PROPOSED STRATEGY FOR THE RECOVERY OF THE KALEDUPAN COASTAL FISHERIES

Discussion document
prepared by
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Frontispiece

Map of Kaledupa reefs with main fishing grounds marked. Pop. 17,000 (est. 15,000 Kaledupan Butonese; 2000 Kaledupan Bajo), est.1345 fishers, over 17 Desas. Ambeua, Buranga, Langge, Mantigola, Peropa & Sampela house 75.5% of fishers (May, 2003). Kaledupan near-shore fishing grounds cover approximately 78km of fringing reef and approximately 135km^2 of reef flat.

1. Introduction

The reef fisheries around Kaledupa are in decline, with perhaps irretrievable socio-economic and ecological consequences for the island. Kaledupa is more reliant on fishing as part of its' economy than any of the other islands in the Wakatobi (containing 49.6% of the fishers in the Wakatobi, Local Government Census, 2000) and the impact of a collapse in the reef fishery will be particularly hard for communities such as the Bajo who are dependant on fishing for cultural identity and subsistence living. Fortunately there are a number of organisations with relevant skills available in the Wakatobi to assist Kaledupan communities to avoid the collapse of the fishery. With these organisations working together, the fishery could be sustainably managed to increase yield resulting in higher catch levels for local fishers.

This report is a discussion document to propose a way in which the various organisations operating in the Wakatobi can collaborate together. The report starts (section 2) by describing the evidence that a continued decline in the Kaledupa reef fishery is the inevitable outcome of the existing open access unrestricted fishery. Section 3 describes the work done to date on the development of a Kaledupa island-level fishery management structure and how this can be meshed with the COREMAP proposals. Section 4 describes how a registration scheme, which is a necessary precursor to implementing many of the needed management changes, can be introduced by the Fisheries department to protect the fishery and can be policed by National Park rangers. Section 5 describes the management options that are available once the registration process is implemented to help the fishery recover.

Section 6 describes the monitoring programme that needs to be implemented to provide the feedback data necessary to assess the effectiveness of the various fishery management measures adopted. Many of the resources needed to implement the changes needed to protect the fishery are already provided within the COREMAP and TNC/WWF funding programmes. However, there are a few additional requirements that would need to be funded in order to ensure success and these items are discussed in section 7.

2. Evidence for the potential collapse of the Kaledupan fishery:

There are a number of lines of evidence that all point to a looming collapse of the Kaledupan fishery: fisheries catch surveys, fish counts in the water from dive surveys, interviews with fishers, collapse of some commercial fisheries; data on massive recent increase in fishing power in order to maintain the catches and the lack of normal bionomic controls in the Kaledupa system to prevent a collapse occurring.

Fisheries Data

Operation Wallacea fisheries surveys performed between 2002 and 2004 have shown two disturbing elements to the fishery; a very low catch per unit effort (CPUE) in comparison with the other areas and a very high percentage of immature fish being exploited.

Figure 1 compares the catch per unit effort (CPUE) of various Kaledupan fishing techniques with the results from similar fisheries. The CPUE values for all the techniques used on Kaledupa are very low compared to those in the relatively under exploited fishery in Papua New Guinea, and are very similar to heavily exploited fisheries on the Spermonde Archipelago, SW Sulawesi and Malalison Island, Philippines. Both Spermonde and Malalison are noted as fisheries with serious problems where fishers have fished stocks down to a level (and/or the habitat has been degraded to a point) where CPUE will only decline further with increased effort.

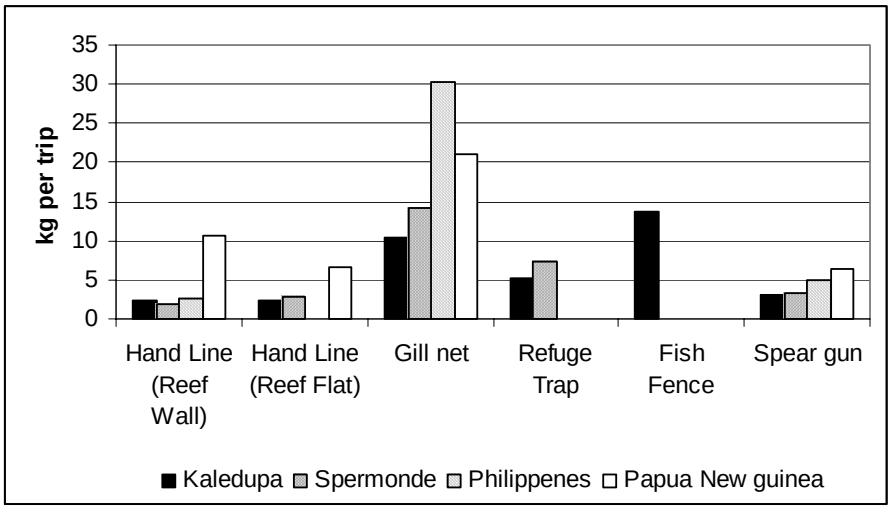


Figure 1. Catch Per unit effort in kg per trip, for Kaledupa (2003), West Spemonde Archipelago, Malalison Island (Philippines) and Papua New Guinea.

Figure 2 gives a second even more worrying line of evidence. Length frequency data from catches from the three techniques, which form the majority of landings on Kaledupa (gillnets, fish fences and Bubu traps), show that most of fish caught are still immature. The size of maturity of the same species varies in different parts of the World so the data presented

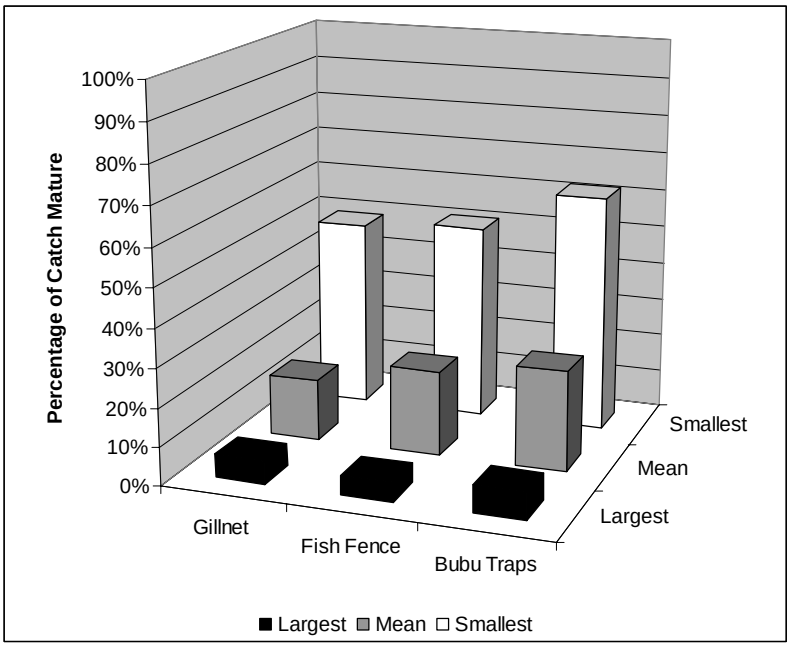
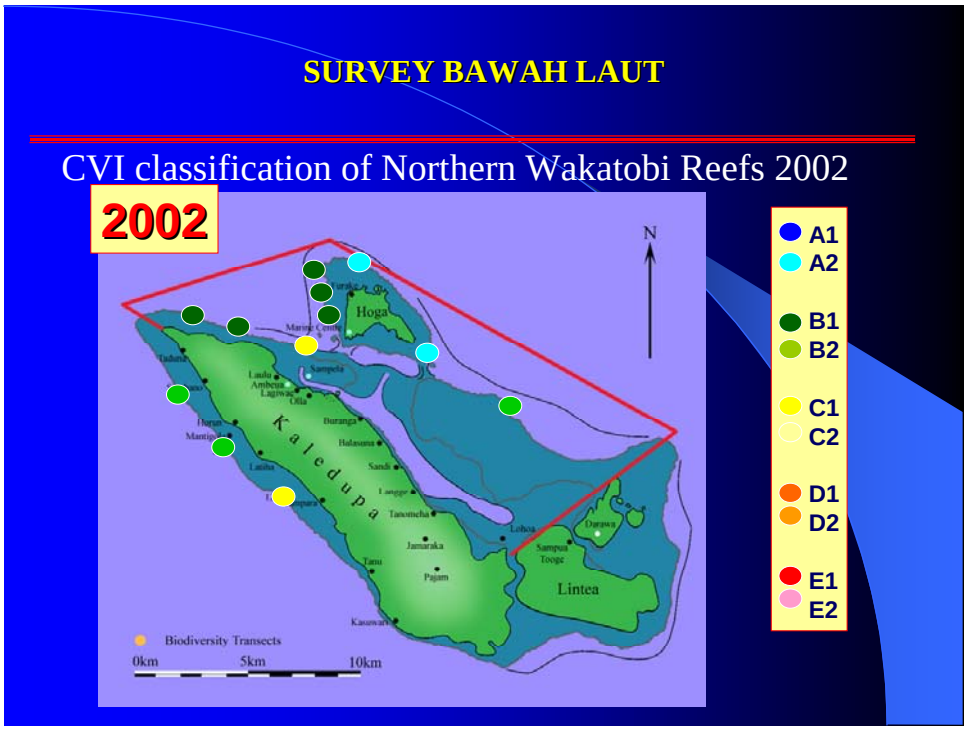


Figure 2. The percentage of mature fish caught per technique, when mean, smallest and largest sizes for maturation from FISHBASE are used.

include the range of maturation sizes quoted by FISHBASE. Assuming the Kaledupa fish stocks mature at the average size for the species then the majority of the catches comprise immature individuals.

