analyses of the samples collected by the programme) that esterase gene frequencies in an area and time may make it possible to predict the direction in which skipjack tagged in those areas and times would move after release. Dr Richardson's suggestion was exciting; it seemed a most likely hypothesis, at least before the Skipjack Programme's tag recapture information became available.

As had been found by Fujino (1976) and Sharp (1978), there was a definite gradient in serum esterase gene frequency of Pacific skipjack, with much higher frequencies in the west of our survey area and lower in the east. The lower frequencies at around 140 degrees west were very similar to those much further to the east. However, the movements of tagged skipjack recorded by the Skipjack Programme did not support Dr Richardson's hypothesis. Nor did they support the existence of discreet subpopulations of skipjack that were sufficiently different to warrant consideration for separate management, as had originally been suggested independently by both Fujino and Sharp.

The observations of the behaviour of skipjack within schools (see Chapter 18) and the estimate of school integrity have, for years, impacted my thinking on the very first objective of the Skipjack Programme: 'To provide a better understanding of the migrations and stock structure of skipjack'. The patterns of movements of individual tagged skipjack described a great deal of long-distance movement and a huge amount of variability in the directions of that movement. The lack of significant and consistent deviation from random directions, except for the obvious seasonal migration to and from New Zealand, was largely responsible for the conclusion that the skipjack resources of the central and western Pacific could best be managed as a single stock. The implications for management of constant change in the integrity of individual schools, other than attempting to be with other individuals of the same size, and the apparent approximation of 'Brownian' (random direction) movement in the actions that support that change, remain a mystery, at least to me. And I have thought about it a lot in the past 44 years.

That skipjack would constantly restructure school integrity so that individual fish could be with others of the same size has obvious advantages. The hydrodynamic advantages for fast swimmers, runners or cyclists to be with individuals of the same size and headed in the same direction (what bike

riders call the 'Peloton effect') are well accepted and documented. But why do so by relatively random movement in and out of schools while ensuring at the same time the school remains, at least approximately, the same size? Is it possible that the small pods of skipjack observed leaving much bigger schools were adopting the role of scouts looking for patches of prey?

It would be reasonable to expect that there would be different areas that would be more attractive to skipjack of certain sizes and that individual fish would head for these, or at least not leave them so readily once they encountered them. If being with individuals of the same size in schools of predetermined size (for example, from 45 to 35 tonnes) is so important, why don't individual schools of approximately 40 tonnes coalesce and then, allowing for time to 'socialise', split into two 40-tonne schools of more precise median sizes? Such a strategy would appear to have advantages over small pods of fish for the 'safety in numbers' component of school structuring.

The enormity of, and lack of structure in, their environment, coupled with the extensive, apparently unstructured, movement of individual skipjack throughout the study area, are obvious factors that tend to support the probability that the total skipjack population is structureless, at least from the perspective of its management. The existence of significant and consistent variation in esterase gene frequency across the whole study area, however, confirms some structuring – the goal, outcome or cause of which has not yet been explained.

Considerable variation in growth rates of skipjack was confirmed in different parts of the study area and in the same parts of the area at different times. Such variation had been regarded by earlier researchers as another possible indicator of stock structure. The large numbers of tag releases and recoveries over the whole study area made it possible to investigate this hypothesis in considerable detail. It was concluded that the observed variability in growth was more likely to be due to environmental variability than stock differences. Sibert, Kearney and Lawson (1983) provide a succinct summary of Skipjack Programme results relevant to this variability as follows:

> Results presented here show that there are significant geographical differences in both growth increment and von Bertalanffy parameter estimates. These differences are not stable, however. Repeated visits to the same region yielded significantly different estimates of growth increments. These results provided further confidence in the conclusion that from a fisheries management perspective the skipjack within the area of the SPC could best be managed as a single stock.

Skipjack growth is considered in more detail under point C (presented later in this chapter).

The degree of interaction between coastal fisheries that existed at the time of the programme's fieldwork (from 1977 to 1980) was able to be evaluated in more detail and with more certainty than was thought possible at the commencement of the programme. The results are detailed in the final country reports. This superior outcome was facilitated by several unanticipated outputs and outcomes from the research:

1. The larger-than-anticipated number of tagged fish released and recaptured with usable information on each
2. The tremendous dispersal and mixing of tagged skipjack throughout the study area and beyond
3. The approximation of Brownian movement from all releases except those in the higher latitudes, which displayed seasonal migration to warmer waters (discussed briefly earlier).

The continuing accumulation of more detailed catch and effort data on all fisheries in the region since the conclusion of the fieldwork has enabled increasing confidence to be placed in assessments of interactions between fisheries.

