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Skipjack or stripeys

From my perspective, *Katsuwonus pelamis* had not always been skipjack.

My introduction to skipjack tuna (*Katsuwonus pelamis*) occurred off the southeast coast of New South Wales (NSW). I was on the legendary Australian pole and line tuna boat, the *Catriona B* (the Cat). The skipper of the Cat, Frank Broder, widely recognised as an outstanding tuna fisherman, had agreed to take me, a PhD student at the University of Queensland, on a regulation tuna fishing cruise. Stan Hynd, the senior tuna scientist at the Cronulla laboratories of CSIRO, had convinced Frank that this would represent a contribution to fisheries science, and it was in the fishing industry's best interests to support it.

My stated responsibilities on that cruise were solely to collect tuna blood samples for my University of Queensland research project. My thesis subject was the comparative physiology of fish species with hugely variant activity levels. Skipjack were known to be one of the most highly mobile tuna species. Their blood chemistry confirms their extreme athleticism (see Chapter 19). They were the species at the top of my activity scale; flathead (*Platycephalus fuscus*) was at the bottom, for those species whose blood I had access to.

My girlfriend at the time, Hope Fraser, who was later to agree to marry me, was one of the first of many who helped catalyse my career by facilitating privileged opportunities for me. Hope had spent the previous year working at the CSIRO Division of Fisheries and Oceanography in Cronulla as Stan Hynd's research assistant. She had persuaded him that helping me would be a good thing to do.

The 10-day cruise commenced in Eden, on the far south coast of NSW, and progressed north to Sydney, then back again. Striped tuna, or 'stripeys' as they were singularly called in this area at that time, were common over much of the trip. Interestingly, they were most apparently abundant in inshore waters, not more than a few kilometres from the coast. They were not the target species for the *Catriona B*; southern bluefin tuna were. Stripeys were considered to be of little value to the crew of the Cat. We still caught more than enough for my samples.

I had lived in Kingscliff, on the far north coast of NSW, for the previous 15 years, and even though I had fished commercially for several years and was friendly with the few other commercial fishermen in the district, I had never seen a single stripey. I had never even heard of anybody catching one in the region. When I later showed my fishing friends from the area a photo of a 'skipjack', they did not know what it was, but assumed, because of its stripes, it was a bonito of some type. The French would certainly agree; the name for skipjack in French is *bonite à ventre rayé*.

My research a decade later (Kearney and Gillett 1979) confirmed that my failure to catch even a single stripey at Kingscliff was not a manifestation of gross incompetence on my part. There is a significant discontinuity in the distribution of skipjack off the east coast of Australia: they were found in subsequent research as part of the 'Skipjack Programme' (discussed in detail throughout this book) to be completely absent from 26 degrees south to 32 degrees south from the coast to an unknown, but significant, distance seaward, probably of the order of 50 kilometres. In the absence of any prior exposure to stripeys, other than on the *Catriona B* in southern NSW, my deduction up until 1971 was that the species must favour temperate waters and prefer to be coastal in its distribution.

After this rather mild introduction to this apparently 'inconsequential' species, how did I come to do stock assessment research on skipjack for the next two decades?

As I drew close to the completion of my PhD degree in fish physiology, three positions of fisheries scientist in Papua New Guinea were advertised in the Australian press. A fellow postgraduate student, Theo Helbig, who had lived in Papua New Guinea as a youth, promoted the advertisement around the University of Queensland Zoology Department. I talked to Theo about what might be in store. He was convincing. I applied, but with some uncertainty. I knew extremely little about Papua New Guinea and had

doubts about the wisdom of taking my first full-time job as a scientist in a developing country environment. Could I count on decent supervision? Or would I get any supervision? I presumed that in my first full-time job, I would need it.

Two friends of mine from the Zoology Department, Barney Smith and Tony Lewis, applied at the same time. All three of us were offered interviews in Brisbane. I thought my interview went well. I got the strong impression that my experience as a commercial fisherman with at least some knowledge and experience with tuna, coupled with the completion of my PhD program that included work on tuna, was well received. A key question asked of me was whether I would like to work on tuna or prawns, these subjects being the basis of the two biggest developing fisheries in Papua New Guinea at the time. To me, this question was a no-brainer. I was an addicted fisherman, and pole and line fishing for tuna was about as exciting a fishing experience as a 24-year-old Australian male could realistically hope for: sorting through big piles of prawns and 'trash fish' in the bottom of a trawl net paled into insignificance.

I may have taken a little 'poetic licence' in explaining the extent of my experience in burleying-up schools of long-tail tuna (*Thunnus tonggol*) in Morton Bay and the extent of my knowledge of stripey fishing on the south coast of NSW, but I was encouraged to be a little expansive by the interviewer's enthusiasm when describing the opportunity I would be presented with by moving to Port Moresby. I suspected that the Papua New Guinea Department of Agriculture, Stock and Fisheries (DASF) did not get a lot of applicants for these jobs. This suspicion was reinforced when Barney, Tony and I all received job offers. Only three positions had been advertised. Was there something wrong with these jobs that we were the only ones who did not know? The fact that my first full-time job was to be as a fisheries scientist I found very exciting, and as it was to be in a new country, about which I knew extremely little, the package was exhilarating.

My assumption that 'stripeys' were a temperate, inshore species was seriously tested when I arrived in Papua New Guinea in early 1971 to find that the tuna fishery in this country was totally dominated by *Katsuwonus pelamis*, known locally, and throughout the world's major oceans, as skipjack tuna. The rate of increase in the domination of the global catch of tuna by this species at this time was such that the addition of the word 'tuna' to the title of the species was being progressively regarded as unnecessary, even

inappropriate. It was certainly redundant. They were becoming the world's dominant tuna species. Any self-respecting fisheries scientist should know that this skipjack was a tuna.

I was surprised, but nonetheless pleased to find on arrival that my assigned title was 'principal scientist', with which came responsibility for developing the country's first tuna research program. It quickly became obvious that this exalted title, and associated attractive salary, were singularly correlated with the fact that I was the only staff member who had completed a PhD. It was immediately obvious that if I were to do justice to the faith that had been afforded me, a 'crash course' in all aspects of *Katsuwonus pelamis* was obviously at the top of my duty statement.