Fish counts and observations on habitat damage

Fish diversity and abundance and coral diversity and cover data have been completed on a



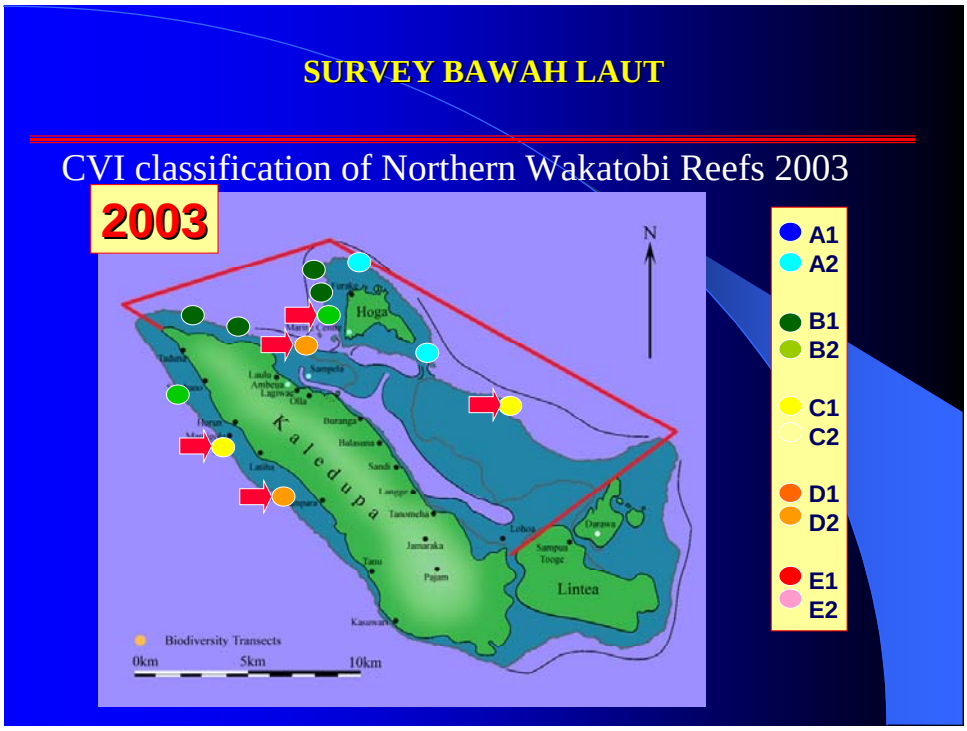


Figure 3 A comparison of the coral value index figures in 2002 and 2003 from a number of sites around Kaledupa

number of transects around Kaledupa each year from 2002 (Figure 3). These data when expressed in the form of a Coral Value Index (developed by Operation Wallacea staff) which grades the quality of the reefs from A to E and the abundance of fish from 1 - 5 shows a

substantial decline in the fish stocks in just one year (one site from B1 to B2; one site from C1 to D2, one site from B2 to C2 and one site from C2 to D2).

Evidence from fishers

There is significant evidence from interviews with fishers in Kaledupa of a loss of species, reduction in catch weight and species specific reduction in average size of fish in the last 5 years (fig. 4). Elders have particularly noticed long term changes and are the first to point out that they believe that increased use of nets has caused a decline in fish abundance.

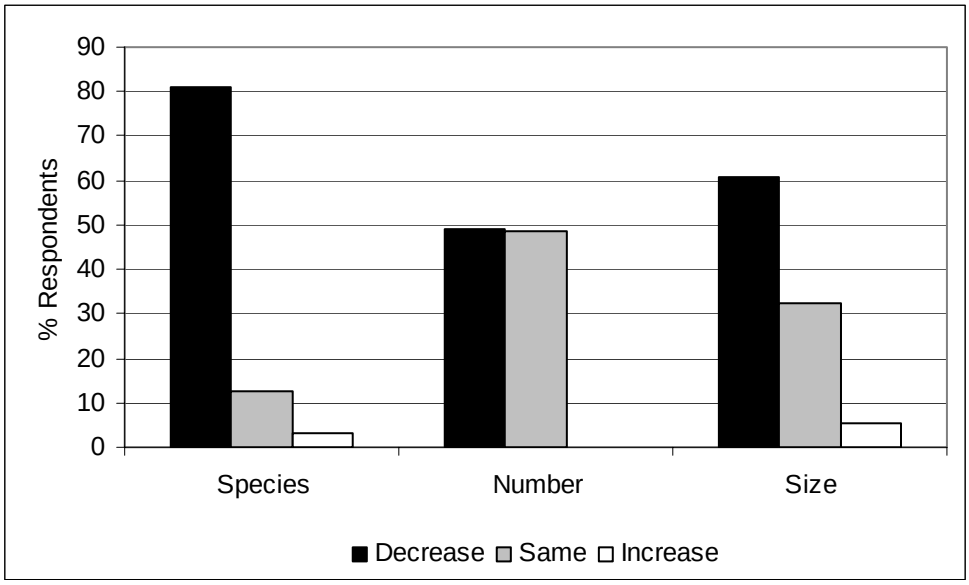


Figure 4. The perception of 315 Kaledupan and Bajau fishers interviewed in 2003 and 2004 on the changes in fish species, numbers and sizes caught over the last 5 years, using the same fishing technique and fishing period.

Extinction of some commercial fisheries

There have been visible losses of near-shore predators between 1996 and 2002 identified by Operation Wallacea divers but also by fishers, reflected by low CPUE for line fishing on the Kaledupan reef walls (Figure 1). Local middlemen have described how they cannot depend on locally caught shark or groupers, which now almost exclusively come from the outer atolls. Lobsters traders have also complained that the local stocks dropped to below a commercially sustainable level between 2002 and 2004, and also depend on stocks from atolls. The impact of commercialisation has also been seen in octopus catches, which have increased dramatically in the last 3 years. Though octopus are resilient to heavy fishing they are predicted to collapse by experienced middlemen who have come to Kaledupa to trade in octopus. Previous studies of fisheries in Rodrigues of the same species of octopus support the belief that octopus can be fished heavily up to a point after which stocks drop unexpectedly to below a fishable level for many years. Middlemen trading in sea cucumbers have complained of a decrease in size in commercially important species and as a consequence, species that were previously non-commercial are now being collected for sale. All middlemen have identified a decline in stocks and have voiced a need for size limits to protect their livelihoods, though middlemen continue to collect irrespective of size as they know others will if they don't.

Increase in fishing effort

The recent movement from subsistence to economic reliance on the fishery during the last 10 years, combined with rapid increase in population, is creating more fishers who must fish harder. The increase in economic importance of Kaledupan fisheries is reflected by the development of the export of live fish and lobster (1993), and fresh octopus (1995) and tuna (1997) in the last seven years. Since the 1950's there has been a rapid increase in fishing power, from low efficiency techniques used at a subsistence level, to highly efficient commercial techniques (fig. 5), which with the opening up of new export markets has compounded stock depletion.

