A PROPOSAL FOR REFASHIONING A TRADITIONAL MANAGEMENT SYSTEM, *SASI*

(A Case Study of Trochus, *Trochus niloticus*, in Kei Besar, Maluku, Indonesia)

by

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ABSTRACT

This thesis examines the management system for trochus (mother of pearl) resources in Kei Besar, Maluku, Indonesia. Overexploitation of these resources caused the Indonesian government to impose a moratorium on harvest of wild stocks. However, the moratorium placed has created severe economic stress on coastal communities for which trochus had been an important source of income. Prior to the moratorium trochus stocks were managed locally by a system known as *sasi*, which involved periodic harvest closures enforced by a set regulations derived from local traditions. The hypothesis investigated in this thesis is that a co-management system, added to *sasi*, can replace the current moratorium by establishing a sustainable resource use regime which combines the traditional regulations with modern scientific knowledge.

The analysis in this thesis proceeds in the following steps. First, a biological dynamic model was developed which involves three harvest variables adopted from restrictions normally placed in the *sasi* tradition. These variables were the length of closures, the length of openings, and the size of first capture. Then, economic parameters were introduced to form a bionomic model. This bionomic model was used to predict the outcomes of several management scenarios. Decision making was carried out using a multiattribute analysis where the bionomic predictions were compared based on biological, economic, and social management criteria given by interviewed stakeholders. Finally, the feasibility of implementing the optimal scenario was analyzed based on the lessons learned from the *sasi* system as it was applied in the past, and on an assessment of current social, economic, and cultural conditions in the study area.

The computer simulation shows that, theoretically, there is an opportunity for these resources to move away the present moratorium to a system which allows limited harvest. A combination of harvest restrictions consisting of a one-year *sasi*-period, two-year age-of-first-capture, and 40-percent actual-to-potential harvest-ratio, would result in the optimal exploitation of the resource. Other results indicate that the development of proposed management system can benefit from an awareness of local cultural characteristics: recognition of the interdependence of life and nature, belief in supernatural powers, respect for the wisdom of traditional leaders, and kinship. Finally, we argue that implementation of the proposed management system will be constrained by several regional demographic components, most importantly the lack of local human and physical capital.

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CHAPTER 1. INTRODUCTION

1.1. Goal and objectives

The goal of this dissertation is to develop a management framework for coastal sedentary resources in the Indonesian province of Maluku based on a long enduring tradition in the region known as the *sasi system*. The purpose is to provide planners with relevant guideposts for the adoption of a management alternative that is more compatible with local conditions. The fundamental question pursued in this dissertation is whether or not *co-management*, added to the *sasi* tradition can combine the positive characteristics of the traditional system with modern science so that management can be made more effective.

The research is focused on trochus (*Trochus niloticus*) stocks in and around a selected location, Kei Besar Island, Maluku, Indonesia (Figure 1.1). Trochus was chosen as a case species for the proposed management framework because of its important historical contribution to many village economies.

Due to the growing concern over declining stocks, trochus has been subject to a no-harvest policy introduced by the Indonesian government in 1987. Kei Besar Island was chosen as the site for the study because it is recognized as the most important location in the trochus producing region in Indonesia (Retraubun, 1996).