The embryonic development of a tuna research program

My wife, Hope, had been much more confident than I was about the benefits for both of us in me taking the job in Papua New Guinea. Throughout our long married life, she was always far more adventurous than I. She was very confident that my job would be extremely interesting, and she was optimistic about her own job prospects. Working in academic administration, which is what she assumed she would be doing, in a new university in a developing country would be nothing if not exciting.

As we descended the stairway from the plane from Brisbane onto the tarmac at Port Moresby airport, my ridiculously little knowledge of the country that we were about to declare home for an unknown period of time immediately became obvious. We had not even done enough homework to prepare us for the climate in our new home. As our feet touched the tarmac, I comforted Hope with the advice that it would be cooler once we got out of the jet stream from the plane's engines. I had failed to notice that the engines had been switched off well before we left the aircraft. What we were experiencing was the ambient temperature of Port Moresby. Should we have done more homework on what we were committing ourselves to? A bit late to worry about that now!

I at least had a job, which brought with it not only an attractive tax-free salary but also housing. Hope was comforted by her confidence that her experience in university administration at the University of Queensland

would enable her to get a job in administration at the new and growing University of Papua New Guinea. We were, after all, young and bulletproof. The prospects were exciting, and we were nothing if not optimistic.

Right from the beginning in Papua New Guinea, our ducks began to align. We were met at the airport and driven to our allocated house; it was brand new, having only been completed a week before. It was perfect for a tropical climate: excellent ventilation and large ceiling fans. The appliances were new, and the 'survival kit' of household essentials was more than adequate. The location in the Port Moresby suburb of Tokarara was lovely.

I was to be picked up and taken to the fisheries research station at Kanudi the next morning, and yes, transport could be arranged to take Hope to the university, which, as it turned out, was even closer to Tokarara than the fisheries research station.

The introduction to where my job was based, the Kanudi Fisheries Research Station, was comforting. The location was excellent, and the staff were welcoming. My office was spacious, bright and airy. Most importantly, I quickly developed a feeling of genuine acceptance of the need for somebody to begin some tuna research. I was a little surprised at the lack of knowledge of the country's tuna fisheries by my new colleagues, but from my perspective at least, there appeared to be acceptance that we needed to find out more as a matter of some priority. After all, my job was to establish the tuna research program, and I had been appointed the 'principal scientist'. It was expected that I would show some leadership.

My expectation of supervision was quickly abandoned. The bright side of this was that I had more freedom to shape tuna research than I could have dreamed of. I thought it wise not to let on that, apart from some knowledge of its cardiovascular system, I knew very little about *Katsuwonus pelamis*.

Papua New Guinea had a developing tuna fishery, which, as it entered its second year, was showing considerable promise. It had already grown from a single joint-venture company to an anticipated three, or perhaps four, by the end of its second year (1971).

There had only been one joint-venture company fishing for tuna in the previous year, 1970, but the catches of skipjack, in particular, in that year were extremely encouraging. It was not difficult to become excited about the outlook for the fishery. There was even a rather haphazard collection of catch returns on my desk, presumably in anticipation of the new tuna

scientist doing something scientific with them. The fact that nobody else wanted them was somewhat liberating. I had to quickly accept that as far as tuna research went, I was it – at least for the time being.

By the end of the first week, my crash course in skipjack fisheries research was well underway. I had a somewhat hurried meeting with the executive of the DASF, which included the director, Bill Conroy. Their enthusiasm for the developing tuna fishing was obvious. I was expected to be off and running immediately. They had planned a trip for me in the next week to the site of the first joint-venture tuna fishing company, Gollin Kyokuyo, in Kavieng, New Ireland. This visit was to include a day or two of fishing for skipjack from a standard commercial pole and line boat. They said they were looking forward to what I had to say about the fishery. Seeing that I knew almost nothing about it at the moment, this might be interesting.

During my first visit to Kavieng, which included a couple of days of skipjack fishing on their boats and observing their bait-catching techniques, I was greatly surprised to see that all of their bait was captured by the 'drive-in' method. This involved most of the crew being in the water with goggles and a very large, small-mesh net, which they manipulated around coral bommies by constant diving to 5 metres or more for as long as they could hold their breath, which was a long time. They did it every day and got very good at it. I was advised that the vessel I was on had, at that time, three of the Okinawan crew in hospital with ear infections, which were a direct outcome of the technique they used for catching bait. The vessel I was on for the second day had two crew members in the hospital. They advised me that these ear problems caused a great strain on the health of their crew and, hence, the efficiency of their total operation. It was common to have as many as five or six men in the hospital in Kavieng at the same time. Every so often, one of the crew members had to be flown back to Japan for more intensive treatment of an ear problem.

This bait-fishing technique also led to problems with local fishermen who correctly believed the fish the bait fishermen were catching included juveniles of many of the species that were the basis of their own subsistence fisheries. As the technique involved fishing in daylight around coral outcrops, it made their activities very obvious to local fishermen. It also took up time in the early mornings that were a premium for skipjack fishing.

I had had some experience with catching bait in the Australian tuna fishery and knew that baiting was mostly done at night using bright lights to attract the bait, and then lampara, or small purse seine, nets to catch them. Certainly, the crew did not have to dive for them. My crash course on *Katsuwonus pelamis* also made me aware that in Japan, underwater lights were commonly used for fishing for baitfish for tuna pole and line fishing. Why not here?

Immediately after I got off the boat, I spoke to the senior people in Gollin Kyokuyo: Geoff Clegg from the Gollin component and Ken Shiokawa from Kyokuyo. They told me that the problem with ear infections was so great that the future of skipjack fishing in Papua New Guinea was in serious danger. I told them I was very confident that the use of bright underwater lights to attract baitfish at night and appropriate nets to catch them would work. I was truly amazed they did not already know about the use of lights to catch bait. I could only conclude that there had been inadequate communication between the crews on the Okinawan boats and the Japanese component of the parent Australian–Japanese joint-venture company. As soon as I started to give details of the 1,000-watt underwater lights I thought they would need and the type of nets they might try, they both began taking notes, rather enthusiastically.

