Research for Sustainable Development of the Tropical Rock Lobster Fishery in Torres Strait

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Introduction

The commercial fishery for the rock lobster, *Panulirus ornatus*, in Torres Strait began in the late 1960s and is now a major source of income for Torres Strait Islanders. It is a diver spear-fishery as these lobsters will not enter pots. Divers operate from 4-5 metres outboard powered dinghies, sometimes using hookah equipment but often simply free-diving with a short spear. Most divers return their catch to island based processors or semi-permanently moored mother vessels. There are, however, about a dozen smaller mobile freezer boats which each support a team of 2-6 dinghies. Since the fishery began effort has increased substantially, whether in terms of number of participants, boats, days worked per year, or hours worked per day. Current catch per hour is about one-third of historic levels, hence there is a continuing need for quality assessment and monitoring of the lobster stocks to provide advice to management.

Lobster Life History

Past research has provided basic information on the life history of the rock lobster. Larval development occurs in the open ocean and takes about six months, after that lobsters settle into small holes in the seabed in Torres Strait and grow very quickly, recruiting into the fishery about one year later at ~100 mm tail length. These juvenile lobsters are fished until they are just over 2.5 years old; at this time (August-October) most emigrate from Torres Strait and catch rates decline markedly. Tagging studies have shown that some of the emigrating lobsters moved north-east into the Gulf of

Papua (GoP), undergoing reproductive development at the same time. The emigration causes major changes in the lobster population on reefs in Torres Strait:

- nearly all the larger (> 2+ yrs) lobsters disappear, those remaining are mostly small;
- more females emigrate than males, leaving an excess of males; and
- there is a major synchronous moult before the emigration.

The tagging studies also showed that lobsters on reefs off the north-east Queensland coast do not participate in the migration across the Gulf of Papua but in general tended to move to the south-east. Nevertheless, despite the different movement patterns, the Torres Strait and Queensland coast populations are part of the same genetic stock. The migration into the Gulf of Papua used to be targetted by trawlers and catches up to ~200 t were recorded, but this activity was banned in 1984. Some of the migrating lobsters move as far as the coastal reefs of the eastern Gulf of Papua where there is a breeding ground. This breeding population forms the basis of a seasonal artisinal fishery which lasts only a few months during the summer.

This fishery existed in traditional form prior to written history but the origin of the lobsters became known only in the early 1980s. The lobsters on these Papuan coastal reefs are in very poor condition – the muscle tissue is wasted and the body tissues are mostly water. Measurements of the water content of the tissues confirm that the physiological condition of lobsters declines as the migration moves across the Gulf of Papua and through the breeding season. This lead to the hypothesis that almost all lobsters die after breeding and is why the Papuan artisinal fishery lasts only 2-4 months.

More recently, research has confirmed the catastophic mortality of the Papuan breeding population and the focus of current research is to quantify parameters such as lobster abundance, fishing and natural mortality, settlement and recruitment, and the extent of the breeding grounds. This information is essential for sustainable development of the fishery through sound stock assessment.

Mortality of Breeding Lobsters

It was important to establish the fate of the Papuan breeding population as this affects understanding of the fragility of the stock. The disappearance of the population each year could be due to very high natural mortality, or over-exploition by fishermen, or emigration off the coastal reefs into deeper water. In the summer of 1988/89, several complementary research methods were used to distinguish between these alternatives.

The catch of the artisinal fishery was monitored – it was low early in the summer, but increased abruptly following two major influxes of lobsters into the shallow fishing grounds; each pulse was followed by rapid decline.

Tangle nets were deployed off the main fishing grounds to reveal whether lobsters moved off the reef into deeper water. Lobsters were caught in the nets, but the catches occurred in two pulses around the full moons of January and February, prior to major influxes into the fishery. These lobsters were all females that had moved off the reef to hatch their eggs and tagging showed they moved back onto the reef. The tangle nets did not catch any lobsters when the fishery declined through March, and it was concluded that lobsters do not emigrate off the reefs into deeper water.

The effort in the fishery was also monitored and the declining catch per unit effort (CPUE) following the two influxes was used to estimate mortality rates. For males the total mortality rate (Z) was ~12 and for females it was almost 12. These rates are extremely high, as a Z of ~4.6 corresponds to 99% mortality in a year, and for lobsters in Torres Strait Z is estimated at only ~0.4.