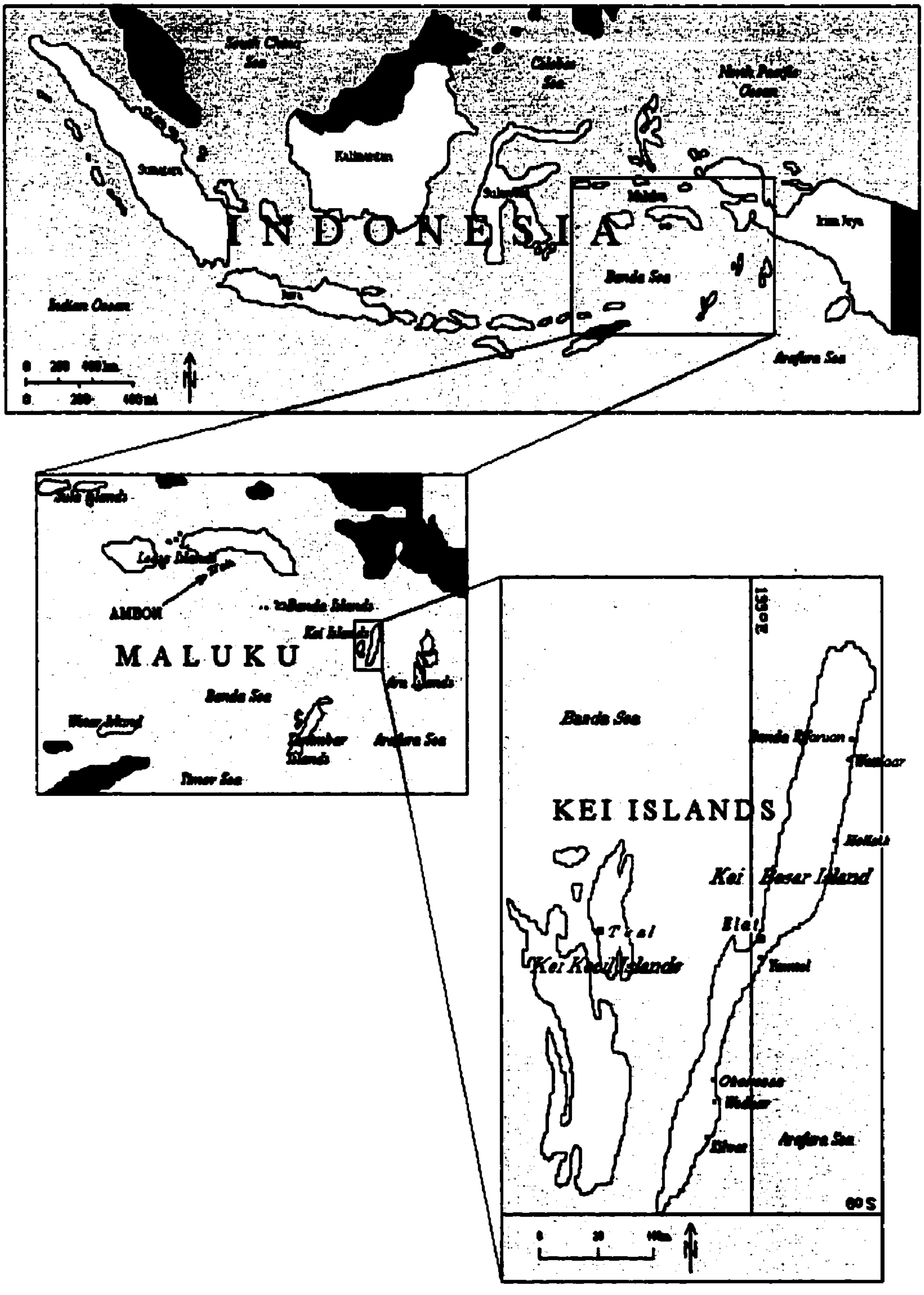

Figure 1.1. Maps of Indonesia, Maluku, and Kei Besar Island

The more specific objectives of the research are the following:

1. To evaluate the characteristics of the *sasi* system as it was applied in the past in this region and identify components which can be integrated into the proposed co-management regime.
2. To design a computer simulation model on harvest rationalization schemes and analyze the potential to develop a safe exploitation pattern for the trochus stocks, and
3. To assess the operational feasibility of the proposed *sasi*-based co-management regime under current social, economic, and cultural conditions.

1.2. Organization of The Thesis

The material in this thesis is organized as follows:

- Chapter 1 provides readers with a general description of the main topics referred to in the study.
- Chapter 2 presents a literature review which traces the origins and establishes the importance of the research.
- Chapter 3 discusses research methodology and analytical procedures used in the thesis.
- Chapters 4, 5, and 6 set out the process of development of the management framework, which include:

i. Drawing lessons from the past *sasi* practice that are relevant to the development of the proposed management framework;

ii. Development of dynamics modeling to assess trade-offs among possible harvest arrangements;

iii. Contextual analysis of the operational feasibility of a co-management framework.

- Chapter 7 provides a summary of the results from Chapters 4, 5, and 6 and formulates the relevant policy implications.

1.3. General description of the Indonesian aquatic resources and conservation issues

Geographically, Indonesia is a maritime country, the biggest archipelago in the world with 17000 islands encircled by a large body of water that spans 3 time zones. These islands straddle the equator from 94°45' to 141°05' east longitude and from 6°08' north latitude to 11°15' south latitude. The combined land area of these islands is 1.9 million square kilometers, which is significantly smaller than that of the water area coverage of 5.5 million square kilometers. This water area is classified into territorial water (0.3 million sq. kms.), inter-island water (2.8 million sq. kms.), and the exclusive economic zone (EEZ) (2.7 million sq. kms.) (Likadja and Bessie, 1988).