Only a week or so later, Geoff Clegg rang to tell me that after discussions with their colleagues in Japan, lights and bouke-ami nets (the very large Japanese version of a stick-held dip net) were on their way. In a matter of a few weeks, after they arrived and were tried, every boat in the fishery was transitioning to the new baiting technique. As the bait supply improved in both quantity and quality and the health of the crew took a huge turn for the better, my relations with the joint-venture companies, not surprisingly, also blossomed. As did the quality of the catch and effort data. They were extremely grateful.

Back at Kanudi, a quick scan of the pile of catch returns that had been on my desk confirmed that the joint-venture company had already been providing some data on effort and catch and a little, rather inconsistent, information on the species breakdown and size of individual fish. Working out how to get our data entered into a database that could be easily accessed and manipulated was obviously a high priority. Once we could see what we had, it would be much easier to improve the data collection and analysis

system. Determining what additional data were needed and how they could be collected was clearly going to be a major component of the research program that was my responsibility to design and then implement.

My next meeting with members of the executive of the DASF, which included the director, was most encouraging and therefore enjoyable. They had heard of my success with the Kavieng fishermen. I was definitely in their 'good books'. Included in the outcome a few days later was an introduction to the director of the National Computer Centre. His enthusiasm for getting maximum benefit from computerising what was worth computerising was infectious. Our goals were aligned.

There was only one computer in Papua New Guinea at the time, and I am now confident that there would not have been more than one or two more in all the Pacific Islands.

Under the guidance of its director, the Papua New Guinea Computer Centre had an impressive approach to the use of data compilation and analysis. But they had few datasets of sufficient size and quality to make computer analysis an obvious requirement. So, if you had quality data that could be massaged to describe an opportunity for Papua New Guineans, and you made a case for support, that included appropriate departmental backing, the staff were keen to work with you to optimise the value of the computer and their use of it.

The senior staff of the centre were visionary, particularly the director, and they wanted to see their computer used to best effect for Papua New Guinea. Once you convinced them of the value of your request, they would do all software development and data entry for you. And so I made a case, with very strong support from the hierarchy of DASF. The fact that the tuna fishery represented an exciting development opportunity for the country at that time was clearly a major factor influencing the strength of the support I was given from both DASF and the Computer Centre. My success at Kavieng with bait fishing was obviously contributing to my standing.

Within not much more than a few months, I was receiving fully computerised analyses of catch and effort data from each tuna boat. The backlog of data sheets had been addressed. The processed data were compiled and presented in such a way that, as the tuna research program developed, I could cross-reference all commercial catches with our scientific sampling. The Computer Centre delivered me monthly printouts of the daily catch by every boat, aggregated by area, time and any other classification

I specified. The Computer Centre also combined the catch and effort data with summaries of the limited size-sampling of skipjack from every boat and area. So, we had a reasonably good handle on the tuna fishery, which we could correlate with other scientific information as it became available. It could clearly be improved once I could work out what extra data and analyses we needed.

I had been most impressed by my introduction to the Australian–Japanese joint-venture tuna fishing companies. And after the advice I had given them on catching bait, they were definitely on my side. Their keenness to commit to the collection and analysis of data on the fishery was comforting. But the data being collected were less than perfect. My request to have size data collected from all catches was adhered to, even if I did have to work a bit to get them to provide the size data for each boat and not the daily average for the company.

My initial duty statement, imprecise though it was, was simple. I had to write it myself, and I was still very much unsure of what we were going to be able to do. I was confident I could 'evolve' my duty responsibilities as my knowledge grew. It was most unlikely that anybody was going to complain.

Canned fish, predominantly mackerel in oil, imported from Japan, was a hugely important component of the Papua New Guinean diet. Therefore, the prospect of having one or more local tuna canneries was extremely attractive, even if it was accepted that we should not get ahead of ourselves. The reality was that the knowledge of the tuna resource base was limited, but the available information was encouraging.

My initial priority was to design and implement a tuna research program that gathered the necessary extra intelligence on the tuna resources of Papua New Guinea to support the planned growth of the fishery and increased participation by Papua New Guineans in that fishery. Developing and then implementing a viable plan for assessing the size of the stocks of tuna, the species composition of them, their distribution and accessibility, and their ability to support profitable and sustainable harvests was, in essence, the job I had been given and rather gleefully accepted. I had already delivered on one major facet of the fishery: catching bait. It was much easier and safer to train Papua New Guineans to catch bait with a bouke-ami net than the now-outdated 'drive-in' technique.

My next task, after ensuring that the computerisation of the catch and effort data was as good as it could be, was to develop an outline of the type of research that was going to be necessary to supplement catch data in support of answers to the management decisions that were looming. How could we ascertain the size of Papua New Guinea's tuna resources, their distribution and dynamics, and the factors that determined their ability to withstand fishing pressure within Papua New Guinea's waters and even beyond? How much fishing pressure could they sustain? Some form of survey of at least the most promising areas of Papua New Guinea's waters was clearly necessary. But in 1971, even the extent of what qualified to be called 'Papua New Guinea's waters' was not well established. Papua New Guinea was still officially the Australian Territory of Papua New Guinea, and marine Exclusive Economic Zones were not yet even on the fantasy list.

The data that were being gathered from the joint-venture companies constituted the only real 'survey' information we had. As the fishery expanded in time and space, these data were becoming more useful for both scientific and economic assessment of the dynamics of the fishery. But their use for contributing to the biological parameters, such as growth and mortality rates, both fishing and natural, of the key tuna species was limited. Even the distribution of key species beyond the relatively small areas currently being fished was unknown. So, we needed a survey program to better describe the distribution of key species, coupled with an assessment program that used this distribution data together with growth, mortality, spawning, migration and stock structure information on the key species.

The distribution data needed could most efficiently be gathered by aerial survey using light planes. But it of itself would be of limited value without knowledge of the biological parameters to underpin the assessment of stock dynamics. Aerial surveys would be necessary, but they could wait until we were confident we would be able to get the necessary biological data, including assessment of the movement of individual fish and even populations.