B. To provide valuable survey information on the distribution and availability of skipjack and baitfish as a basis for further development and management of these resources within the region. Detailed survey data on skipjack were gathered in a variety of complementary forms. Clearly, the tag release and recapture data provided the most definitive descriptor of numerous measures of skipjack abundance and distribution, which are the most common goals for, and outputs from, quality fishery surveys (see point C). In addition, of the 21,583 skipjack that were caught from the same schools from which skipjack were tagged but were not tagged and released and instead were subjected to at least some biological sampling, 10,926 had their sex determined and 9,574 were examined for the presence of juvenile skipjack in their stomachs.

Other indicators of skipjack distribution and availability, such as school sightings by area and time, provided valuable confirmation of the remarkable uniformity in the degree of variability in the distribution, abundance and relative homogeneity of the total population of skipjack throughout the study area (see point C).

Survey and assessment of the baitfish resources suitable for pole and line fishing for skipjack and other tunas in the waters of all countries and territories in the SPC were one of the primary objectives of the Skipjack Survey and Assessment Programme. At the time of conception of the programme, pole and line fishing was the technique that offered the greatest potential for island states to participate in and benefit from. An adequate supply of suitable bait fish, usually as live bait, is a prerequisite for the operation of a viable pole and line fishery.

The size, origin and topography of islands were, as expected, excellent indicators of baitfish resources. Islands with large water catchment areas and high freshwater run-off bringing nutrients and sediments into extensive lagoons and/or sheltered inshore environments provide habitats suitable for many bait species. In general, countries with large land masses, such as Papua New Guinea, the Solomon Islands, New Caledonia and Fiji, have the greatest baitfish resources.

The great diversity in the topography of the many countries and territories is reflected in the capture of 286 bait species during the three years of the programme. Most of the sizable catches of good-quality baitfish were from four families: Engraulidae (anchovies), Dussumieriidae (sprats), Clupeidae (sardines and herrings) and Atherinidae (hardyheads).

A comparison of the cost-effectiveness of natural bait species and those available from aquaculture was carried out and published by the programme (Kearney and Rivkin 1981). Due to the great variation in fishing conditions, by area and time, little confidence could be placed in many of the comparisons. However, even the least effective bait species could at times support reasonable catches of skipjack. At other times, such bait could be ineffective. Much depends on what other food is present at the time. Whether aqua-cultured species can provoke viable catches over time was considered doubtful. It was concluded that within the commission area, the prospects for the cost-effective replacement, or even meaningful supplementation of natural bait by aquaculture, were limited.

C. To provide better knowledge of the population parameters (growth, mortality, etc.) of each skipjack stock, thus enabling better assessment of the current status of these stocks and of the effects of fishing on them.

This objective covers the components that necessitated the most in-depth analyses and interpretation of the bulk of the data generated by the programme and/or available in the scientific literature. Most staff were involved in the data collection, compilation and presentation in tabular or graphical formats, and as the programme progressed, most were increasingly involved in the writing and production of the many reports, such as the individual preliminary and final country reports, as well as the technical reports. These reports were the main medium for the delivery of information to the region's fisheries officers, donor governments and the public. Two of the technical reports, numbers 10 and 11 in the Tuna and Billfish Programme series, deal specifically with the first item in point C of the Skipjack Programme objectives – skipjack growth.

Information on skipjack length at time of tagging and length at subsequent recovery, together with the time at liberty for individual fish, was used to compute skipjack growth in the waters of all countries and territories for which adequate data were available.

Detailed analyses of the data from each country, or for each visit to a country for which there was more than one visit, clearly showed that the data for each visit warranted unique analyses, as did whether or not the data came from recaptures inside or outside the waters of the country in which the tagged fish were released. Differences in the size of the growth increments were found to occur as a result of variations in growth between countries, or areas of release, time of release and location of recapture (Sibert, Kearney and Lawson 1983). The variations in growth between countries and between different times in the same country (Table 19.1) were much greater than expected. They strongly suggest that skipjack growth is greatly influenced by changes in oceanographic conditions that are not obvious and are certainly not well understood.

Skipjack are known to grow a great deal bigger in the eastern Pacific than in the west. Joseph and Calkins (1969) reviewed skipjack growth data for the eastern Pacific and found growth estimates ranging from 11.16 centimetres per year to 21.84 centimetres per year, and maximum lengths (L infinity) from 729 to 881 millimetres (some fish were well over 20 kilograms). Skipjack in the Papua New Guinea fishery have a growth increment of 7 centimetres per annum and an L infinity of 65 centimetres (with a maximum weight of 6 to 7 kilograms, with fish of more than 6 kilograms being uncommon).