The archipelagic geographical setting of the country has made marine resources inherently important, particularly when they are viewed with respect to the contribution they can make to the national economy and world natural conservation. Marine resources provide employment for over 2.5 million people, account for 75 % of the country's total fisheries production[1] (Bailey *et al*, 1992), and supply approximately 75 % of the total animal protein intake of the population (Mortimer, 1994). With respect to natural conservation, the role of these resources is associated with concerns over the need to maintain the world bio-diversity necessary to provide options available for sustaining the future of human beings (Watson, 1995). Burbridge and Magaros (1985) note that Indonesian marine resources constitute one of the world's most diverse, complex, and extensive aquatic ecosystems. Watson (1995) even goes so far as arguing that Indonesia's aquatic bio-diversity probably could be ranked first in the world. Thus the relevance and extent of diversity in the Indonesian aquatic system has drawn the attention of conservationists worldwide. Recently, this important role in aquatic ecosystems has received an increasing recognition from the Indonesian government, which has designed a variety of strategies and actions in accordance with it (Watson, 1995).

These two important roles are often in conflict with each other. While the need for economic development provides an argument for maintaining or even increasing the level of resource exploitation, the need to protect bio-diversity underscores the relevance of conservation. In many instances, the balance between conservation and resource exploitation is problematic because many aquatic species, believed to have high non-market values[2], are threatened by exploitation from people who have limited economic alternatives. Consequently, the growing awareness about environmental issues has so far only seemed to emphasize the gap between the need to conserve and the pressure to

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[1] Other part of production comes from inland fisheries

[2] Non market values are the benefits that come from a currently non-marketed good or service

exploit. As a result of this conflict in roles, the creation of proper management solutions is perceived as increasingly urgent.

The case of Maluku Province represents a perfect example of the general phenomenon that occurs at the national level. In fact the predominant marine feature of the province has made the economic significance of marine resources even higher here than in that of the other Indonesian provinces. In addition, such a distinct geographical characteristic strongly influences the cultural life of the population. For example, in their daily colloquial expressions, people never refer to west, east, north or south, but simply to go-land (*kedarat*) or go-ocean (*kelaut*). On the other hand, the fact that 80% of the population resides in the coastal areas shows the magnitude of the human threat to the coastal aquatic resources, many of which already are classified as endangered.

While the expansion of offshore fisheries in Maluku has shown signs of success in terms of the growing total fisheries production, these gains have not significantly reduced pressures on coastal resources. New incentives have been offered, such as the opportunity to trawl fish in some areas of the province (Anonymous, 1999), and to encourage large companies to increase their participation in offshore exploitation. While this strategy has increased the size of the industry as a whole, artisanal fishers earn few benefits from such development. Therefore, the economies of many of coastal communities still depend on the heavy exploitation of near-shore fisheries. Consequently, these people remain in a situation where pressure on in-shore resources, often-rare high-value species such as trochus (*Trochus niloticus*), is inevitable.

1.4 Trochus and its significance to the economy of Maluku Province

Trochus (*Trochus niloticus*) is a tropical herbivore marine gastropod belonging to family *Trochidae* and order *Archeogastropoda*. In international trade, it is normally referred to as "topshell" or "mother of pearl". For local people in Maluku, trochus is known as *lola* or *bia lola*. While in the Indonesian language, it is called *troka* or *siput susu bundar*.

Trochus populations inhabit intertidal and subtidal coral reefs down to a depth of ten meters (Yusron, 1987). In their natural habitat, trochus can be found attached to or moving slowly around dead coral reefs. The main reason for the presence of trochus in this habitat is the microalgae, their primary source of food, which grow on the reefs. In general, trochus movement is limited to foraging for food mainly at night. During the day they normally remain in holes, cracks, crevices, or other hidden places in the reefs, evading their enemies.

Maluku trochus spawn for the first time at the age of one year, when they reach approximately 5.5 cm in size (Arifin and Purwati, 1993). It is believed that trochus might live as long as 15 or even 20 years (Bour, 1985), reaching a maximum diameter of 14.2 cm. However, the lifespan of trochus in Maluku has never been longer than 8 years (Dwiyono, pers. com.).

Maluku is among the few places in the world where trochus can be found in abundance. Other important producers are Indo-Malaysia, Melanesia and some islands in Micronesia (Hahn, 1988). In addition to these regions, various levels of production are reported in the area between Ceylon and Samoa (from west to east) and from Ryukyus Islands to Western Australia (from north to south) (Shokita *et al*, 1991).