I already held a strong opinion that tag and release of whatever tuna species were assessed to be of priority was going to be a fundamental plank in the platform of the tuna research effort. My searches of the scientific literature, meagre though they were, had already led me to be somewhat concerned that stock assessments of skipjack were notably absent. I was unable to find a single example of successful modelling of a skipjack population based on the progression of cohorts of fish through a fishery. If this were going to be possible in Papua New Guinea, we would have the catch and effort data

to do it, provided I managed to ensure that the size composition data we collected were truly representative of the population we were trying to assess. That was a big unknown. But even then, it would take years to get a large enough dataset to enable the observance of cohorts passing through the fishery – the most common technique used for fisheries stock assessment at the time. As my knowledge of the Papua New Guinea tuna fishery increased, my faith in size composition data from the commercial fleet being suitable as the backbone of adequate stock assessments diminished. The size composition data we had, meagre though it was, suggested it was most unlikely that such data would ever be able to be used to monitor the progression of age cohorts through the fishery. My commitment to establishing an adequate tagging program as the foundation of our research program intensified.

After only two or three months in Papua New Guinea, I had the outline of a research program that I was confident, if implemented, would provide a sound scientific basis for the development and management of the tuna fishery. There were, however, several major problems: the program had only one staff member, me, and no vessel, equipment or even an approved budget. I was told by the executive that if I could provide convincing details on how the program would work, staffing and budgeting issues would be considered. The support for an effective tuna research program among the executive appeared genuine, as it was proven to be. I felt confident that if I could provide a sound design and realistic costings of a workable program, success was possible. I found it an incredibly exciting opportunity. Perhaps I should have been concerned that this was my first full-time job and I did not have much research experience with tuna population dynamics, but I wasn't. I had more immediate concerns – like how to get an adequate research vessel.

Obtaining a successful outcome from the total program was dependent on getting reliable data on the biological and movement characteristics of the key species, particularly skipjack, on which the current fishery was based. Tagging was the logical way to fill this gap. How to get access to live tuna to tag was the immediate challenge. It had to be overcome. The whole of the program, as I was proposing it, depended on it.

Of course, the best platform for tagging tuna would be a purpose-built tuna research boat. It was immediately apparent that cost was going to prevent this from being an option. The key executives of the department were definitely supportive, but not that supportive. Alternatives included chartering one

or more commercial vessels for specified periods or putting scientists on commercial boats under some agreement to tag and release a percentage of the catch. Once I had ascertained what the budget for tuna research would be, I could investigate all options. High on the list of support requirements for either of these options was excellent cooperation with the joint-venture companies. This did not appear to be a problem. I was in their 'good books'.

I was already aware of the critical role of live bait in pole and line tuna fisheries. I was also increasingly aware that fishing for bait by the joint-venture companies, even at night, was still a source of conflict with local fishers. Surveys of the country's baitfish resources and descriptions of the characteristics of the key species would be essential components of the assessment of Papua New Guinea's tuna fishing potential.

Papua New Guinea is a big country with many islands, creating a huge total coastline with immensely variable habitats for potential baitfish species. I could not imagine a way in which sufficiently comprehensive baitfish surveys could be conducted without the service of a suitably large mobile marine research platform – that is, an appropriate boat.

DASF clearly did not have a boat that was purpose-built for tuna and baitfish research. I would have to work up a budget for chartering one. Or perhaps modifying a vessel that was built to work in another type of fishery was a possibility. The fisheries research division of DASF did have a 60-foot research vessel, the Fisheries Research Vessel (FRV) *Tagula*, but as soon as my enquiries led to this revelation, I was rather firmly informed by other staff members, including the chief scientist at Kanudi, that the *Tagula* was built and rigged as a prawn trawler, and even though it was currently in dock, its future was committed to prawn, and possibly lobster, research. Interesting!

Over the next month or so, I investigated the possibilities for chartering a vessel from the joint-venture companies and then discussed the likely costs with senior members of the DASF hierarchy, including the director. I was truly impressed with the enthusiasm within the department for having a quality tuna research program to support an expanding tuna industry. The fact that I had quickly got on and had the available data computerised had gone over well, as did the solution to the industry's baiting problems. They already had something to see from my efforts, and I was promising much more. It was envisaged that the tuna industry would eventually include

processing plants and canneries. But the cost of a charter for the time that would be necessary for both tuna and baitfish research of sufficient scale was well beyond the currently available budget.

Shortly after taking up my position at Kanudi, I developed a firm friendship with the captain of the *Tagula*, Reg Eginton. That we both came from the far north coast of NSW helped. Reg was from Ballina, and I came from Kingscliff – coastal towns only 80 kilometres apart – and we were both fishermen. Our numerous discussions included the feasibility of modifying the *Tagula* for tuna research. Reg was almost immediately attracted to the possibility of cruising around the many beautiful islands of Papua New Guinea, fishing for tuna and baitfish; it was much more appealing than being confined to the relatively turbid waters of the Gulf of Papua, the only known prawn-fishing area, on a prawn trawler. But the *Tagula* had not been built with tuna fishing being one of its planned uses.

The size and design of the vessel were such that it was going to be very difficult, if not impossible, for it to carry sufficient water to keep a viable quantity of bait alive to support effective pole and line fishing. Below-deck bait tanks were out of the question; there simply was not enough space. Reg thought it extremely unlikely that the *Tagula* would be able to safely carry on-deck bait tanks that were sufficiently large to make live bait and pole fishing rewarding. But he agreed to talk to the engineers at Steamships Shipyard, who had the contract for servicing the *Tagula*, about just how much water could be carried on deck and what additional pumps would be needed to circulate the water in the tanks. My few trips on the Okinawan boats operating in the Papua New Guinea fishery had already convinced me that water sprays would also be needed to help attract tuna to the fishing area at the stern of the *Tagula*.

Reg was extremely surprised by the engineers' assessment of the size of the tanks that could be safely carried. He remained sceptical. We were confident that the amount of bait that could be accommodated in tanks of the size the engineers proposed would be sufficient to enable the tagging of at least enough tuna to meet a modest research target of 5,000 to 10,000 fish. With this information and Reg's enthusiasm for the cruise plan we had discussed, a meeting with the director of DASF led to an agreement to make the necessary modifications to the *Tagula* and its commissioning to tuna research for three years in the first instance. This part had been rather painless, for me at least. My prawn research colleagues at Kanudi did not regard me as 'the flavour of the month'.