Table 19.1: Growth increments standardised to an average length at release of 50 centimetres and average time at liberty of 90 days

Country	Year of tagging	Increment (cm)
Fiji	1978	3.7 (± 6.9)
	1980	5.6 (± 1.3)
Kiribati	1978	1.4 (± 1.2)
Palau	1980	8.5 (± 6.4)
Papua New Guinea	1972–74	2.6 (± 1.5)
	1979	3.2 (± 1.5)
Ponape	1980	4.1 (± 4.1)
Solomon Islands	1977	2.5 (± 1.4)
New Zealand	1979	1.5 (± 5.2)

Source: Kearney (1983)

From the distribution of juvenile skipjack throughout the Pacific, Klawe (1963) concluded that there is very little spawning activity in the eastern Pacific. This lack of spawning is thought to allow eastern Pacific skipjack to invest more metabolic resources into growth, thus enabling them to grow much faster and bigger. Skipjack that do spawn produce phenomenal numbers of propagules and expend tremendous amounts of energy in the process.

There was concern among Skipjack Programme staff that bias in the measurement of tagged skipjack at the time of release and recapture may be a cause of the significant variation in growth apparent from the tag release and recapture data in the same areas at different times. However, bias in the length measurement at the time of release of tagged fish was found (from detailed analyses of recorded measurements at the time of release) to not be significant. Recapture length measurement bias was, however, found to be significant for all recapture categories other than those from skipjack recaptured on the Skipjack Programme research vessel. In all cases of significant bias, the effect was to reduce the apparent increase in length. This was somewhat surprising considering that a popular assumption is that fishermen tend to exaggerate the size of the fish they catch, which, if recorded, would increase the estimate of the growth increment, not reduce it.

Responsibility for the creative and scholarly development of the analytical models that delivered 'better assessment of the current status of these [skipjack] stocks and of the effects of fishing on them' (from point C), the

core of what the Skipjack Programme was about, very much rested with Pierre Kleiber and Sandy Argue. Throughout the programme, occasional appointments of experts, such as Sam Bledsoe and Dave Fournier, for a few months for analytical tasks proved very valuable. Towards the end of the programme, in 1982, John Sibert was recruited as a senior analyst. He made a significant contribution to several components of the overall assessment. After the conclusion of the Skipjack Programme, staff of the Tuna and Billfish Assessment Program (TBAP), and subsequent staff appointments to the SPC's ongoing Oceanic Fisheries Programme, continued the collection and analysis of skipjack data, including the reanalysis of the original Skipjack Programme data. It is most significant that when the tagging experiment of the Skipjack Programme was repeated a decade later, it produced the same estimate of population size: 3 million tonnes. That an experiment can be repeated to yield the same result is the fundamental criterion for confirmation of the quality of the science that underpinned the experiment.

Skipjack Programme staff, under the scientific direction of Pierre Kleiber and Sandy Argue, had to first develop the data capture and processing methods that ensured that the information generated by the programme, including the catch and effort data from all skipjack fisheries in the study area, was both precise and in formats that would adequately facilitate all the necessary analyses. This was a monumental task involving a great deal of originality: tagging had not previously been used to estimate the population size and dynamics of any skipjack stock anywhere in the world, let alone one as large and widespread as the one the Skipjack Programme was created to assess.

The necessary analytical models had to first be developed before being skilfully applied to the massive collection of data that was progressively becoming available.

Following the conclusion of the fieldwork and one extra year of analysis of results, at the Thirteenth Regional Technical Meeting on Fisheries in Noumea in August 1981, the concluding results of the programme were publicly presented. Pierre Kleiber gave an excellent presentation of the results of the complex analyses (see Kleiber, Argue and Kearney [1987] for full details) in language that could be understood by the general audience. This audience was the largest that had attended any SPC conference other than the annual South Pacific conferences. It included the fisheries officers of almost all countries and territories of the SPC, numerous international tuna fishermen and cannery representatives, a reasonable number of interested

scientists, and quite a few representatives of 'Conservation' nongovernmental organisations (NGOs) – plus, of course, representatives of the governments that had funded the programme. It was a seminal event in the history of fisheries research and development in the South Pacific. The results of the Skipjack Programme were to have a huge influence on the future direction of broadly based tuna research and management throughout at least the central and western Pacific.