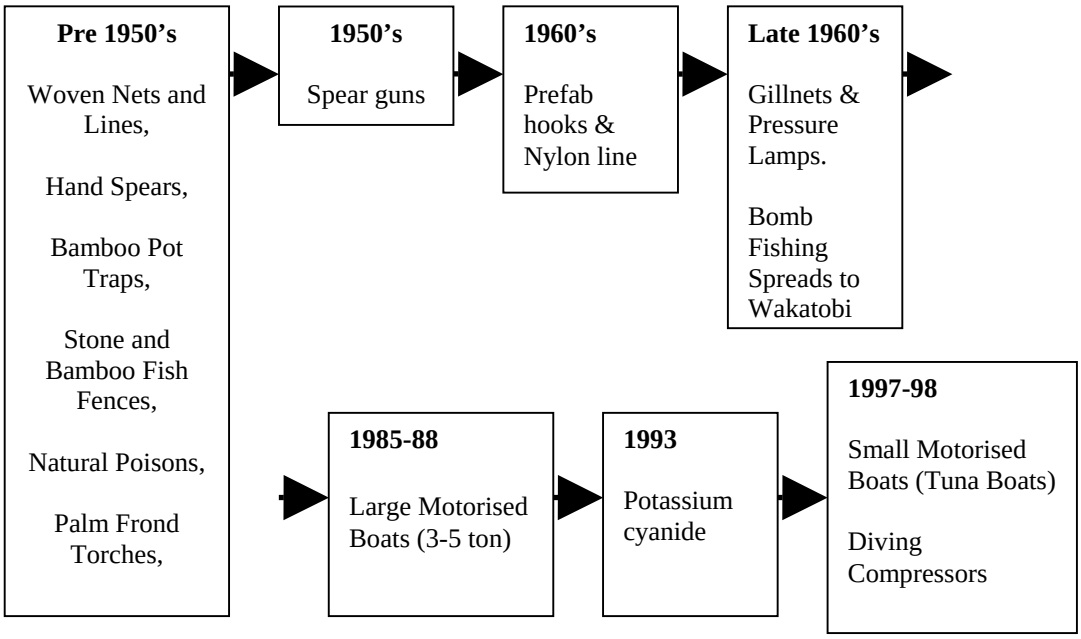


Figure 5. Change in fishing techniques (power) around Kaledupa in the last 60 years.

Many fishers comment that they have changed fishing techniques in recent years from line fishing to net fishing or net fishing to fish fences, to maintain catch levels as the catch dropped in previous techniques. This shift from low efficiency to high gear efficiency, indicates a drop in standing stock. In 2002, 2003 and 2004 there were 37, 70 and over 100 fish fences respectively, and it is this development to more efficient techniques with biologically inappropriate size selection that represent a major management concern.

Lack of bionomic controls on the fishery

In fisheries in other parts of the World the costs of fishing (boats, gear, labour, fuel etc) eventually limit fishing effort as the costs of fishing outweigh the financial benefit (known as a bionomic equilibrium). In the absence of viable economic alternatives within an open access fishery, people tend to enter the fishery for employment and subsistence. As a consequence, fishers' incomes are very low as they "chase the last fish". This is compounded, as there is zero labour cost and low capital investment in gear, as well as strong economic and cultural barriers to exit the fisheries. A bionomic equilibrium is further removed as Kaledupan Butonese fishers do not rely on fishing as their only source of income. Again the bionomic equilibrium is removed for Bajo fishers because subsistence fishing forms the basis of traditional Bajo culture. Fishing effort is therefore likely to continue to increase with decreasing stock, only to be restricted at a point where it is physically impossible to catch fish. In this case fishers will never be able to rise above the poverty level.

Conclusions

These are strong indicators of a collapsing fishery, and in the absence of long term catch data, it can be concluded that fishing at its present effort and efficiency is both ecologically and economically unsustainable. There are no fishing restrictions, management or even guidelines on how to fish responsibly, and little or no local knowledge of the effects of local fishing methods on future stocks. In this current situation economic collapse of the fishery is inevitable and difficult for fishers to understand, as in previous generations stocks have been plentiful enough for subsistence living. The reality of the situation is that there are too many fishers fishing too hard and removing too many immature fish with inappropriate gears for the area and habitat quantity and quality around Kaledupa, to support. Furthermore, current stocks available are too depleted to supply the amount of fish needed now and in the future, without effective fisheries management.

3. Management structures and technical expertise required

Fortunately many of the political structures, technical expertise and funding needed to implement the necessary changes in the Kaledupa fishery are already in position or due to start shortly. The Wakatobi has recently been awarded Kabupaten status with its own government in Wanci, with a new fisheries department and capacity to develop fisheries laws applicable throughout the Wakatobi. Funding from COREMAP is also due to start shortly which is aimed at providing the resources necessary to sustainably manage fisheries in the Wakatobi. TNC/WWF have established a base in Wanci and are working closely with the National Park, which is responsible for conservation of the reefs throughout the Wakatobi. Their input and funding has enabled the National Park team to become an effective enforcement organisation against bomb and cyanide fishing and provides the basis for a policing structure that could be expanded to help with fisheries enforcement activities. Operation Wallacea has established three research centres (Hoga, Ambuea and Sampela) around Kaledupa to complete research into fisheries, biodiversity and socio-economic aspects of reef management and has been running research programmes in the area since 1995. Operation Wallacea has large data sets on Kaledupa fisheries, reef biodiversity and socio-economic aspects and has published over 100 papers in peer reviewed journals and university dissertations on different aspects of the Kaledupa reefs.

In 2003, Operation Wallacea in conjunction with local government on Kaledupa helped with the formation of a representative body for fishers on the island called the Kaledupan Stakeholder committee. This committee, which is due to be renamed the Kaledupa Fisheries Committee, comprises representatives from each village, who form the legal representatives of all registered fishers in Kaledupa district. Representatives can vote on issues as directed by fishers within their community but the weight of their vote is proportional to the number of fishers registered within each village to account for the disproportionate number of fishers per village. The committee also contains other leaders of the community including, Kaledupan NGOs, Police, Army, Women's groups, and is chaired by the Camat.

The Kaledupan Fisheries Committee already has members in each village willing to start the Reef Watcher scheme proposed by COREMAP and aid National Park expulsion of external and destructive fishers, with the installation of a radio network. Furthermore, there is a general enthusiasm that at last something can be done about the mounting fishing issues stemming from over fishing.

Given 1) the large amount of information already known about the Kaledupan fisheries, 2) the importance of fishing to Kaledupa in comparison with other islands in the Wakatobi, 3) the imminent collapse of the fishery unless action is taken, 4) the existence of the Kaledupa Fisheries Committee 5) and the strong political will on Kaledupa to take action to halt the

fishery decline, it would be advantageous to concentrate initial work under the COREMAP scheme on Kaledupa. The changes necessary for Kaledupa could be fast-tracked with similar changes introduced on other islands as the background information and political structures were developed. COREMAP is going to need example sites where the successes of the scheme can be demonstrated to Kabupatens elsewhere and Kaledupa is in a unique position to fulfil this role.

Figure 6 gives a schematic diagram for how the COREMAP fisheries management and enforcement structures are proposed. The Coastal Community Empowerment Board (CCEB) will manage COREMAP implementation throughout the Wakatobi with the executive function being provided by the Project Management Unit (PMU). The CCEB will have input from the fisheries department, National Park, TNC/WWF, Op Wall and other NGO's. On each of the 4 main islands though an island level committee is proposed to advise on management of fisheries in their area and to co-ordinate the training officers, community facilitators, village motivators and reef watchers. The existing Kaledupa Fisheries Committee could perform this function. Technical input to the Kaledupa committee could be provided through Operation Wallacea by use of the existing research centres and programme.