While arrangements for data processing and access to a research vessel were progressing rather smoothly, the staffing of the tuna research team developed slowly, but the small quantity of staff was more than compensated for by quality. Firstly, Barney Smith arrived to take up a scientist position in the tuna program. I did not have to intervene in this process, as the position Barney filled had been allocated to tuna research right from the time the three research positions had been advertised. But when Tony Lewis arrived at Kanudi a few months later, I did have some smooth talking to do. The prawn researchers had already surrendered their research vessel, and now they were being asked to forfeit a position that they had been told was earmarked for prawn research. The argument that without the *Tagula* to do the trawling, there was no real need for an extra prawn research scientist was not one on which it would be wise for me to go public.

To this day, I am not sure what won the debate about what job Tony would fill, but I have a feeling Tony's insistence that he had always been led to believe he would be working on tuna had something to do with it. Who gave him that assurance remained a mystery. Much as I would like to take the credit for the outcome, I am fairly confident that all I told him was that I would work very hard to have him on the team. This I had done.

Discussions with Reg Eginton confirmed that the Papua New Guinean crew of the *Tagula* were very competent seamen. Reg was extremely confident they would quickly adapt to skipjack pole and line fishing and to baitfish fishing both night and day (with small-mesh beach seine nets and not the 'drive-in' technique the Okinawans had been using), provided I knew enough to be able to train them. Fortunately, confidence was not something I was short of.

Perhaps I should have been worried that all three scientific staff members of the tuna research program were embarking on their first full-time jobs, but I wasn't. Regardless of what limitations the three of us had, the grouping was to hold for more than 40 years. Collectively, we were to play a significant role in Pacific skipjack fisheries research and management, not just in Papua New Guinea but in the broader Pacific, Australia and even Southeast Asia and beyond, for at least several decades. Included in our collective contributions was the involvement of each of us, for different periods, as director of the SPC's Offshore Fisheries Program (under its evolving titles, which included the Skipjack Survey and Assessment Programme and the Tuna and Billfish Programme) for a combined total in excess of two decades.

The commissioning of the FRV *Tagula* as a tuna and baitfish research vessel became effective on July 31, 1971, when the vessel departed Port Moresby Harbour heading east-southeast. The stated two primary objectives of the cruise were (1) 'to develop an effective method of tagging skipjack tuna from the *Tagula* and commence a long-term programme with the ultimate aim of releasing 5,000 to 10,000 tagged fish' and (2) 'to investigate over a wide area the extent and nature of baitfish stocks suitable for use in the live bait fishery for skipjack' (Kearney, Lewis and Smith 1972).

It had taken at least a month longer than anticipated to get the vessel ready to begin tuna research. The engineers assured us that we would be rewarded for taking the extra time to make sure everything was 'ship-shape'. Their definition of ship-shape would prove to be considerably distant from reality.

We, the scientists, had been busy accumulating the necessary tagging and biological research equipment, which included 10,000 yellow plastic dart tags manufactured by Arthur E King and Company in Newtown, Sydney. We also had the net-making team at Kanudi make a bouke-ami net to catch bait. Fitting the net to the research vessel turned out to be a bigger problem than we anticipated: the *Tagula* was by no means the ideal length and shape for such a net. But we persevered, and in the end we got there. Details of the methods used in the whole of the research program, including the evolution of the design and construction of tuna tagging cradles, are provided in Kearney, Lewis and Smith (1972).

As cruise leader, I had the additional task of being the providore for both scientists and crew. We had to anticipate that it could be up to three months before we could reprovision the vessel. I had no great difficulty with the food for the scientists – lots of frozen chickens, prawns, legs of lamb, whole beef rumps and appropriate vegetables, both fresh and frozen, to be supplemented with additives like rice, spaghetti, bread, butter and breakfast cereals would keep us out of trouble. I was assuming, of course, that there would be limitless supplies of fresh fish and occasional mud crabs and lobsters. But when it came to the crew's rations, my ideas were significantly different from those of the captain of the vessel, Reg Eginton. If we were going to take the likes of a dozen frozen chickens and half-a-dozen legs of lamb for the scientists, I maintained that we had to take at least the same number of such items for the Papua New Guinean crew. Reg advised that his extensive experience with Papua New Guinean seamen was that I should not worry about trying to match what they would eat with what we would, even though they had the services of the same cook and cooking facilities

as we did. We should instead supply copious quantities of canned mackerel and bully beef and lots of rice. Of course, all of us would have access to as much fish as we could eat. I found fundamental discrimination in food to be at least demeaning, perhaps to the point of having racist overtones. I was the boss, so we took a dozen frozen chickens and eight legs of lamb and quite a bit of other European staples for the crew, but acknowledging Reg's experience, we also took four cases of canned mackerel and three of bully beef, and loads of rice.

Right from the outset of this cruise, the vessel was plagued by serious mechanical and electrical problems. But the waters we covered and the small islands we visited on the way to Samari were so spectacularly beautiful that complaints were minimal. You could not buy a holiday cruise to take you to the places we went. Reg planned the cruise such that we anchored in the lee of a new island late almost every evening. We were such a novelty to the residents on these islands, many of whom had not seen a visitor for quite some months, that they paddled out to greet us, and hopefully trade, in large numbers. We would always top our list of items we wanted from them with mud crabs and lobsters, whereas their desirables were almost always dominated by plug tobacco. Ice cream was popular, though.

I well remember one small island where we were greeted by at least a dozen men in dugout canoes, including the island's one schoolteacher. He wanted to chat, in English, for as long as we would keep talking. When I questioned him about what we might be able to give him, his immediate reply was newspapers. I was most impressed yet disappointed that it had not occurred to us to offer a schoolteacher such. I quickly gathered up three or four of the most recent *Sydney Morning Herald* editions that we had and offered them to him. I could immediately see by the look on his face that he was not overjoyed. 'Haven't you got any Australians?' was his verbal response. Again, I was impressed; the standard of the journalism, or perhaps the national perspective of the journalism in *The Australian*, was driving his priorities! But when I asked him why he preferred *The Australian*, his response was, 'The *Herald* won't stay alight'. He didn't want newspapers to read but rather in which to roll his tobacco so he could smoke it. It was widely accepted across Papua New Guinea at the time that *The Australian* was the superior medium for this purpose.