Commercialization of trochus is due primarily to the high value of its shell. While there is at least one report on commercial canning (Clarke and Ianelly, 1995), trochus meat is more commonly processed by a simple technique such as cooking, drying, or smoking and used only for domestic consumption (Arifin *et al*, 1998). Therefore, even though it is edible, the meat is in fact only a by-product of shell exploitation. The shells, on the other hand, are never wasted. They represent a highly valuable marine commodity very much in demand by the world's fashion industry as a raw material for the manufacture of high quality buttons (Bour, 1990). For the button industry alone, it is estimated (Hahn, 1988) that an individual trochus shell is worth no less than US$10.50. In addition, the non-meat by-product of the button industry can either be crushed into paint pigments used in the automobile and nail polish industries, or processed to produce mother-of-pearl chips. It can also be turned into a decorative inlay work (Clarke and Ianelly, 1995).

In Maluku, this sessile species contributes significantly to the income of the small-scale inshore fishing industry. Relying on an essentially cost free catching technique as simple as skin diving, villagers are able to generate a significant amount of revenue by collecting the shellfish. In fact, the trochus fishery has been a multi-million-rupiah[3] business for artisanal fishermen in the region for many years (Arifin, 1993). This is especially important because trochus-harvesting villages are generally economically

[3] February 1996's rate, US$ 1 = Rp 2250

underdeveloped, so the average of Rp 15 million annual benefit flowing from the resource to them is very significant. This amount is comparable to the Rp 20-million annual government assistance provided to underdeveloped villages through the IDT (*Inpres Desa tertinggal*)[4] project.

Unlike other marine products (i.e., food fish) which need certain handling techniques to prolong shelf-life, trochus shells can be stored without special treatment for long periods before they reach the buyer. Thus, many village communities find trochus to be a reliable source of funds needed to provide a variety of essential services such as the education of the village's children or the purchase or maintenance of village facilities like electric generators and road improvements. Food-fish trading, on the other hand, is by and large, limited to consumers who live on an island, or at the most with those from a few adjacent islands.

1.5. *Sasi* management and resource exploitation in Maluku

Strictly speaking, *sasi* is a Malukuan term for a prohibition on doing something. It refers more commonly to a community-operated natural resource management system; a system by which community members are notified when to and when not to, harvest resources (Kissya, 1993; Rahail, 1993). However, it may also apply to certain kinds of social affairs, such as regulations intended to prevent immoral conduct in the village. An example is a *sasi* that prohibits males from going to the area of a village's public water

[4] IDT project is a central government financial assistance program aimed at the empowerment of the economy of under-developed villages

spring assigned exclusively for females, or vice versa (Kissya, 1993). The root of the word is unclear. Although, some authors argue that it is originated from the word *saksi*, which literally means witness, or to witness (e.g., Zerner, 1994).

In general, a typical *sasi* practice has certain common elements: *sasi* is established by and in an assembly of community members or their representatives, which then form a village council, normally composed of *customary elders*[5], to be responsible for setting up the practice's detailed arrangements. For example, based upon the feedback given by community members or representatives, this council is in charge of formulating the appropriate details regarding boundary definitions, harvest restrictions (if it is about harvest regulation), and sanctions and punitive arrangements reserved for those who do not comply with the rules. Based on specific considerations, such as weather patterns or biological cycles of the resource, the most appropriate day to perform a traditional procession / ceremony signifying the beginning of the closure on use of the resource, is determined. This procession is called *tutup sasi*, which literally means closing *sasi*. Within the course of the *tutup sasi* ceremony, all rules are reinstated and prayers are offered. Markers are placed to notify people about the imposition of *sasi*. Once the *sasi* markers are placed, a *masa sasi*, which literally means the duration of *sasi*, is in effect, and no one is allowed to harvest the resource. When the time comes again for harvest, i.e., when the *sasi*ed crops or fish have met a certain level of maturity or abundance, and weather permitting (in the case of marine *sasi*), another procession is held to mark the

[5] Customary elders are persons selected by all members of clans to represent them in the village council

time to lift the closure. This procession or ceremony is called *buka sasi*, which literally means opening *sasi*.