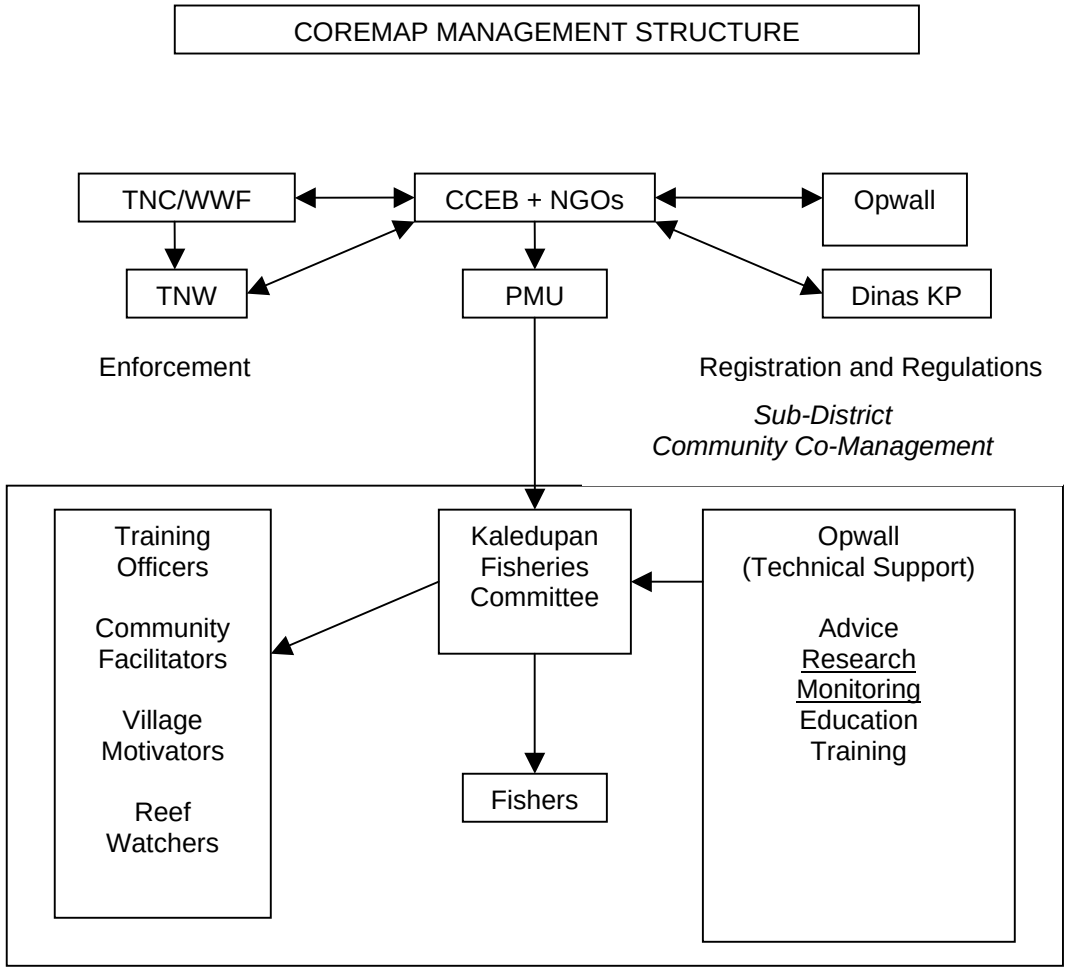


Figure 6. The proposed Kaledupan Fisheries Management Program model superimposed on the COREMAP management structure to clarify Operation Wallacea's proposed technical support and co-management role.

The enforcement role would be best performed through the National Park who have the personnel, equipment and expertise to run an enforcement programme and it would be

valuable to extend their remit to include fisheries enforcement and supervision of the reef watcher teams.

4. Registration

Categories of registration

The concept of registration has enormous support from Kaledupa communities. Out of 200 randomly selected fishers interviewed in 2004, 198 agreed with the registration of themselves, boats and gear, in the understanding that they would become legal fishers and external fishers around "Kaledupan waters" would be removed. The introduction of such a scheme should therefore be relatively trouble free. However, the registration process should be concentrated on three aspects of the fisheries: motorised boats, the most effective types of fishing gear and the middlemen/exporters who are controlling the commercial fisheries. With these categories of registration the necessary fishery management measures could be taken and would avoid the complicated system necessary to register line or spear fishers, reef gleaners or the numerous canoes. The Wanci government would need to introduce legislation to make the scheme legally enforceable. It is proposed that a fisheries department office is established on Kaledupa and equipped to organise and implement the registration scheme.

Motor boat registration

All boats belonging to Kaledupa based fishers would be licenced by supplying a large numbered metal plate to permanently attach to the prows of the boats. Display of these plates would allow external boats to be easily identified by Rangers. Annual registration would be required which would allow young people wishing to enter the fishery to be registered and licensed, and unused licences to be voided.

The following conditions could be fixed for all boat licence recipients;

1. Licenses would only be issued to those born in or permanently living within the Kaledupan district.
2. Licenses can be removed from persons convicted of bomb, cyanide or compressor fishing within Wakatobi waters for a time period at the discretion of the Kaledupa Fisheries Committee.
3. Licenses can be removed from persons convicted of infringement of restrictions named within Wakatobi fisheries law for a time period at the discretion of the Kaledupa Fisheries Committee.
4. Licenses legally oblige licensees to allow Kaledupan fisheries surveyors to examine and measure their catch.
5. Licenses entitle the licensee to vote on Kaledupa Fisheries Committee decisions.

Fishing gear registration

The three types of fishing gear currently having a disproportionate effect on the fishery are; fish fences, gill nets and bubu traps. All registered gear would have to display a numbered brass tag attached to it and the licence holder would have had to complete a form describing the gear (eg length of net, mesh size etc). The Rangers would then check all nets and bubu traps being seen operated during their routine patrols both to ensure that a brass licence tag was being displayed and that the description of the fishing gear matched the registration details for that numbered tag. Unlicenced gear would be impounded by the Rangers. The licence holder would be able to use his licence tags on new gear of the same type. Bubu traps for example tend to be replaced every 3 months so the tag would simply be attached to the new trap. This would also apply to gill nets but if an old net was replaced with a new net with different dimensions or mesh size then a new licence would need to be issued in exchange for the old licence.

Exporters registration

Under National Park regulations the export of any fish or invertebrates from the Park is illegal. However, in practice there are numerous commercial fisheries operating inside the National Park, which make a significant contribution to the Wakatobi economy. It is proposed that this should be recognised but that all exporters of fish and invertebrates are required to register. These licences would have a series of conditions attached to them allowing the Rangers to enforce minimum landing sizes, quotas or close seasons depending on the particular fishery requirements. The licence conditions could include:

1. Licenses would be required by the captain on board any boat, which is removing fish or invertebrates from Kaledupan waters or any person purchasing fish or invertebrates for export from Kaledupan waters.
2. Licenses would be open to all Indonesians who abide by Wakatobi Fisheries Law.
3. Licenses can only be issued to those agreeing to abide by minimum size restrictions per species, quotas or close seasons agreed by the Kaledupa Fisheries Committee.
4. Licenses would be removed from persons convicted of infringement of restrictions on size limits, quotas or close seasons for a time period at the discretion of the Kaledupa Fisheries Committee.
5. Licenses would legally oblige the licensee to inform Kaledupan fisheries surveyors, Department of Fisheries, Police and Rangers of when any catches were to be exported and to allow examination and measurement of invertebrates and fish to be exported.
6. Licenses would be removed if fish are found to contain cyanide or suffering from bomb damage, for a time period at the discretion of the Kaledupa Fisheries Committee.

5. Fishery management options after registration

In order to return to higher catch levels around Kaledupa, there has to be a significant reduction in fishing effort in the short-term. The registration process provides the mechanism by which this reduction in fishing effort can be applied fairly across the fishery by using a range of measures.

Gear restrictions

Technical restrictions on gear are aimed at allowing more immature fish to escape, to be available for capture in future years at a larger size. This increases the reproductive capacity of stocks, as well as increasing the size of fish caught in the future which is of economic advantage to fishers. Technical restriction measures could include: minimum mesh sizes for gill nets and fish fences, maximum lengths for gill nets, maximum lengths for leaders on fixed fences, location of fish fences etc.

Although technical restrictions will help in reducing the impact on immature fish, they cannot be relied on alone to effectively reduce the damaging effects of any technique to all species. This is because every technique targets many species, each of which has different sizes of maturation, activity patterns and body forms and thus require different sizes of mesh. Moreover, in the case of gillnets mesh size increases may target larger fish more efficiently, whereas with smaller mesh nets they literally bounce off.

Interview data from Kaledupan fishers in 2004 showed strong support for restrictions of net mesh size and some support for restrictions on net lengths (Figure 7). Surprisingly

restrictions on hook size for line fishers also commanded majority support although no such restrictions are proposed at this stage.

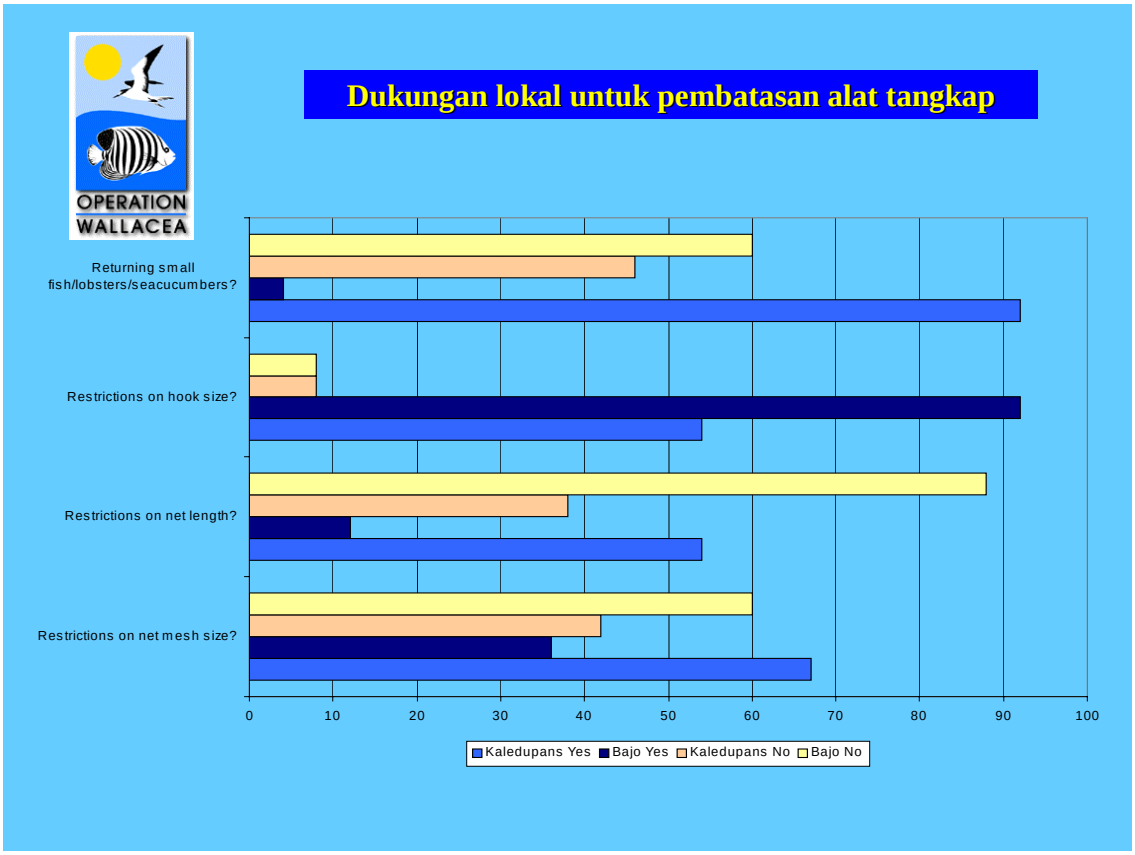


Figure 7. Percentage of 25 Sampela Bajo and 24 Ambeua Butonese fishers who agreed with restrictions on size of fished species, hook size, net length and mesh size.