So poor was the mechanical state of the *Tagula* that in the 138 days of this first cruise, on only 21 of them was even a small amount of tuna fishing possible. Even the calculations behind the engineering of the modifications

that had been made to the vessel were found seriously wanting: the bait tanks that had been designed and purpose built for the *Tagula* were found to hold almost twice as much water as the vessel could safely carry on deck; the first time the vessel ventured on to the open sea with them full, they had to be emptied as a matter of emergency; the 5-inch bungs in the bottom of the two tanks had to be immediately punched out to get rid of the water as quickly as possible while the vessel was maintained heading into the prevailing swell. A wonderful load of bait had to be sacrificed. But of more consequence was that all fishing had to be suspended until the tanks were removed and severely modified. The *Tagula* had to go back to port for this to be undertaken, and it took several weeks.

Unfortunately, this was not the end of our mechanical problems with the *Tagula*. It was only in the last week of the cruise that gear and techniques were serviceable to the extent that tagging could be commenced; only 74 skipjack were tagged and released on the entire cruise, which was concluded in Madang Harbour on December 15, 1971.

Considerable baitfish research was possible during the cruise, even though the areas able to be covered were greatly restricted by the mechanical problems with the vessel. More than 160 species of baitfish were identified from 37 locations. Eleven of these species had not previously been recorded from these waters (Kearney, Lewis and Smith 1972). Catches of bait taken at most sampled sites were at least adequate in both quantity and quality to support skipjack fishing.

The baitfish survey had already confirmed that there were numerous places not currently in use by the joint-venture fleets where tuna fishing boats could be based, at least in the short term. The utility of these sites would be greatly increased if vessels were able to be adaptable in where they baited and fished. We were already confident that bait supply would not be the limiting factor on the total size of the Papua New Guinea skipjack fishery. Of course, the importance of bait in the management of skipjack fisheries in Papua New Guinea and other Pacific countries and territories was to be greatly diminished in some countries, with the progressive displacement in later years of pole and line with purse seining, which did not need bait.

The frequent returns to port of the *Tagula* did afford the opportunity to assess the skill of the providore in catering for both scientists and crew. The first inspection of remaining supplies was possible after little more than two months. The remaining rations for the scientists were almost exactly

as predicted, but when I checked the crew's rations, it was immediately obvious that in the future I should leave this aspect of planning to Reg. The crew had disposed of two chickens (probably one meal), one leg of lamb, the whole of the four cases of canned mackerel and all but two of the many tins of bully beef. To this day, I struggle to understand why the crew didn't eat more chicken and lamb: they had the same cook as the scientists did, and the way they hung around the window to our mess area looking for leftovers when we were concluding our meals left no doubt that they really enjoyed such food. I accepted the Papua New Guinea axiom that nothing flavoured a kilo of rice more efficiently than a can of mackerel in oil, but our crew really did like chicken or lamb with baked potatoes! The saving aspect of my 'providoring' was that when, at the end of the cruise, I asked the crew how the food had been so far, they were extremely positive. They had had what they wanted. But they agreed with the scientists; more lobsters and mud crabs would be appreciated. The supply of these two cherished commodities was less than ideal because we did not normally spend more than one night at each location, and it commonly took the locals at least overnight to catch lobsters and mud crabs.

Despite the severe restrictions imposed by the poor mechanical state of our research vessel optimism among scientists and crew remained: the last week or so of the first cruise had confirmed that we could indeed catch and tag tuna from the *Tagula*, even if so far only in small numbers: the modifications we were making to the vessel and our fishing practices were working, and we were confident that we would continue to improve. The improvements we had developed for handling baitfish had already enabled us to double the amount of bait we could carry in our smaller-than-ideal tanks. The dawning of the new year would bring with it rekindled enthusiasm. The two local senior research assistants, James Aewai and John Tokias, deserved special recognition for their contributions to the maintenance of the positive attitudes of all crew.

The second phase of seagoing skipjack research began in March 1972 when the FRV *Tagula* departed Madang Harbour headed for the south coast of New Britain. An excellent bait haul was made in Gasmata Harbour, but the vessel was once again rendered unserviceable by a major mechanical failure on April 4; it had to remain at anchor until it could be towed to Rabaul for repair. Only 14 skipjack had been tagged on this cruise so far. By April 17, despite continuing mechanical problems, 101 skipjack were tagged, only to have a serious illness by one crew member necessitate the urgent return *to* Rabaul. Serious mechanical problems were to continue right through to the

end of June. By the middle of the year, I had become so disillusioned with the vessel that I concluded a greater priority needed to be given to the use of aerial surveys in the survey component of our goals. I approached the appropriate individual members of the executive of DASF seeking funding to commence an aerial survey program.

On July 2, circumstances finally began to improve on the *Tagula*: 240 skipjack were tagged in one week and 59 tagged in the next. However, the good times did not last; the *Tagula* had to again be towed back to Rabaul in the second week of August.

In September 1972, DASF approved AU$60,000 for the aerial survey of Papua New Guinea's tuna resources, with the two primary objectives being:

> 1. to investigate the distribution and abundance of surface-schools of skipjack and other tunas in waters adjacent to Papua New Guinea; and 2. to derive an estimate of the proportion of the resource lying within twelve miles of the recognised land mass, i.e. within territorial waters and the declared fishing zone.

The survey was approved to commence in mid-November 1972.

This time, I did accept that experience was necessary. A highly qualified professional tuna spotter was required. Largely on the advice of Kevin Williams of CSIRO, and my wife Hope, who had worked on the CSIRO aerial survey team the year before she moved to the University of Queensland, Ted O'Connell, from Eden, Australia, was recruited.

Further good news was to come in October when more than 2,000 skipjack were tagged on the *Tagula* and almost another thousand in November. The impact of this success is clearly evident in the statement in the log of the cruise relating to this period: 'Finally operating at something approaching full potential' (Lewis, Smith and Kearney 1974).