Geographical markers such as rivers, big rocks or tips of forelands are often used to define *sasi* boundaries. People usually recognize that a place is under *sasi* when a certain type of sign is placed on those boundaries. These signs may be in the form of stone or leaf markers (Zerner, 1990). *Sasi* rules apply to basically everyone, including outsiders who happen to visit or stay in the village. On rare occasions an exception may be made to the *sasi* in an emergency situation. A needy passer-by, for example, might be granted permission to take one or two pieces of *sasi*ed coconut to satisfy his hunger or thirst.

Enforcement methods for the closure vary from place to place and may change over time. In some places, a police unit specifically established for *sasi*, may be in charge of monitoring and enforcement. In others, monitoring and enforcement may become the responsibility of all individual members of the village community. Fines and sanctions may also be used to discourage violations and to support enforcement.

For the people of Maluku, this community management system is very popular. There may be variants with different local names, for example, *fuso* and *siboboso* in North Maluku and *yot* and *yutut* in Southeast Maluku (Hualopu, 1997). However, the main purpose is similar, i.e., to regulate the harvest of various natural resources, both land crops (Bailey *et al*, 1991) and marine species (Zerner, 1990).

There is no historical evidence setting out a definite time for the adoption of this system. Some claim that *sasi* was an invention of the Maluku people of the past. Several local sources (e.g., Kissya, 1993; Rahail, 1993; Retraubun 1996) argue that *sasi* has existed for centuries and is an indigenous invention which was initially developed as a local custom-based response to resource management problems. Such a claim can be found in a written record of the Paperu Village (*reglemen negri Paperu 1913-1922*): '*Sasi itoe soedah moelai masa orang-orang toea ada lagi berdiam di goenoeng negri lama*', which literally means: '*sasi* was there since the old dwellers inhabited the old village's mountain'. On the other hand, some authors argue that *sasi* is merely a response to a variety of modern social issues, which are changing over time (Benda-Beckmann *et al*, 1995). Finally, Zerner (1994), sees *sasi* as a system introduced by the former colonial government to secure a monopoly over the trade of natural resources.

What is clear is that compared to the case for agricultural crops, *sasi* for trochus is relatively new. While the application of the *sasi* system for various crops had been adopted before the turn of 20th century, it was not until the 1960s that the system was applied to the trochus fishery (Zerner, 1994). Previous research shows that dramatic price increases for the shells in the 1960s were the main trigger for the development of the trochus *sasi*. Communities were encouraged to apply the system to the trochus fishery to gain the best long-run return from trochus exploitation.

1.6. Kei Besar Island

Kei Besar Island is a Maluku sub-district in the southeastern part of the province. It is located between 5° and 6° south latitudes and 132° and 134° east longitude. Villages where this field work was done are among the 44 villages under the jurisdiction of this sub-district administration. The population density of this island is classified as moderate by the national standard. The latest figure (1994 statistics) shows that this island has a population of 39,845. With a total area coverage of 585 square kilometers, the population density is approximately 68 persons per square kilometer.

To reach the field-study sites on Kei Besar from Ambon, the provincial capital, several modes of transportation are required. First, the district capital, Tual may be reached by a one-hour, three-days-a-week air service, or alternatively there is the 40-hour, bi-weekly passenger ship service. Small boats then carry passengers twice a day from Tual to the sub-district capital, Elat. Subject to the weather conditions, specific study sites can be reached by an irregular long-boat service, a chartered speed-boat, or in the case of Weduar village, by a chartered minibus. In the windy season, however, some of the villages are totally isolated and people might have to stay in the same village for several months.

CHAPTER 2. FORMULATION OF RESEARCH GOAL AND OBJECTIVES

In this chapter we review the literature and empirical background of the research study. Organizationally, the presentation starts with addressing the theoretical basis of the two management systems in the Malukuan trochus fishery: the old system, i.e., the *sasi* community-based limited exploitation, and the more recent one, i.e., government total banning on harvest. We continue with a description of problems that arose following the implementation of these two systems. Then, we conclude with a proposal for an alternative policy, for which the research discussed in later chapters becomes relevant.

2.1. State management

Managing fisheries resources is generally understood as dealing with fisheries resource exploitation and allocation problems. These problems usually stem from various concerns expressed by existing users; concerns which demand different arrangements for resource harvest/utilization. Consequently, a proper management scheme is supposed to be a compromise solution with respect to all existing interests. Therefore, economic, ecological, and social aspects concerned by stakeholders, should be reflected in terms of the harvest regulation package, which might include technique, timing, rates, and several other harvest control arrangements.