Several hundred lobsters were tagged and their recapture rate was recorded; from this it was estimated that 20-30 thousand lobsters were present on the coastal reefs at the start of the season and another, independent, total mortality estimate of Z~10 was obtained. About one-third of the tags were returned, suggesting that the fishermen were responsible for about one-third of the decline; the remainder was attributed to catastrophic mortality probably due to the stress of migration and breeding.

This conclusion was supported by measurements of the water content of digestive gland tissue which confirmed that most lobsters were in very poor physiological condition. The important implication from this conclusion is that each year, settlement into the fishing grounds may depend entirely on the breeding success of the preceding years migration which should therefore be protected; there is no buffer against poor recruitment that would exist if there were several year-classes of breeding lobsters.

Source of Recruitment

It was important also to examine whether larvae hatched from coastal reefs in the eastern Gulf of Papua could be carried by the currents and later settle back into Torres Strait. Ocean current drifters were deployed in deep water off the Papuan coastal reefs, these buoys were tracked by satellite and revealed a clockwise gyre in the north-west Coral Sea that could potentially return larvae to Torres Strait. A buoy released by AIMS also showed this pattern.

Stock Abundance

In any fishery, knowledge of the abundance of the stock is very valuable, it is also the central parameter in fisheries science. In 1989, lobster abundance in Torres Strait was estimated using almost six hundred 4x500 metre transects distributed over the ~25,000 square kilometre area of the fishery. The methods involved laying a 500 metre transect line onto the seabed from a dinghy. Two divers swam down each side of the line with a two metre measuring rod counting all lobsters in the four metre wide path. The narrow path meant that the habitat could be searched intensively and in any case lobsters were generally conspicuous. Lobsters were seen virtually throughout Torres Strait (including areas that are rarely, if ever, fished), with densities varying from ~2 to > 100 per hectare. The exception was the north-central area mid-way between the Warrior and Orman Reef complexes where the silty-muddy seabed was unsuitable for lobsters. From the transect data it was estimated that there were between 11-17 million lobsters in Torres Strait, of which about 8 million were legal sized. The population was sampled as it was surveyed; thus, the relative abundance of year-classes in the survey population could be compared with the fishery catch. In 1989, divers fished about 10% of the stock, which indicated that fishing mortality (F) was about 0.1. With knowledge of the stock abundance and the average catch, and estimates of the natural mortality rate from a number of sources, it was possible to make a rough

estimate of the potential long-term sustainable yield. These estimates averaged just over 600 tonnes, and contrast with the current average catch of ~250 t.

In June each year after the stock survey, monitoring of the lobster population has continued at 100 of the 600 sites used in 1989, to determine the relative abundance of all the year-classes and provide an index of stock abundance relative to 1989. This smaller survey showed that the 1990 fishable (>legal size) stock was only about half of that in 1989. It also indicated the size of the year-class about to enter the fishery (recruitment); the 1990 recruiting year- class was about the same size as the 1989 recruiting year-class suggesting that the 1991 fishable stock would be about the same as in 1990. This annual monitoring survey is an ongoing project and will also provide estimates of growth and mortality rates.

Catch Monitoring

The island-based sector of the fishery is likely to be the most susceptable to over-fishing as it lacks mobility. Consequently, the catch and effort of the Islander fishery based around Mabuiag Island is monitored annually during June and July. The CPUE of the Islanders in mid-1990 was similar to 1988, but significantly less than in 1989. This decline was expected from the results of 1989 stock survey which revealed a relatively small pre-fishery (1 +) year-class that became the fishable stock in 1990. The catch monitoring also enables comparison of the CPUE of hookah and free-divers and has shown that the catch-rate of hookah-divers is greater than free-divers. However, the disparity in catch rate of divers using the two methods has steadily reduced over the last three years; there does not appear to be any reduction in catch-rate of free divers associated with continued use of hookah.