The cruise was completed on December 13 when the *Tagula* arrived back in Madang. A total of 3,469 skipjack and 115 yellowfin tuna had been tagged; extensive biological samples from all major pelagic specimens had been captured and analysed; and 150 species had been identified by baitfish research (14 of which were new records for the area surveyed). New baitfish handling techniques were developed that greatly improved the survival of baitfish loaded into the bait tanks. The two major goals of the research programme, to tag 5,000 to 10,000 fish and to describe the extent and nature of baitfish stocks, were no longer mere fantasies.

The year 1973 brought with it the first broad-scale analyses and publication of the results of the Papua New Guinea tuna program and the integration of these results into consideration of how the knowledge of Papua New Guinea's tuna resources had been advanced. There were four basic components to these results:

1. Fishing and tagging techniques onboard the FRV *Tagula* had progressed to the extent that the lower boundary of the program's original goal of releasing between 5,000 and 10,000 tagged skipjack seemed certain to be met within the year, and the more ambitious target was likely to be approached within the next two years. Perhaps even more importantly, the recapture of tagged fish and the provision of the necessary information on where and when they had been recaptured, and in sufficient cases, the size of the fish at the time of recapture, was continuing to improve. Our tagging techniques had been proven; the fish survived being caught and tagged, and the tags stayed in. In fact, by the end of 1974, 8,748 tagged skipjack had been released, and 593 of these had been reported as recaptured. The quantity of adequate data on where and when the fish had been recaptured and what size they were at that time continued to grow.
2. The collection and analysis of data on the performance of each and every boat in the Papua New Guinea fishery since its beginning in 1970 had progressed to the point that by the end of 1973, the database was sufficiently detailed to match that in the world's biggest tuna fisheries.
3. The aerial survey of surface schooling tuna confirmed the value of this type of exploratory research under the circumstances that prevailed in Papua New Guinea at the time. The relevant results were summarised in Kearney, Lewis and Smith (1973):

   > Over the survey period the best concentrations of skipjack indisputably centred on the Eastern Bismarck Sea. *It was estimated that the commercial skipjack catch taken from this area during the survey represented only a fraction of the tonnage seen. Furthermore, the joint venture fishing boats were rarely observed in areas of optimal school density, even though these areas usually lay withing their range*. Other good concentrations of skipjack were seen in areas not worked at present by the joint venture fleets for example around the D'Entrecasteaux and Trobriand islands.

   There was an overall conclusion that the efficiency of the total skipjack fishery could be considerably improved using one or more light planes and fish spotters to direct the fleet to the most productive areas,

perhaps on a weekly or, at times, a daily basis. The efficacy of doing so on a cooperative basis between all joint-venture companies was worth consideration.

4. The survey of new areas where adequate quantities of baitfish could be taken had been extremely successful. Furthermore, the taxonomic and biological data collected and analysed, predominantly by Barney Smith and Tony Lewis, on more than 160 potential baitfish species greatly increased the utility of the knowledge of Papua New Guinea's total baitfish resources. The changes that were developed for baitfish capture and handling techniques, particularly for the more delicate species, greatly increased the utility of Papua New Guinea's total baitfish resources to support pole and line fishing for tuna. *It was established that the supply of bait would not be a limiting factor in the ability of the skipjack fishery to be expanded.*

At the commencement of the Papua New Guinea tuna program in 1971, very little was known about the country's skipjack resource, its distribution around the country and its dynamics that may make it more or less vulnerable to fishing pressure inside or out of Papua New Guinea's territorial waters. We had quickly eliminated the first premonition I had brought from Australia, that *Katsuwonus pelamis* was a temperate species, but the second, that it was predominantly coastal in distribution, would require further investigation. The aerial survey found that there tended to be more schools of skipjack within territorial waters (within 12 miles of land), but the schools outside 12 miles were much larger (an average of 20.1 tonnes outside compared to 6.6 tonnes inside). Once more tags were returned, more light could be shed on the dynamics of schools and the movement of individual fish.

In the first few months of the Program, tag returns were restricted to fish that had been caught by the Papua New Guinea joint-venture vessels. Then one or two came back from the Solomon Islands. I remember well the excitement that was created by the first tag to come back from the expanding purse seine fishery to the east and north of Papua New Guinea. It had been recovered in a tuna cannery in American Samoa. It arrived at Kanudi in a letter from Dr William Bayliff, a senior scientist at the Inter-American Tropical Tuna Commission (IATTC) in La Jolla, California. This tag return had more impact on me than any other in my life, even though it came with very little information. The only information Dr Bayliff had for certain was that it had been recaptured by one of the large purse seine

vessels operating in the waters well to the east of Papua New Guinea. But its recovery was enough to confirm several of my assumptions that had underpinned the selection of tagging as our primary skipjack research tool. We now had confirmation that at least some of our tags were staying intact after having spent at least days in the refrigerated hold of a distant-water fishing vessel and the rigours of the unloading and processing that was associated with tuna canneries. Plus, of course, the major revelation that at least some skipjack from Papua New Guinea were moving well beyond the confines of Papua New Guinea's local fishery.

I immediately wrote to Dr Bayliff explaining the importance of this tag, as it represented our first confirmed venture into the wider world of tuna research, and asking him if there was anything we could do to get more information about its recapture. Thus, was started a professional friendship that was to intensify and last the best part of 40 years. As it turned out, this first tag was quickly followed by many more from tuna canneries and even from distant-water fishing vessels themselves. Bill Bayliff was to do a great deal more work for us in tracking down which vessels had unloaded at the time of each tag recovery and where they had been fishing. The excitement continued to mount.

A month or two after our tags started coming in from the broader Pacific, I received a letter from Dr James Joseph, the director of the IATTC, explaining that he knew very little about the Papua New Guinea tuna fishery except that it was an exciting development, both for skipjack fishing in the Pacific and the science of research on skipjack. He asked for any information I could send him. As an international, dedicated tuna research institution, the IATTC was, in my opinion, as close as any institution could be to nirvana. And as the director of this august institution, Dr Joseph must be very close to God. I was determined; one day, I was going to meet this guy. I sent him copies of all of our publications, which at that time numbered about three preliminary reports, and drafts of a couple more we had in preparation and summary tables of our catch and tag return data, to date.