Government has traditionally been the central actor in the formulation and execution of fisheries management policies (Bailey & Zerner, 1991; Jentoft, 1989), where an open access situation is the most common structure of the industry. Assumed to be the most credible representative of public interests, government through its agencies is responsible to set up and enforce all management strategy packages, which might include licensing, quota allocation, taxation, incentive, and several others.

Unfortunately, government ability to run a management scheme is often limited when compared to the scope of the assigned management functions. As a result, while some governments are able to obtain a certain degree of success in developing and implementing their management schemes, many others simply fail. Bailey and Zerner (1991) have observed that the incapability of government agencies to perform surveillance on so many kilometers of coastline, scattered within national boundaries, often becomes the major factor in causing the failure of a government management framework. It is obvious then that for the case of maritime countries such as Indonesia, where many such problems exist, a government management scheme will inevitably face a high probability of failure. In such cases, monitoring the implementation of any management scheme would likely be cost-ineffective and technically problematic.

Centralized government management schemes also often face difficulties resulting from low compliance and/or participation of fishers. Jentoft (1989) has observed that while fisher support is crucial, many government schemes in fact lack it. This problem generally stems from the fact that regulations are often incompatible with conditions in the field because they are usually based on the government's understanding about the fisheries problem, which frequently deviates from the problems actually encountered by fishermen. As a result, fishers may instinctively be compelled to look for their own solution, which might be in contrast to government regulations. Towsend

(1995) describes this situation as one where many government regulations often create "games" which provide an opportunity for fishers to violate them and thus lead to policy failure.

Pinkerton and Weinstein (1995) argue that the problem with government management schemes might also be linked with the type of training that officials in most government agencies normally receive. Employees of government agencies generally are taught that management should focus only on the fish, not the fishermen. Government agencies, as Pinkerton and Weinstein (1995) say further, are trained to assume that fishermen will behave like predators, who will not stop fishing as long as the opportunity to do so is there. On the other hand, they believe that human beings do not react the same way that predators do; and therefore there is an opportunity for governments to position fishermen as stewards of the resource which will help to make fisheries management schemes effective. In general, what we could infer from this argument is that government policy might fail because its design overlooks the stewardship potential of fishermen.

Further, due to the high costs of running government resource management systems, there might be cases where the best management option would be the no management one. As proposed by Christy (1973), management of a fishery resource will only be feasible if the benefits exceed the total costs incurred by management. This proposition demonstrates why management systems with a high enforcement cost, such as in the case of many government management systems, are often impractical. When constrained by a limited budget, a government might have to prioritize its budget to limit regulation to the most profitable fisheries. Consequently, an open access situation might occur in the less profitable ones, and a portion of the potential benefits from them might inevitably be wasted. In these cases, consideration of more feasible alternatives such as ones discussed below becomes relevant.

2.2. Community-based management

A traditional community-based system is an alternative to a central government management scheme. Several social scientists have noted the advantages of traditional or tradition-based systems over other modes of management (e.g. Johannes; 1982; Pinkerton and Weinstein, 1995; Pomeroy and Williams, 1994; Ruddle, 1988). It is not surprising then that traditional management has drawn the attention of many fisheries management experts (Richards, 1985).

Traditional management systems, commonly associated with communal use rights, are widely believed to have the potential to promote the optimal exploitation of many inshore fisheries. Compared to most other management modes, a functioning traditional management system can be more efficient because it might reduce enforcement costs. It also often provides better equity because it may deliver more benefits to economically marginal communities who share the right to harvest the managed natural resources. It also is likely that traditional management systems may turn out to be more environmentally friendly because communities, as the effective property right holders, usually have the motivation to conserve the resource. All of these positive features are possible because the assignment of a more significant role to community members allows them to maintain the common interest necessary for them to treat the resource optimally.

Community-based management schemes, which are believed to be capable of mitigating problems that are present in central government management systems, can be found in all parts of the world. Experience shows that they work well in the United States, Japan, and the South Pacific, among others (Bailey and Zerner, 1991). In Indonesia, various types of community-based resource management systems (CBRM) exist; in fact they are reported to have been adopted by communities both in the eastern part (Nikijuluw, 1997) and in the western part of the country (Nikijuluw, 1996).