The essence of Pierre's conclusions was that there were good reasons to be confident that the data collected by the programme were truly representative of the stocks of skipjack and baitfish in the tropical central and western Pacific. The standing stock of skipjack (the quantity of fish in the total population at a single point in time) was estimated to be 3.0 million tonnes, with the 95 per cent confidence range being 2.5 to 3.7 million tonnes. Perhaps even more importantly from the fisheries management perspective, the turnover of fish in the total population, due to natural mortality, fishing mortality and emigration out of the huge study area, was 17 per cent per month. The natural mortality alone was approximately 87 per cent per annum. This outstanding revelation in practical terms meant that 87 per cent of the population of skipjack of the size that had been sampled throughout the three years of the programme's fieldwork (that is, the total population in the SPC) died of natural causes every year.

By combining the figures on the standing stock and turnover, the annual throughput (the total flux of exploitable skipjack through the study area over 12 months) was estimated to exceed 6 million tonnes. This figure is approximately 27 times the annual catch of skipjack from the study area during the time of the Skipjack Programme.

Pierre did an excellent job of handling the many questions that followed his presentation. As he always did, he stuck to the detail of the data, and his and other programme staff's analyses of that data. He left the conjecture to others.

When Pierre was asked what all these analyses meant to fishermen who wanted to know how much skipjack could be sustainably harvested each year from the area of the SPC, he gave his usual analytically perfect answer:

> My job is to provide the scientific estimate of how much is there and what the dynamics of the population are, and I have done that. I will leave the discussion of how much could be safely caught to the managers. Effectively, over to you, Bob!

While the answer to this question may not require the mathematical abilities of Pierre, Sandy and other programme staff, it was by no means straightforward. But I must be honest and admit that for the previous five years or so, I had been dreaming of being in a position where I would be asked this question. I anticipated that I would be the first person in the world to have the necessary information to answer it with accepted accuracy.

The first statement in my response was the safe answer: 'Even with minimal management, the total catch could be a great deal more than what is currently being taken'. This statement was undoubtedly correct, but it did not do justice to the three years of groundbreaking fieldwork and the excellent analytical techniques that Pierre, Sandy, John Sibert and other staff members had developed and then applied to this data, together with the detailed catch and effort data that had been compiled and analysed by Meryl Williams, and later Tom Polacheck and their team, to make a more informative answer possible. At the time of the meeting, I was still a little overwhelmed by the enormity of the 3 and 6 million tonne figures that Pierre had given me only a few days before. I would attempt to make up for this in the discussions I had with the various interest groups outside the meeting itself.

What I did say at the meeting was words to the effect that while the resource is indeed huge, it is not infinite. Much more skipjack could clearly be sustainably taken than was currently being harvested. However, I would not be promoting attempts to take the 27 times more that the throughput estimates superficially, and out of context, might suggest. The overwhelming message to be taken from the composite data we accumulated and analysed was that the skipjack, *Katsuwonus pelamis*, is an extraordinary creature:

1. It is the dominant tuna species in the huge area of its distribution.
2. Individuals display an extraordinary amount of movement throughout this area.
3. They grow extremely quickly and are recruited to the fishery at little more than one year of age.
4. Natural mortality is exceptionally high, with 87 per cent of the population dying of natural causes each year.
5. They grow fast, but at tremendously variable rates impacted by both area and time.
6. In the huge area in which they spawn, they do so almost every night (every 1.18 nights to be precise).

7. Individual females lay approximately 300,000 eggs each time they spawn.
8. Skipjack are extremely cannibalistic, to the extent that no other species eats more juvenile skipjack than adult skipjack do.
9. It is probable that there is heavy consumption of skipjack eggs and larvae by skipjack juveniles.
10. Variations in localised abundance can be extreme; catch rates in normally highly productive areas can fall to close to zero for weeks at a time (as was experienced in the very first month of the Skipjack Programme's fieldwork in a normally extremely productive area to the north of Papua New Guinea; see Chapter 14).
11. Conventional models used for stock assessment developed for other fish species in other fisheries, such as age- and length-structured models, are of little, if any, value for skipjack. I caution against their use for such purposes.

In summary, there are many reasons why skipjack should not be considered as a 'normal fish'. Their management should not be bound by conventional thinking (see Chapter 20). While the total skipjack population may be huge, extremely dynamic and cover a huge area, if fisheries are concentrated in small areas, then excessive localised depletion could occur, and local fisheries that are close together could have a detectable, negative impact on each other.

Various combinations of the points listed previously dominated my comments at the Thirteenth Regional Technical Meeting on Fisheries in Noumea in 1981. I then publicly offered to discuss the issues in more detail with the various interest groups at breaks during the meeting and following its conclusion.

The essence of what I said to the various groups in response to questions during the meeting was largely as follows.