As the tag returns mounted, it became increasingly apparent that Papua New Guinea skipjack were intimately connected to at least some of the fish to our east and possibly north and south. I started combing through the scientific literature to sniff out what I could about the possible stock structure of skipjack in the broader Pacific and how this might help the assessment of Papua New Guinea's tuna fishery. It was not easy to get a lot

of information in Papua New Guinea in the days well before the internet and personal computers, but within about a year, with considerable help from the DASF librarians, who were extremely helpful, I had compiled enough for a publication on exactly this subject: its title was 'The stock structure of skipjack resources and the possible implications on the development of skipjack fisheries in the central and western Pacific'. It was published by the Food and Agriculture Organization of the United Nations (Kearney 1975b). Researching for this paper in combination with the growing evidence from our tag recoveries convinced me that the sound management of Papua New Guinea's skipjack fishery was going to require much more information on the stock structure, growth, mortality and breeding behaviour of skipjack over a much bigger area than we were currently researching. But nobody else was doing research that would adequately fill these gaps. So began my quest to answer the question, where to from here?

But first, back to 1973, which continued as a pivotal year for my thinking on what the priorities should be for the research that was necessary to support the managed development of Papua New Guinea's tuna fisheries. If only all other Pacific Island countries were doing research like we were, the problem of where our skipjack were coming from and what cooperative management arrangements would be necessary to manage them would at least be a tractable issue. The success of our tagging to date firmly cemented, in my mind, that tagging was the way to go. It was, however, already apparent that by only releasing tags in Papua New Guinea's waters, we were never going to be able to assess the full population of fish that may come and go from those waters. To get a proper stock assessment from tagging, we would need releases across the whole area of the distribution of the stocks we fished, preferably evenly distributed across the total area of the distribution of the stock.

I made up a list of what island countries and territories might be able to support some form of a cooperative tagging program, but apart from two obvious candidates, Solomon Islands and Fiji, which had existing pole and line fisheries for skipjack, and perhaps one or two of the French or American territories, the chances of getting a good coverage of participants looked bleak. But the total skipjack fishery in the Pacific was growing rapidly, and the world's biggest fishing nations were expanding their involvement. Why not consider expanding our Papua New Guinea operation into an international venture? Would it be possible to distribute tagged fish sufficiently evenly across the whole area of the populations of skipjack that contributed to the total fishery? We would certainly need a great deal better research vessel

than the *Tagula*, but the distant-water fishing nations already operating in the area of interest, particularly Japan, certainly had such things. Worth thinking about! And thinking I did a lot of.

I discussed the concept of a broader tagging program with Barney and Tony. Barney thought that the concept had merit, but to do it properly would be too expensive, probably hundreds of thousands of dollars that would be impossible to raise. I thought it best not to tell Barney that my first estimate of the cost of what I was thinking was millions of dollars, not merely hundreds of thousands: $2 million over three years was my first estimate (guess!). Even $2 million was only half what the cost of the Skipjack Programme would turn out to be ($2 million in 1973 equates to $23,933,000 in 2026). Tony was even less supportive. He thought that there was still so much good work we could do in Papua New Guinea that I should not give serious thought to deserting the team by moving on to do something that he thought would not work anyway. He thought it would be impossible to get sufficient fish tagged across the whole area to enable an adequately precise estimate of population size. I did not often disagree with these two guys, so I went away to think some more.

Barney was, as usual, right; the big project I was suggesting would be extremely expensive, and I did not, as yet, have a plan of any sort for how I would raise the money. But my commitment to the concept was such that this did not put me off. I would simply have to work on it.

I had respect for Tony's concerns, but they did not worry me. I believed I had good reason not to agree with him. I was strongly of the opinion that the research program we had already implemented had been sufficiently successful to answer most of the questions it was designed to address:

1. We had solved a huge problem for the joint-venture companies by convincing them to change to night-time fishing for bait.
2. We had surveyed the baitfish resources of Papua New Guinea and developed new baitfish capture and handling methods and techniques, to the extent that we were confident that bait supply would not be a limiting factor for the development of Papua New Guinea's pole and line fishery.
3. The aerial survey had clearly demonstrated that there were more than enough skipjack present to sustain the fishery, even in the areas that were being fished, and there were many areas of good concentrations of skipjack that were not being fished.

4. We had overcome the limitations of our research vessel to at least release enough tagged fish in good condition to enable sufficient tag returns with adequate data to answer the primary question of the independence, or otherwise, of the skipjack stocks in Papua New Guinea waters. We had documented that Papua New Guinea skipjack travelled huge distances to at least many parts of the central and western Pacific Ocean, and that the skipjack being captured in the Papua New Guinea fishery were only one or two years old, and they grew fast.
5. We had identified the additional major aspects of skipjack stock dynamics that we needed to know, but for which further research in Papua New Guinea would not provide the answers, including: Where do the skipjack in Papua New Guinea come from? How will the development of other skipjack fisheries in the region, or outside it, impact Papua New Guinea's fisheries? How big is the total population of skipjack to which Papua New Guinea has access? What is the likely maximum, or optimum, catch from this population?

I believed I now knew enough about skipjack population dynamics to know the limitations of what I knew. But most importantly, I believed I knew what I needed to know to give the Papua New Guinea government adequate advice on what research was necessary to support the management of their skipjack fishery. What everybody with an interest in the skipjack of the central and western Pacific, including the Papua New Guinea government, needed to know was this: How would the fisheries developing in many different areas of the broader Pacific interact with each other? Did they all need to be managed as part of one big fishery?

I was convinced that the big research program I was considering was the only way we were going to get the necessary answers. Papua New Guinea needed answers to these questions as much as any Pacific Island country or territory did, perhaps more so, as it had the biggest domestic fishery in the region. Researching the Papua New Guinea skipjack fishery had been a fantastic experience, for which for the rest of my life I would remain extremely grateful. But it was in all parties' interests for me to move on. If I were to leave Papua New Guinea to pursue the broader perspective, I would not be deserting the team. In any case, at this time, I did not have a project to move on to. Where was I going to move to?

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