Among other elements, relatively well-defined property rights are major contributors to the superiority of community-based management over centralized government management schemes. Of course, this comparison only applies as long as the community adopts a non-open access practice to the resource they manage in common. As pointed out by Gordon (1954), the absence of a clear definition of property rights in common property cases will motivate individual fishers to disregard future benefits as long as these individuals can maximize their share of immediate ones. Therefore the fact that in most community-based management schemes the community collectively shares the property rights (Bailey and Zerner, 1991), makes the proposition that community-based management is superior generally valid.

The implications of the existence of well defined and commonly held property rights are mostly stated in terms of effectiveness, efficiency and equity. In general, within a community-based management scheme, efficiency and equity are more possible because it is relatively easier for fishermen to promote collective action. This is because such a scheme is believed to give benefits to all. With the clearly defined right over the resource, every individual member in the community will have an incentive to enforce regulations. Therefore, the highest achievable level of collective benefits can be expected. Unlike the open access situation under central government management where there is no previous agreement on shared benefits, the community-based management systems allows the incentive to enforce regulations to exist. Moreover, as stated by Bailey and Zerner (1991), a community-based management scheme is effective because monitoring is relatively easy. The enforcers, the community members themselves, are always present in the area and are able to guard the resource practically all the time. Equity also is more probable because it is the members themselves who determine the allocation of the shared benefits. Even though it may not always be the case that community members are directly involved in determining resource allocation, their concern is relatively more evident compared to that in the case of a state-management scheme.

Distortions in some of the more practical aspects of the community-based management scheme, however, might cause the system to appear to be as vulnerable to failure as in the government managed open-access case. For example, it can be argued that the *sasi* community-based management system as practiced by the people in Maluku, Indonesia has failed to maintain the conservation function despite its long existence. Beckmann *et al* (1995) suggest that economic elements have played a role in distorting this traditional management system. An example that he cites is the decision of a number of leaders to increase the rate of harvest for the sake of short-run returns.

Other researchers tend to support Beckmann's concern. While Zerner (1994) notes that in the past immature trochus were not taken by traders because they had no commercial value, in my own recent field observations in Maluku market centers I found traders purchasing considerable quantities of illegal immature trochus. Antunes and Dwiyono (1998) report similar findings. Regulation enforcement problems apparently have arisen because of the presence of what Pinkerton and Weinstein (1995) refer to as 'potential actors', i.e., participants who have the power to dictate the market. In this case influential traders cause market imperfections. For example, due to their financial capabilities, these traders are able to command a strong position in the market. In fact Panell (1996) has shown that these traders are often powerful enough to influence decisions normally made by communities concerning harvest arrangements, including length of season.

2.3. Co-management

The above review provides background for the need for a search for an alternative management arrangement which can eliminate or reduce problems attributed to incapability of the two previously mentioned options. One possible alternative is co-management, in which cooperative partnerships between competent actors are established to formulate and implement management schemes. Even though in theory delegating fisheries management responsibilities to government bodies appears to be justifiable, in developing countries as discussed above, the probability of success of such an approach is constrained by the fact that governments often lack adequate resources necessary to implement and enforce regulations. Consequently, delegating fisheries management responsibilities to communities should be considered. Their involvement in the formulation and implementation of management measures can promote voluntary compliance of regulations. However, as pointed out in the preceding discussion of community-based management, delegating the entire function to a community may contain potential pitfalls.

One possible arrangement might be one where some responsibilities are delegated to the fishermen/community, but where opportunity also exists for participation of other competent parties. Such an arrangement is usually referred to as co-management. In some cases, the notion simply means delegating a particular function, such as a responsibility of enforcing the regulations on its members (Jentoft, 1989). In others, co-management is interpreted to mean that the responsibility for management functions is shared by government agencies and fishermen (Bailey, in Jentoft, 1989). According to Pinkerton and Weinstein (1985), co-management can also mean that an existing community-based management arrangements are incorporated into the government management system.

Some experts, such as Bailey *et al* (1992) use the term collaboration to describe the relationship between government and fishermen in the co-management concept. They also note that collaborative arrangements do not necessarily mean that the community and government should share a balanced influence. The reason for this is that equal influence is not necessarily the ideal mode of network within a co-management scheme. Equal sharing of activities may be difficult, if not impossible to achieve. On the other hand, delegating responsibility for enforcement and surveillance of regulations to fisher communities may result in a more cost-efficient management system. In theory, this kind of collaboration should allow management to better handle problems related to resource use and conservation because both parties are expected to be able to contribute positively toward arriving at an effective management scheme. For example, community members might be more effective in the surveillance function because of their close physical contact with the resource.