To attempt to maximise the sustainable yield, fishing would need to be distributed across the whole area of the resource roughly in proportion to the relative abundances in each individual part of this area. This was not going to be possible in the foreseeable future, if ever. However, as discussed further in the following, with the extremely high turnover and great mobility of most skipjack, it would be safe to say that fishing at any likely level would not be a threat to the survival of the species. At an earlier fisheries technical

meeting, I had offered the opinion that if skipjack were a million dollars each, you could not threaten the survival of the species with known fishing technology. I stood by that statement. As I still do, almost 50 years later.

In summary, with an annual turnover figure of 6 million tonnes, it is difficult to find fault with a harvest target of 3 million tonnes per annum, if fishing could be spread over at least most of the area of the SPC. With an annual throughput of 6 million tonnes, if it took a year to catch the 3 million tonnes of allowable harvest, then by the end of that year, the other 3 million tonnes of the throughput would be, at least, becoming available. Gulland's classical basic equation for 'a back of the envelope' estimate of sustainable catch being half MB0 (where M is natural mortality, that has in this case been estimated by the Skipjack Programme at 2.0, and B0 is the size of the unfished population of more than 3 million tonnes) adds considerably to the confidence that can be placed in the estimate of the sustainable catch being at least 3 million tonnes. The 3 million tonne estimate was of the lightly fished population, as it was at the time of the Skipjack Programme's fieldwork, not the virgin population, which would be higher.

The resource is huge, but it is not infinite. Furthermore, the distribution of the resource is not completely uniform, and it varies considerably in time. The memory will linger with me forever of the almost complete absence of skipjack in the first month of the Skipjack Programme's fishing in the well-established fishing area of northern Papua New Guinea. We averaged little more than one skipjack per day, and what few skipjack were there were smaller than the Papua New Guinea Skipjack Program had ever caught anywhere in Papua New Guinea (see Chapter 14).

Oceanic and environmental variability, particularly that which is not predictable, may cause major problems for attempts to maximise catches. Optimum sustainable catches will almost certainly be a more appropriate goal. Such catches will be very large but, almost certainly, below the theoretical maximum. Furthermore, if heavy fishing pressure is concentrated in small areas, there will be detectable depletion of those areas, for at least short periods of time. There will be negative interactions between areas that are heavily fished and are close together.

In consideration of the wellbeing of the skipjack species, fishing will become uneconomical long before the survival of the species is threatened. The species has a short life span, grows very quickly and spawns almost every night, with individual females laying approximately 300,000 eggs each time

they spawn. There is an enormous amount of room for poor management before long-term damage to the total population could be anticipated. However, careful and well-informed management of fishing by area will be necessary if total yields and economic returns to individual countries and territories are to be optimised.

After the session of the meeting in which the discussion of the results was the focus, the meeting adjourned for coffee. The fisheries officers I spoke to at the break were very happy with what we had told them. In fact, they were excited by what the options were for further developing their own fisheries and/or licensing foreign boats. Certainly, there was plenty of food for thought and optimism.

I then spotted most of the American fisheries representatives in a tight huddle. I thought they would be delighted by the news they had just been given; they had been pestering me for weeks. So, I walked up to the group rather boldly. Before I could say anything, Tony Nizitich, a purse seine boat owner and representative of Starkist and, I thought, good friend of mine, immediately looked at me and said, 'Do you realise you just took $200 off the world price of a ton of skipjack?' – clearly implying that if there are that many out there, he and his colleagues will find it difficult to get a decent price for their catch: and that was our fault!

The next group I had a discussion with was a selection of the representatives of the environmental NGOs. The main message many of them were going to take home was that we had just given the purse seiners open slather. They were not particularly receptive to my assertion that the primary thing we had done was to give Pacific Island countries and territories the scientific information to enable them to manage their own fisheries sustainably, including allowing significant numbers of purse seiners to operate in their waters. Even though I was confident I knew the answer, I asked why NGOs had a particular problem with purse seiners. The answer was simple: 'They catch too many fish!' For a total resource as lightly exploited as this one had just been assessed to be, this was a supposition that I felt would be extremely difficult to defend. But it was very much to the fore in the arguments put forward by conservation NGOs at the time. Purse seiners and trawlers were never likely to be the flavour of the month for conservation NGOs. Efficient harvest of renewable resources at levels approaching the maximum, or even the optimum, is not sought by all! But the results of the Skipjack Programme

had clearly given the Pacific Island countries and territories confidence in the sustainability of the resources, of which they were gaining increasing managerial responsibility.