Restricting licences

Registration of the three most effective gears allows the numbers entering the fishery to be restricted. However, to make an impact on fishing effort in order to allow the fishery to recover, there will need to be reductions in the numbers of registered fishing gears. This could be achieved by offering investment in alternative income streams (eg mariculture, chicken farming, sea cucumber ranching etc) to individuals in exchange for surrender of gear licences.

Figure 8 shows only a small majority of Bajo and large minority of Kaledupan fishers believe that there should be restrictions on the numbers of fishers allowed in the Kaledupa reefs. However, this question did not differentiate between gear types and was aimed at determining the level of support for restricting the rights of Kaledupans to have open access to the fishery. The proposed scheme would not restrict access to the fishery by Kaledupa fishers who would have open access for line fishing and reef gleaning. However, it is clear that additional socialisation of the reasons for fishing effort restrictions, will be needed to ensure majority fishery support. The linkage of investment for alternative income sources to licence holders who would surrender their licence would make this concept much more acceptable.

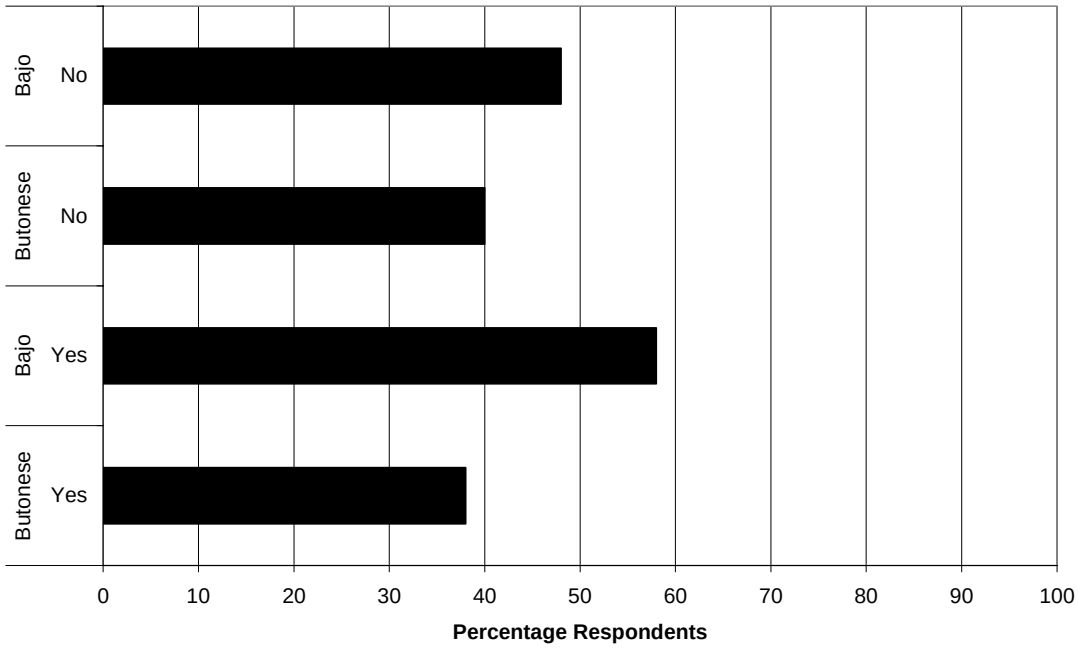


Figure 8. Percentage of 25 Sampela Bajo and 24 Ambeua Butonese fishers who agreed with restrictions on Kaledupan fisher numbers.

No Fishing Areas

No fishing areas have been shown to have very positive effects on fish stocks in surrounding areas by offering refuges to fishing pressure and forming broodstock areas which can supply the surrounding areas with larvae. At present the Hoga No Fishing Research Area (NFRA), which has been locally protected since 2000, is being presented to the Bupati to be protected by a local perda. A second No Fishing Area (NFA) has been proposed outside the Bajo village of Sampela to protect a section of diverse habitats and stimulate awareness of ecological concepts to local Bajo.

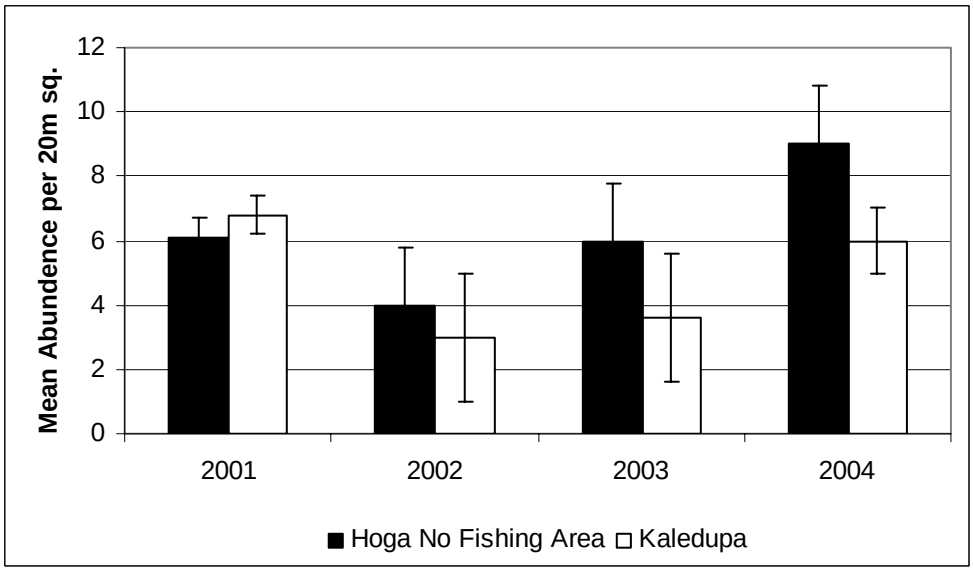


Figure 9. Grouper density within the No Fishing Research Area on Hoga and adjacent reefs of similar habitat structure on Kaledupa.

Monitoring of the Hoga NFRA illustrates that even small protected areas can have a noticeable impact on fish stocks within the protected areas. Figure 7 shows that the numbers of groupers in the Hoga NFRA have increased in the last 4 years. With community involvement and enforcement a network of small NFAs (perhaps centred around existing agar beds) could be a useful tool to the Kaledupa Fisheries Committee. It is estimated that constructing a management initiative to increase fishery yield using a network of NFA's requires 20-40% of the traditional fishery area to be designated as NFAs. However, the development of many NFA's should be seen as an addition to fisheries management, not a management tool to replace fisheries regulation.

There is majority support for the continuation of the existing Hoga NFRA, the establishmnet of a new NFA and the designation of agar beds as NFA's (Figure 10).