Breeding Grounds Survey

Until recently, the coastal reefs of Papua were the major known breeding grounds. Yet only a few tens-of-thousands of lobsters arrive on these reefs each year though several million emigrate from Torres Strait. It was suspected that most lobsters move to other, largely unknown, breeding grounds. In the 1989/90 summer, a small submarine was used to survey deeper waters of the Gulf of Papua and far northern GBR for other lobster breeding grounds. The five metre submarine was able to dive to 400 metres and had been used for similar work in the USA. The Gulf of Papua was divided into more than a dozen sectors and two echo-sounder transects were run across each sector, a sub dive was made at the edge of the continental shelf and at two other random points on the shelf and at other sites where the seabed profile looked suitable. Very few lobsters were found in deep water near the coastal reefs of the eastern Gulf of Papua or in the remainder of the Gulf of Papua, but high densities were seen on a number of deep reef habitats (~75m) on the edge of the shelf of the far northern GBR. It is possible that this area supports the major breeding population for the Torres Strait fishery. However, it is necessary to confirm the extent of the far northern GBR breeding grounds and the abundance of these breeding lobsters, as well as determine whether these lobsters suffer catastrophic mortality after breeding as occurs in the breeding population of the eastern Gulf of Papua.

Modelling

Data collected in the field research projects is continually synthesized to provide up-to-date outputs relevant to management. During the past year information has become available for a preliminary analysis of yield-per-recruit (YPR), (ie. an estimate of how many grams each recruiting 1.5 year-old lobster is likely to contribute to the fishery in future). This involved examining the balance between growth rates and death rates and calculating the change in catch at different minimum sizes and fishing intensity. Currently, with natural mortality (M) estimated at about 0.4, minimum size at 100 mm and fishing mortality (F) at ~0.1 the calculated YPR is ~20gms, which is very low compared with other lobster fisheries. If the current fishing pressure is not changed, the yield would increase slightly if the minimum size was reduced, but very small tails are difficult to market. Nevertheless, the minimum size certainly does not improve yield. It is also possible to increase yield by increasing the amount of fishing (then a minimum size eventually becomes important), but care must be taken not to overfish and reduce future recruitment to the fishery. Exactly how much fishing is appropriate is probably the most important question to answer. After the stock survey it was estimated that the potential average yield may be about 600 tonnes, but the method used was only intended to give a preliminary result.

Another method of estimating potential yield involves consideration of escapement, (ie. the proportion of the population that escapes fishing to emigrate and breed). At present, the average annual catch of the fishery is around 240 t, fishing mortality is about F=0.1, and natural mortality is probably about M=0.4; thus, on average about seven million lobsters emigrate from the Torres Strait fishing grounds each year. This is about 93% of the numbers that could emigrate and breed if there was no fishing at all; in comparison with almost all other fisheries, this is a very high escapement rate. Theoretical fisheries yield models predict that production is maximized when the breeding stock is reduced to half (50%) of unfished levels, though empirical studies suggest that this level may lead to overfishing. For many stocks, a 30% reduction may be more appropriate (this is very conservative compared with the situation for western rock lobster where the exploitation rate is about 60%). Even so, an escapement of 70% in the tropical rock lobster fishery would permit a substantial increase in catch as, with four times more fishing mortality (F=0.4), the projected yield would be just over 800 tonnes on average and escapement would be about 74%. The projected yield would vary from year to year, but could be assessed annually by the research program. These considerations suggest that increased Islander effort should be encouraged in the diver fishery without concern about reducing subsequent recruitment.

Summary of Ongoing and Proposed Research Activities

Islander catch will be monitored (annually) to provide size-frequency distributions of the catch, and catch and effort information.

The lobster population will be sampled in the middle of each year to provide an unbiased annual index of the relative abundance of all year-class in the Torres Strait population, an index of the strength of the recruiting year-class, and growth and mortality estimates.

Studies of the ecology of newly settled juvenile lobsters will document the distribution of puerulus settling sites, micro-habitat use by post puerulus, early growth and mortality, and assess the potential impact of trawling on settlement grounds.

Devices intended to collect the last larval stage, or puerulus, are being trialled. The settlement of the puerulus stage is the earliest that recruitment to the fishery can be assessed. In future, these devices could be deployed widely and sampled regularly to provide an index of settlement, the first feedback of changes in the fishery, catch forecasting, and the timing of settlement.

The information arising from field research will continue to be synthesized into models of the fishery and outputs from these models will provide information of value for management.

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