Over the rest of my career in fisheries management, I was to slowly come to live with the conundrum of trying to get the various sections of the fishing industries and conservationists to agree that any resource assessment was truly correct. It did not matter how good the science was: one or more groups would always have some reason why an assessment should not be accepted. I finally wrote a paper entitled 'Resource Assessment: The Joy of Always Being Wrong' (Kearney 1991; see Chapter 3) for a conference on managing trawl fisheries. The Skipjack Programme was the closest I ever got to research outputs and outcomes that should be acceptable to all parties; the species is simply not like others. Conventional assessment methods, management practices and concerns for the survival of the species are not appropriate for skipjack. A few of the protagonists for particular points of view acknowledge this.

I continued to be required to debate what the programme's assessments really meant for the management of the skipjack fishery for the rest of my time in Noumea as head of the TBAP, which the Skipjack Programme morphed into. My summary conclusions changed little. I did, however, modify the words I used to describe them. Most of the people who asked me what the stock size and throughput numbers really meant for fisheries management wanted simple answers to two key questions: What is the maximum sustainable yield (MSY; the most common management goal in vogue at the time)? What are the priority sustainability issues for Pacific skipjack fisheries that management needs to give priority to?

1. Mention of the issue of MSY opens the debate on whether density-dependent factors will have a major impact on the management of Pacific skipjack. At the heart of this issue is whether, when a population is heavily fished, the remaining fish take advantage of the extra space and food to be more productive (grow faster and/or produce more offspring). If these attributes make a significant difference, then the total sustainable yield per unit of time can become higher than was anticipated before fishing started. Noting the relatively high levels of cannibalism by adult skipjack of juvenile skipjack, density-dependent increases in productivity should be able to be anticipated. Then, if the

levels of cannibalism of skipjack eggs by skipjack larvae and juveniles are high, as suspected, then secondary impacts of density dependence can be expected.

- I strongly believe that it will not be possible to get sufficient total fishing effort appropriately distributed over the total area of the Pacific skipjack resource to achieve MSY from the total resource. In other words, I do not believe that the future management of the fishery will be constrained by concerns for the sustainability of the species. The long-term goal will be to manage the distribution of fishing effort to optimise the catches in the waters of the many individual island states – that is, OSY (optimum sustainable yield), which I believe, for skipjack, will likely remain considerably less than MSY. Attempts to take the MSY will almost certainly provoke more variability in annual yields with associated negative impacts on the realised value of these yields for individual countries and even for the region as a whole.

2. The sustainability of the skipjack species is a significantly different issue from the sustainability of the fisheries on the species. The major skipjack sustainability issues for Pacific Island states will be associated with maintaining local fisheries at optimum levels. The resource is huge but not infinite. And it does vary in total and in local abundance and distribution. The annual migration of skipjack to and from New Zealand is the most prominent example of a major predictable change within the total region. The period of extremely poor fishing experienced by the Skipjack Programme's vessel in its first visit to Papua New Guinea (see Chapter 14), together with detailed examination of the catch returns by the joint-venture pole and line vessels in Papua New Guinea, confirms how variable the abundance of the resource can be in both time and space.

   - Localised depletion occurs wherever fishing occurs; if you take one fish out of the water, the resource is depleted, even if only by one fish and only for a matter of seconds. In the total Pacific skipjack fishery, depletion occurs wherever there are fisheries; a common characteristic of all capture fisheries is that fish are removed from the water, with the result that, at least temporarily, an area is depleted. The use of the word 'depleted' to imply overfished, as the Australian Government's official stock assessments do, is, in my opinion, a serious bastardisation of the English language. At best, it is imprecise and lazy. It is therefore unscientific.

- Wherever multiple vessels exploit the same section of the total stock, competition will have an impact on the catches of individual vessels. The greatest early concern in the Pacific has been over small local fisheries being negatively impacted by purse seiners – for example, in Japan, where the coastal pole and line fisheries have been diminished by the increasing purse seine fishery. Managing all forms of competition to protect the sustainability of individual components of the total fishery will undoubtedly be the major sustainability issue. Trying to optimise and stabilise the returns to each country and territory, and for the whole region, from the licensing of foreign vessels, will be a much more immediate concern than the conservation of the species itself.

An independent assessment of the performance of the Skipjack Programme against its objectives was provided by Paul Judd in 2016:

> The concluding summary of the Skipjack Programme (Kearney 1983) was able to confirm that all of the rather grand objectives for the Programme had been met. Furthermore, collectively the results enabled an assessment of the total skipjack stocks of the whole SPC region and greatly facilitated an estimation of resources beyond these boundaries: objectives that were considered aspirational at the time the Programme commenced. From an administrative perspective it is significant that all research schedules, including the production of preliminary and final reports for each of the countries and territories of the SPC, were met and total expenditure, including for the originally unbudgeted computer, was safely within the budget approved at the commencement of the Programme. The subsequent creation and funding of the Tuna and Billfish Assessment Programme, coupled with the ongoing success of SPC's Oceanic Fisheries Programme, provide testimony to the quality of the scientific and administrative foundations established by the Skipjack Programme.