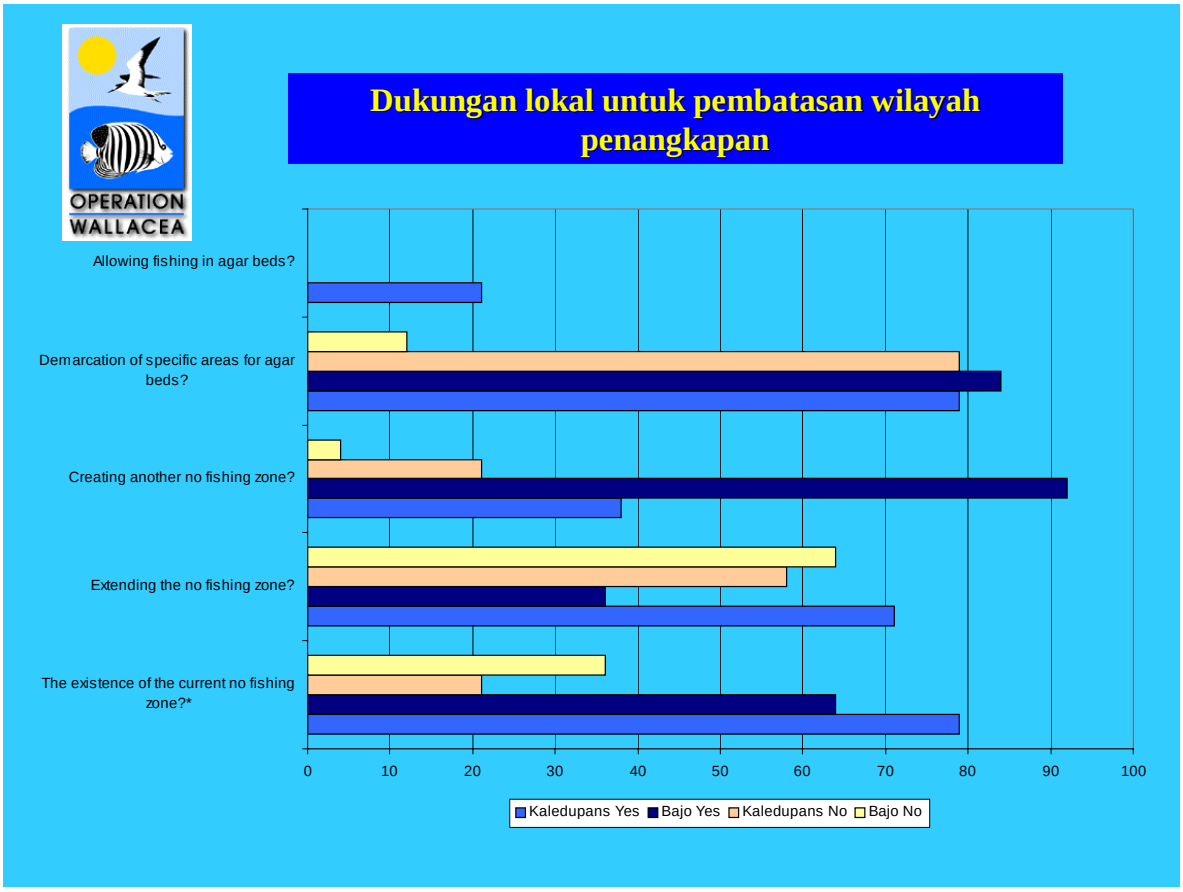


Figure 10 Percentage of 25 Sama Bahari Bajo and 24 Ambeua Butonese fishers who agreed with existing No Fishing Areas, establishing new NFA's and restricting fishing in agar beds

Protection of grouper spawning sites

The protection of fish aggregation sites should be considered for the long-term exploitation of a highly marketable stock. There are 3 main grouper spawning sites around Kaledupa; northern reef of Hoga, northern tip of Kaledupa and western fringe off Darawa. The complete closure of these sites would not be popular, stripping fishers of a needed source of income, and making it very difficult to enforce. However, it would be possible to close one of the sites. It is suggested that this should be the one off the north tip of Hoga since the fishers at this site would still have access to the nearby spawning site off the north tip of Kaledupa.

For the other two grouper spawning sites there should be strict enforcement by the Rangers of live fish exporters of both minimum and maximum size limits. The reason for the fixing of a maximum size limit for groupers is because large groupers produce a disproportionately larger numbers of healthy eggs in comparison to small mature groupers (fig. 11). Just a few large groupers can protect whole areas against recruitment failure caused by over fishing.

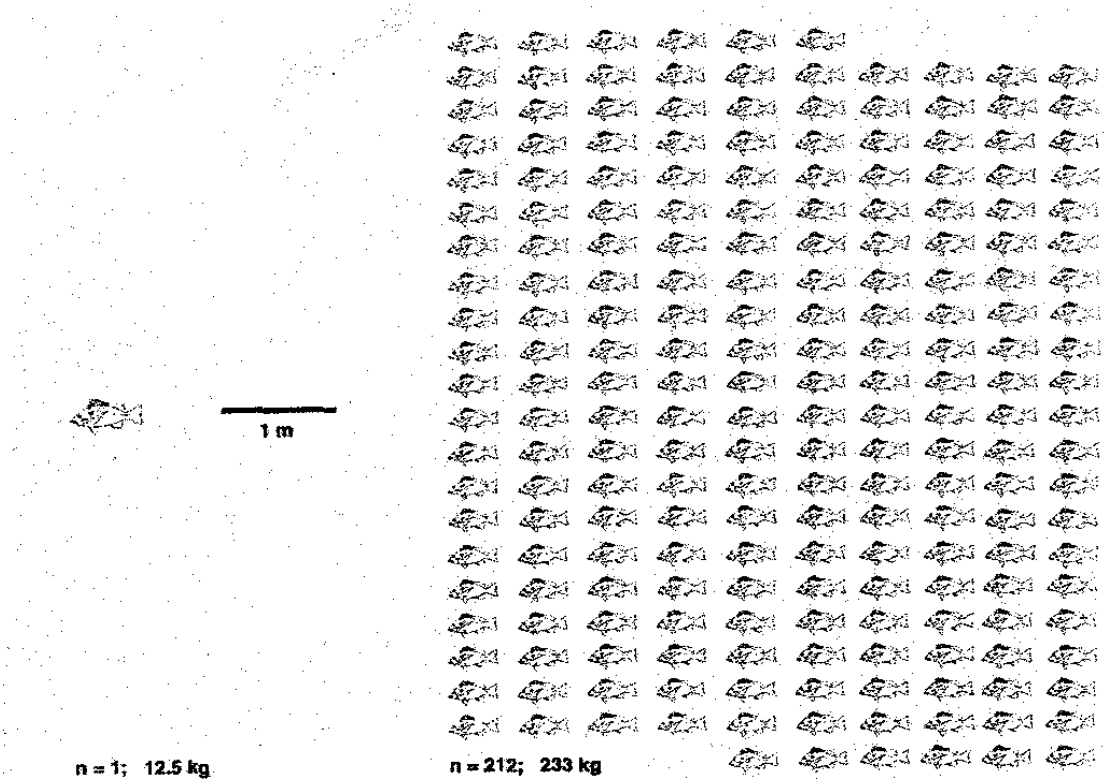


Fig. 11. The number of groupers of 2 different sizes needed to supply the same number of eggs (212 fish of 1.1kg vs. 1 fish of 12.5kg).

Octopus Closed season

Research on the octopus fishery suggests that they could be managed by the use of month long closed seasons, during the biannual mating and spawning season. As an octopus size limit cannot be set to protect immature individuals (because immediately after spawning the females die in their burrows), a closed season would be biologically more appropriate. The Rangers could enforce a close season by checking on purchases of the middlemen and exporters at that time of year. Ultimately, export quotas might be required for Kaledupa if the close season approach did not provide the necessary reduction in fishing effort.

Regulation of size restrictions through middlemen and exporters

Regulation of export of species to agreed size limits would be highly beneficial to long term sustainability of fisheries around Kaledupa. Restrictions on size limits of tuna, octopus, live fish and lobsters could be implemented efficiently through the middlemen and exporters licence system, as the bottleneck of exporters' boats collecting from around Kaledupa could be targeted by Rangers. For sea cucumbers, which are exported dried, enforcement would have to be through middlemen around Kaledupa buying the sea cucumbers prior to drying.

6. Fisheries Monitoring Programme

Factors affecting design of the programme

The Kaledupa Fisheries Committee will require fisheries performance data to provide feedback on whether the various fishery management measures they are implementing are having the desired effects and allowing the fishery to recover. Gathering reliable data on a fishery with scattered landing sites and multi species catches makes a monitoring programme difficult to design. In addition there are three levels of temporal variation that need to be accounted for by stratified sampling: seasonal, lunar cycle and daily. Seasonal variation of fishing areas and fish migrations is defined mostly by wind direction (figure 12), and though highly important is easily dealt with. However, lunar cycle effects on fishing techniques and effort (figure 13) have important repercussions for sub-sampling, particularly with limited resources. Spatial strata consist of villages used for to perform catch surveys, which are ideally where the majority of the catch lands. The number of villages that can be physically sampled per day depends on factors of seven, as the number of days of sampling where fishing techniques and intensity of fishing are similar falls within one quarter of a lunar cycle (i.e. seven days, see below). With a maximum of seven days from which to sample when constrained to one sampling team, a maximum of seven villages or landing sites can be sampled.