Another external review of at least the early stages of the programme was provided by the Rockefeller Foundation in their evaluation statement of their Grant GA AS 7509, The Skipjack Programme (see Chapter 5). The review, quoted in the following, was provided by Gary H. Toenniessen, assistant director of the Rockefeller Foundation, on September 29, 1980:

> This grant can serve as the epitome of how a seed grant should work. It provided one year's support in 1975 which enabled the South Pacific Commission, in collaboration with ICLARM, to hire Dr. Robert Kearney, to design and initiate an assessment program for

> improved management of skipjack tuna, as one of the South Pacific's largest food resources. By 1979, the Skipjack Survey and Assessment Programme had grown under Robert Kearney as Coordinator, to have an annual budget of over $1,100,000 with six developed countries providing a majority of the support. It is expected to continue operations at approximately this same level.
>
> The Program is allowing the island countries of the South Pacific to move towards maximum economic yield from skipjack tuna, while simultaneously ensuring that the resource is not depleted. In short, a small RF [Rockefeller Foundation] grant provided the startup funding for a highly successful and much larger research program which in turn is making a significant contribution to the more effective management of an important component of the South Pacific's food resources.

Having a funding body as prestigious and respected as the Rockefeller Foundation assess the programme as the epitome of how seed funding should work does give most people associated with the Skipjack Programme a rather deep sense of satisfaction: dare I say pride?

From my personal perspective, I could not have been happier with the scientific, management, administrative and technical outputs from the programme. The Pacific Island countries and territories, our primary clients, were clearly happy, and 50 years later, they remain so. The science of the big experiment was proven correct. The extraordinary funding arrangements worked seamlessly. The ease with which I was able to convince four of the six donor governments to support the transformation of the Skipjack Programme into the TBAP provided compelling evidence of the donors' satisfaction. The donors continued to not only fund the programme but also maintained the funding arrangements with me as the recipient of the money and the sole executive of the programme, including the accounts.

I remain extremely grateful to all six of the donor governments to the Skipjack Programme. There is no doubt that they all took a risk in funding it. It was definitely an experiment, even though I may have talked this component down during the fundraising period. Nothing like it had ever been done before; tagging had never been used to provide a detailed stock assessment of a species of tuna. I admit that for at least the first 12 of the 18 months of the intensive fundraising effort, assurances that it would work were disproportionately dependent on my opinion, which itself was heavily dependent on the pioneering work Barney Smith, Tony Lewis and I did in Papua New Guinea (see Chapter 1).

The two governments that did not continue funding of the TBAP were Japan and the United Kingdom. While neither government formally offered a reason for not continuing, I had no trouble in thinking of reasons why they might not. I had myself publicly outlined, at the Twelfth Regional Technical Meeting on Fisheries in 1980, reasons why it might be better for the Skipjack Programme to be suspended once the analyses of results from it had been finalised. If a compelling program of fieldwork were developed, a new proposal could be put forward that more precisely justified and then addressed what needed to be done. It should not be anywhere near as difficult to fund as the first programme had been. Based on the assessment by the Rockefeller Foundation that the seed money they had given to fund the salary and travel expenses for me as the Skipjack programme coordinator (quoted previously) represented the epitome of a successful grant, I was confident that they could be convinced to help kickstart another scientific experiment with similar benefits for so many small Pacific Island nations. Perhaps they would even be prepared to be a significant donor to the program itself?

The Skipjack Programme was a scientific approach to meeting a real need for information that was required by many island states and distant-water fishing nations. It had a very definite design and research program to meet three clearly defined objectives within a definite time frame. At the time of creation of the TBAP, the defined parts of the work program did not yet, at least, include a detailed program of fieldwork. It was assumed that the programme would develop a schedule of in-field research on billfish and other tunas, in addition to skipjack, but details on what this might look like were not immediately available. It was not budgeted in the initial proposed expenditure under the TBAP. The Regional Tuna Tagging Project was approved in 1985, but fieldwork did not commence until December 1989.

Although the results from the 9,596 yellowfin tuna that had been tagged during the Skipjack Programme were indeed informative, it was too early to be confident that a yellowfin tagging program would provide sufficient information to make a definitive contribution to stock assessment. In my opinion, the goal was definitely laudable and worth pursuing, but would the risk be greater than it had been for skipjack? On the positive side, the Skipjack Programme had proven that tagging could be used to measure the abundance of tuna, and 9,596 yellowfin (a significant number) had been tagged while actively seeking skipjack.

The strength of the support for the Skipjack Programme from Japanese scientists had been a major factor in Japan's decision to fund the Programme. Senior scientists, such as Drs Akira Suda, Shoji Ueyanagi, Sigeti Hayashi and their colleagues, in the various Japanese fishery research institutions and the Japan Fisheries Agency, had been immensely supportive. A major reason for this help was their excitement over the magnitude and design of the tagging experiment. I felt that the lack of a clearly defined research experiment was a major factor in the diminished enthusiasm of Japanese scientists for the TBAP. In the absence of that enthusiasm, the Ministry of Fisheries found it much harder to convince the government to support a less well-defined work program of an organisation of which Japan was still not a member. The Skipjack and the Tuna and Billfish Programmes did not formally constitute international organisations in their own right; the money was still being given to me!

The United Kingdom had, from the start of our discussions on the possible funding of the Skipjack Programme six years before, given me the impression that they did not wish to be drawn into negotiations on the Law of the Sea and regional fisheries management in the South Pacific, even from a distance. I had the feeling that their problems at home with international fishing issues in the northern Atlantic, including even between the United Kingdom and others in the European Union, were more than enough to make them wary. Management of living resources that cross national boundaries can be inordinately difficult. The South Pacific has been proven to be an international exception (see Chapter 21).

I had the impression that the British would be much happier to leave funding of international fisheries management issues in the South Pacific to Australia and New Zealand, who were, after all, members of the South Pacific Forum, which had ordained itself to be the focus of international discussion on the issues. I believed the United Kingdom thought that the major issues with fisheries management in the future would be more political than scientific. The Skipjack Programme had demonstrated that the science could be productive. The doubtful bit was now political, and that was what the FFA had been created for, potentially leaving the SPC out of the main game. I was strongly of the view that the lack of a clearly defined work program for the TBAP and the absence of an experimental design that had been adequately peer reviewed were making the United Kingdom's scientific experts at least somewhat uneasy. They had been up front about similar issues in the early stages of our discussions over the funding of the Skipjack Programme (see Chapter 7).

Also relevant to the fundraising for the Tuna and Billfish Programme was the approach I received from Canada.

Right at the beginning of my attempts to raise funding for the Skipjack Programme, I had approached Canada for support, only to receive a very definitive statement of no interest (see Chapter 7). I heard no more from the Canadians until about a month before my planned departure from the TBAP, almost six years later. I received a phone call from a very senior representative of the Canadian International Development Agency (CIDA) asking if he could come and talk to me about the possibility of Canada contributing to the TBAP. We agreed on a date and time a week or two later. The Programme could certainly use some extra support if it was to undertake significant fieldwork. I looked forward to the meeting.

On the day, after an hour or so of rather 'peripheral' discussions in my office about what the Skipjack Programme had achieved and what was being proposed for the Tuna and Billfish Programme, we adjourned to my house, where Hope had done her thing and a lovely lunch awaited. The discussions got more to the point over lunch. The reason Canada had declined to join the donors to the Skipjack Programme, approximately six years earlier, was, at least in part, because of the poor financial state of the commission, as detailed in the secretary general's statement to the South Pacific Conference (see Chapter 4).

The indication this gave of poor financial management would not be missed by any in-depth review. Canada apparently felt that this was not the time to be contributing to the commission's first extra-budgetary project, which was equal to approximately a third of the commission's total budget.

Canada had watched, with some interest, the development of a new financial system for funding the Skipjack Program, specifically giving the money to me personally. CIDA, initially at least, had had serious doubts about the wisdom of such an arrangement. But they had more recently accepted the explanation from the donor governments that they were very pleased with the financial and management arrangements that had been made and the subsequent success of the programme.

Canada was considering an offer of $200,000 a year for three years under the same arrangements. In Canada's opinion, these 'same arrangements' included me staying on to run the programme for at least two years. When I told him that I was leaving in a few weeks and would be taking up a position of Chief Scientist at the IATTC, his only comment was this:

'I wish you had told me that before I left Canada. I could have saved myself a trip'. He confirmed that the condition of my staying with the TBAP was definitive – for the time being, at least. They were not prepared to commit to a project where the director had almost total say in how it was run, when they did not even know for sure who that director would be.

At the conclusion of the Skipjack Programme, I was confident we had more than adequately met the programme's objectives. We had also laid an excellent foundation for the creation of the broadly based fisheries research and management body, which had been one of my goals since 1975. I did, however, think it unfortunate that the creation of that body had been delayed (until 2004 as it turned out), for largely poorly informed reasons, including those discussed in Chapter 16.

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