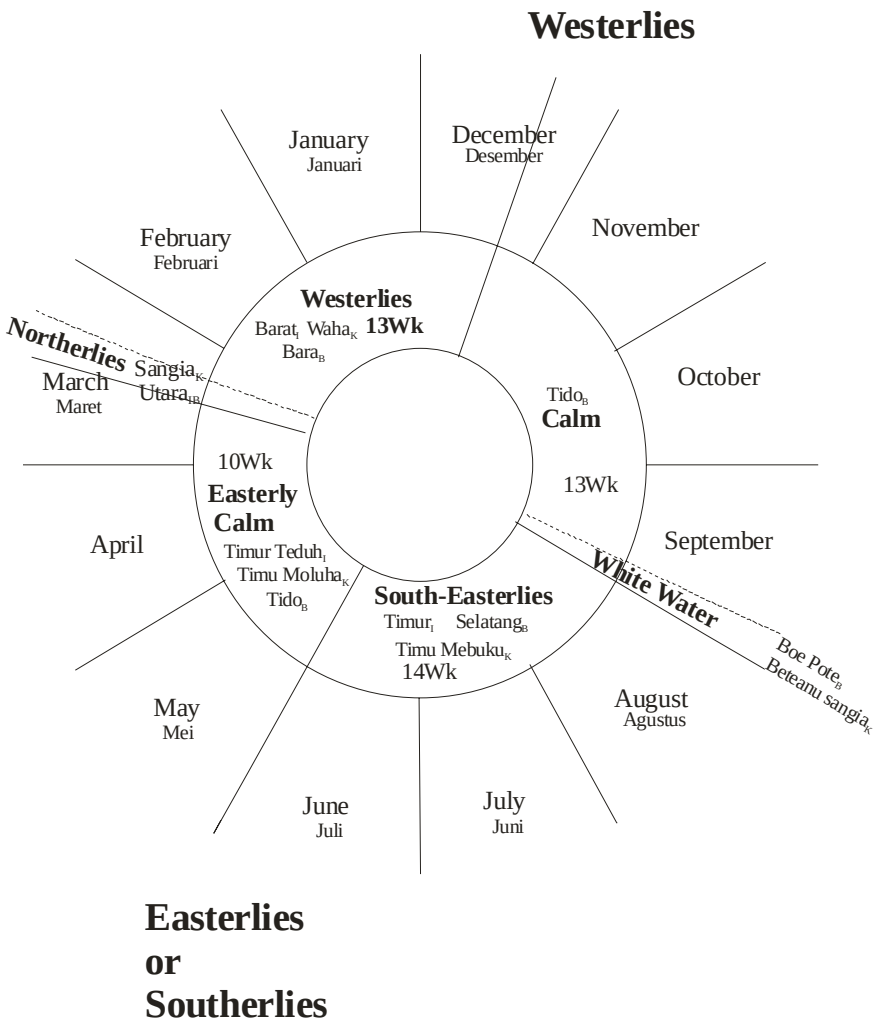


Figure 12. Fishing seasons of Kaledupa, where seasons are believed to be accurate to within two weeks.

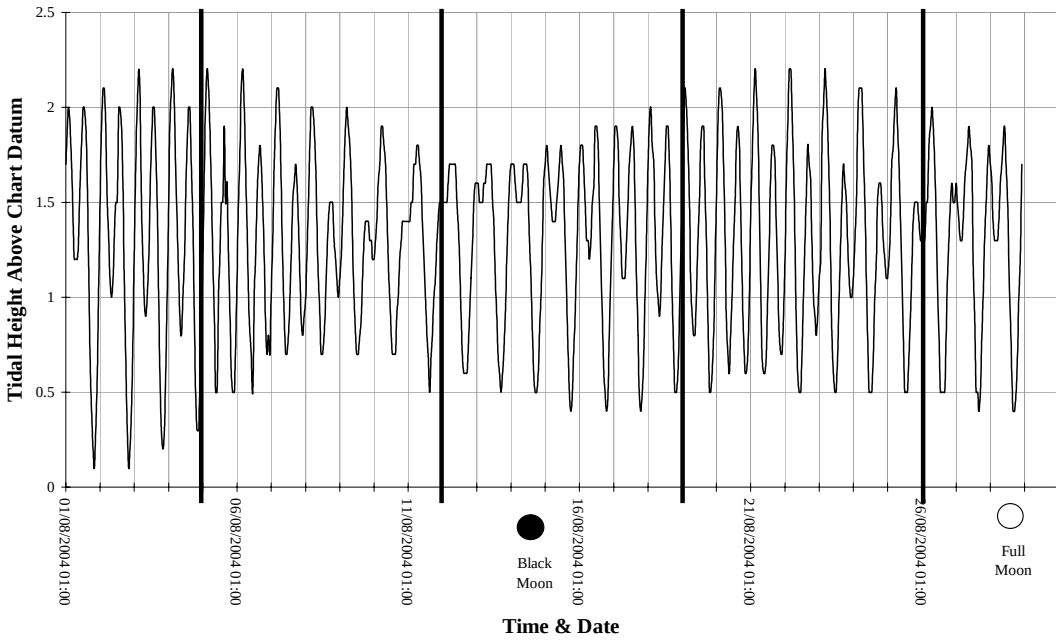


Figure 13. One lunar period of mixed semi diurnal tides around Kaledupa, divided in to four lunar sampling periods according to technique usage.

Components of the programme

A multidisciplinary approach utilising fishery catch and middlemen surveys, social data from interviews, ecological data from Underwater Visual Censuses (UVC) and monitoring of invertebrate exports are necessary to provide appropriate data sets for the assessment and management of fisheries. Without one of these components, judgements will be based on an incomplete knowledge of cause and effect.

Fishing catch analysis allows a direct measure of fishing on the ecology and economy. Monitoring of exports of commercially important invertebrates will provide data on total quantity and economic value of trade species in addition to abundance in commercial size categories. Social data reveals details of fishers' perceptions and behaviours, allowing managers to evaluate changes in responses and actions relating to regulations and management strategies. UVCs allow the collection of fisheries independent data to provide estimates of standing stocks on various fishing grounds, generates data on the quality of habitat essential to support the stock and indicates the level of destructive fishing techniques.

Structure of the catch survey programme

Due to the complexity of the fishery and limited resources, stratified sub-sampling is required. Care must be taken to ensure that sufficient numbers of samples of catch (data units) per strata are taken to generate a mean that is representative of what is actually occurring and allow statistically powerful comparisons (higher resolution) between strata. The exact number of data units needed relies on the examination of the statistical variance as values are recorded, and initially surveys should attempt to sample the same number of different techniques per day until the exact number of data units required is identified.

Catch sampling is aiming to obtain the best estimate of CPUE, and other catch components, within those sampling strata, but these values need to be multiplied up according to effort recorded from census information. An annual census would be required of all fishers in Kaledupa, which takes into account yearly and seasonal changes in total numbers of

technique used per village and total fisher numbers. The census should collect the following: name, village, number of people in residence, other incomes excluding fishing, number of techniques used per fisher and number of days per month of use per season, and details of equipment, including boats. Experience from surveys around Kaledupa demonstrated that effort values estimated by fishers during catch interviews and censuses occasionally suggested effort up to three times higher than observed. Effort values estimated by fishers based on their long term memory should be cross referenced with the observed number of fishers during catch surveys and the estimated number of days fishers say they fished in the last week. Cross-referencing should indicate the possible degree of error and should be quoted whenever referring to estimates based on fisher numbers.

Sampling should be based on the lunar cycle, setting the days of sampling into the 28 lunar days and 4 lunar sub sections according to the two periods of high tidal oscillation and two periods of low tidal oscillation, which affects technique usage. Because of the limit of two surveyors, which are required to work together, only one landing site can be sampled per day. Random selection of the villages that house the top seven highest numbers of fishers should be performed during one lunar sub-section. The strata of four lunar sub-sections eliminates inappropriate random sampling over the entire lunar period, as effort and catch per technique are correlated to the four sub-sections. During the catch survey the optimal number of each fishing techniques per day should be sampled. Sampling of the 24 hr period during each day is not required, as fishers rarely return outside 5:00 and 17:00hrs. Those days where catches occur at night usually fall over the full moon and black moon or when gleaning occurs during periods when low tides occur at night and sampling can be adjusted appropriately.

Data sheets should record the following for each data unit: date, name of fisher(s), technique, technique details (i.e. number of sets, mesh size, net length, number of traps), time spent fishing, time travelling to fishing area, name of fishing area and habitat, the total weight of catch, total number of each species (and each sex if wrasse or parrot fish) and the fork length of the first 20 individuals of each species should be measured. The total weight should be measured to the nearest 100g and the length of fish to the nearest 0.1cm. An estimate of the total number of fishers, fishing that day should be made.

A fishery scientist would accompany each of the exporters removing fish or invertebrates from Kaledupa to record the species, weights and value of all fish and invertebrates exported.

These surveys should produce the following indicators of sustainability:

- **Species composition of catch**. Units: percentage species composition (number of fish & weight)/ fishing technique/ fishing area/ season. The percentage of piscivores would be expected to increase as fishing effort is reduced.
- **Mean size of species in catch and estimated percentage of mature animals in catch**. Units: cm/ species/ fishing technique/ fishing area/ season & % mature animals/ species/ fishing technique/ fishing area/ season. This would be expected to rise as the gear restrictions aimed at reducing immature fish in the catches are introduced.
- **Catch Per Unit Effort (CPUE) of each technique**. Units: kg/ effort specific to technique/ fishing technique/ fishing area/ season. This would also be expected to rise if the management programme is proving successful.
- **Estimated Yield**. Ton/ km^2/ fishing area. The total yield should increase with better fishery management.
- **Total fishing effort** The data would be presented separately for each technique. For example for bubu traps it would the number of trap days fishing each month. The total fishing effort would be expected to decrease as the fisheries management programme was implemented.
- **Total export value and weight.** Units; Rp/kilo, total weight in Kg

Structure of the socio-economic monitoring programme

Much of the baseline assessment information need to implement a social monitoring programme in the Kaledupa area has already been carried out by Operation Wallacea, particularly in relation to the Bajo villages, which make up a large proportion of the fishermen in the area. Research has been carried out using both qualitative and quantitative data collection methods: which include interviews with key informants, semi-structured and open-ended interviews, scenario-based questionnaires, focus groups, participant observation and census data collection. This baseline information is essential as a background framework to the social monitoring programme.

Research in the Bajo village of Sampela has occurred since 1999. Amongst other projects, research has been carried out into Bajo perceptions of conservation and fish decline, perceptions of rules and regulations and their implementation, perceptions of government versus traditional institutions, decision making in the community, perceptions of ownership and responsibility in relation to the sea, Bajo notions of community.

These surveys will be conducted seasonally throughout Kaledupa to quantify perceptions and support for the various fishery management actions and the economic and social impacts of the fishery management programme. These data will be provided to the Kaledupa Fisheries Committee. The seven villages (including two Bajo villages) targeted for the fishery survey will also be used by the socio-economic monitoring team.

The programme will have the following elements:

Perceptions of change in marine resources

- Perceived importance of different fishing grounds: ranking exercise
- Perceptions of the change in fish and invertebrate stocks, including perceptions of catches of species during spawning
- Perceived human impacts: traditional fishing techniques, the development of modern fishing techniques and destructive fishing methods

Compliance with rules and regulations

Monitoring would be carried out through observation, secondary data from the enforcement body of numbers caught breaking which rules, and by an ‘anonymous’ records from the Reef Watchers.

Economic census

- Economic value of catches
- Bi-annual assessment of household income in the target villages
- Changes in the numbers of fishers in the target villages
- Changes in reliance on fishing income in the target villages
- Quantities of fishers participating in alternative income activities
- Monitoring of rate of income generated from alternative incomes

In addition to the various more detailed reports on aspects of the social or economic impacts of the fishery monitoring programme the following bi-annual socio-economic indicators would be presented to the Kaledupan Fisheries Committee as an assessment of the success in moving towards a sustainable fishery:

- **Levels of awareness of the fisheries regulations.** Units: percentage of fishers interviewed. This would be expected to rise to close to 100% as the COREMAP socialisation teams on Kaledupa began to function.
- **Perceived changes in catches**. Units: percentage of fishers reporting declining catches, increasing catches or no change in numbers, weights and species. If the

programme is effective an increasing number of fishers should start reporting higher catches.

- **Catch Value Per Unit Effort (CVPUE)**. Units Rp/ effort specific to technique/ fishing technique/ fishing area/ season & Rp/day. This would be expected to rise if the management programme was a success.
- **Household income levels.** Units: total income in rupiah per household and percentage attributable to fishing. At first the income from fishing as a percentage of each village economy would fall as fishing effort was reduced. The total household income though should rise during this time as replacement income activities are developed for those surrendering their licences. Within 2 years though the total income from fishing should start to rise as the catches improve.

Structure of the Underwater Visual Census (UVC) survey programme

The UVC survey methodology to be used is based on the methodology of the Secretariat of the Pacific Community, New Caledonia. The New Caledonia region is one of the few areas with a higher fish diversity than the Wakatobi region and hence, a suitable methodology to employ in this instance. The methodology employs the concept of swimming transects using scuba equipment and completing fish counts in an imaginary cube recording the numbers and species of fish and their distance from the central transect line.

The surveys would employ a stratified mixed sampling model, including both orthogonal (fixed) and nested (random) treatments, and divided into spatial and temporal treatments. The spatial treatments will include orthogonal measures of fishing pressure and habitat type. Fishing pressure can be divided into high, medium and low intensity from census and catch data. Habitat type can be classified as reef flat, reef crest and reef slope. Differences in habitat type between reefs will be negligible due to the high habitat spatial homogeneity. Eight reefs will be surveyed around Kaledupa and these are classified as West Hoga, North East Kaledupa, West Kaledupa North, West Kaledupa South, Lentea Besar, Lentea Kecil, Lahoa and Sampela. Within each reef, two survey sites will be selected at random within known fishing grounds and three replicate surveys will be carried out for each habitat at each site. The temporal element to the survey will be achieved by completing two surveys per annum at each site, dependent on fishing season.

In addition to the fish count data, each transect would also be surveyed for habitat structure and for signs of bomb damage, coral disease and bleaching, levels of Crown of Thorns starfish etc.

Additional temporal surveys would also be carried out at the three grouper spawning grounds.

The following bi-annual ecological indicators would be presented to the Kaledupan Fisheries Committee as an assessment of the success in moving towards a sustainable fishery:

- **Standing stock biomass and abundance of species components**. Units: numbers/ km^2/ fishing area/ season and ton/ km^2/ fishing area/ season. These data should be expected to increase as the fishery management programme takes effect.
- **Species composition and species diversity**. Units: % species composition (number of fish)/ fishing area/ season & diversity Indices.
- **Length frequency of species and estimated percentage of mature animals**. Units: cm/ species/ fishing area/ season & % mature animals/ species/ fishing area/ season.
- **Levels of bomb damage, coral disease, Crown of Thorns and other ecological indicators of reef damage.** These figures would be expected to be stable or to decline as the fisheries management programme was implemented.

Data on size of maturation

The data on percentage of mature individuals relies heavily on the accuracy of maturation data. Size of maturation is location dependent and no data are available for the Wakatobi. A programme of catch analysis for state of maturity is required.

Database

Due to the volume of data and its complexity analysis of fisheries data is not possible without the construction of a database. This database will utilise catch, UVC and social data to allow efficient analysis of the data sets. Analysis of the data will take the form of multivariate analysis and standard fisheries analysis packages (i.e. FiSTAT & ECOPATH).

7. Resources required

Much of the programme outlined above can be run from the planned COREMAP funding. For example the management structure including the Kaledupa Fisheries Committees is already contained within the COREMAP proposals. The system for socialising the changes needed and increasing the levels of awareness and information amongst each of the villagers is amply covered by the COREMAP proposals. The enforcement system run by the Ranger team with assistance from the Reef Watchers and additional support from TNC/WWF has all the components necessary to make it a great success. COREMAP also contains funding for the registration scheme throught he Fisheries department. The development of a new Kabupaten government in Wakatobi with the powers to pass local laws and with a good understanding of the needs to ensure sustainability of the local fishery, is also an essential component of the plan.

There are however, a few components that will require additional funding if the Kaledupa fisheries project is to be a success. In order to work successfully a consultant fisheries scientist with international expertise in tropical coastal fisheries is required to be on site for the first 18 months of implementation and to ensure the registration, fishery monitoring and reporting system to the Kaledupa Fisheries Committee is properly established. The COREMAP proposals contain provision for a single fisheries scientist for the Wakatobi. This post though will need to be heavily involved in ensuring effective local legislation and be dividing their time between all four of the main islands and the outer reefs. The time input available for Kaledupa will be insufficient to ensure successful implementation of the above project.

There will also need to be 4 local fishery scientists (2 Bajo and 2 Kaledupans) to complete the catch monitoring programme and data collection on size of maturation. In addition a team of 1 Bajo and one Kaledupan interviewers will be needed to complete the social change surveys and a short term social science consultant to design the survey methodologies and prepare the initial reports. The UVC surveys would have to be completed by two qualified divers for safety reasons. One of the pair should be a qualified scientist with experience of Underwater Visual Censuses and a track record in completing standing stock assessments, whilst the other surveyor should be a local biologist who could be trained in completing the UVC's. A short-term contract would also need to be let for development of the necessary fisheries database.

The Operation Wallacea Trust (a UK registered charity), which is currently managing the implementation of a $1 million GEF funded project for the Lambusango forests in central Buton would be keen to co-ordinate the implementation of the above aspects of the Kaledupa projects. The Operation Wallacea Trust was established to help communities in SE Sulawesi develop sustainable activities to ensure the protection of the conservation value of the reefs and rainforests. The Trust has close links with Operation Wallacea and has access to the international expertise within the multi-university teams of Operation Wallacea and their three permanent research bases (Hoga, Ambuea and Sampela) on Kaledupa.