The co-management approach represents a synergism because it contains several advantages of other schemes. While acknowledging that there is no simple answer to deal with so many different management goals, Jentoft (1989) argues that co-management is definitely superior to other systems when benefits and costs are taken into account. Undoubtedly, the low cost characteristic is something handed down from community-based management schemes. Other experts such as Pinkerton and Weinstein (1995) say that co-management promotes sustainability because all parties participate in setting up principles and rules and make themselves accountable in implementing them. Again, this is a benefit that is inherited from community-based management. Something that might not exist in community-based management schemes but becomes more possible in co-management is the opportunity to bolster the arrangement with scientific information, which most probably would be facilitated by the participation of government agencies. The result of all of these features is that although co-management may not bring the results stated by Beckman *et al* (1995), when they say that co-management constitutes some form of a 'magic cure' for environmental ailments and social injustice, co-management may offer improvements over other management approaches.

2.4. The cases of *sasi* and the current government policy in the Malukuan trochus fishery

The term '*sasi*' carries several connotations. To Malukuans, the notion simply is understood to be a restriction that is used to regulate harvests of particular natural commodities. Thus, it may be applied to both marine and land commodities (Zerner, 1990; Bailey *et al*, 1991). Scientists, on the other hand, view this regulative tradition more comprehensively by considering various implications of its adoption by the people in the region. Beckmann *et al* (1995), for example, associate its arrangements of harvest and the internal allocations of rights and duties with both ecological and economic implications; where an exploitation level which yields the highest sustainable revenue and stock levels can be made possible.

In the past, the effectiveness of *sasi* was commonly maintained by local super natural beliefs and the adoption of various moral or physical sanctions. Enforcement of *sasi* took advantage of fear associated with people's beliefs in powerful objects such as empowered wooden or leaf signs called *matakau*, effigies, or holy stones called *batu pemali*, etc. (see Beckmann *et al*,1995). People believed that violation or disrespect shown to *sasi* which was empowered by the placement of those objects, would cause misfortune, accidents, or other kinds of evil or negative occurrences. In addition, various sanctions such as shaming violators by parading them before their fellow villagers were reported as being a common example of moral punishment. Striking violators with a length of rattan rope (Zerner, 1990) was an example of a physical punishment.

In more recent times, new approaches in enforcement strategies have been adopted by communities. Some of the old punishments are now considered to be too inhumane, which has resulted in some moderation or even removal of these traditional sanctions from current practice. For example, shaming has not been performed for a long time; while rattan striking has been reduced to symbolic punishments in several villages (Kissya, pers. com.). In addition, monetary fines have become common. Finally, modern religions such as Islam and Christianity replace part of the traditional function of local superstitious beliefs in the *sasi* system. The results of my field observations are consistent with a report by Beckmann *et al* (1995) that church *sasi* is becoming popular. Religious faith is clearly playing an increasing role in the administration of the tradition. Finally, several prominent village elders (Kissya, Rahail, pers. comm.) asserted that a combination of the newly introduced enforcement strategies have resulted in approximately the same level of compliance as the old approaches did.

Changes in the *sasi* practices occurred not only with respect to choices of enforcement strategies but also in terms of the rationale for the decisions over whether and how to implement the system. Ecological considerations might have been the most relevant factor leading to the adoption of *sasi* in the past, but others are considered very important in the present time. For example the recent growing demand for trochus has caused many local government leaders to emphasize the growing importance of economic factors.

Changes in the rationale for the implementation of the system that have occurred recently might be related partly to the increase in human population pressure. Zerner (1990) indicates that local leaders associate the heavier weight on economic considerations with the increasing frequency and costs of village social events such as weddings, circumcisions, etc. This reflects Bailey's *et al* (1992) concern about the potential threat of population pressure on the effectiveness of the system. Such concern is in fact consistent with Copes' (1990) findings in his report on Papua New Guinean Fisheries which links the increase in population pressure with the degradation of a similar management scheme adopted there.

An indication of the failure of the *sasi* management system in the post world war two period is given by the decreasing volume of the trochus production in many locations in Maluku. Figure 2.1 shows the province's annual total production in the ten years preceding the introduction of the government's banning policy. Some scientists argue that the decline is related to the implementation of too short a *sasi* period (Andamari *et al* (1991) and Arifin and Purwati (1993)). As noted above, however, their concern represents only one manifestation of several underlying problems. For example, economic pressures or other short-run-benefits-driven motives, might have been the underlying reason for local authorities to allow villagers to adopt a more frequent sasi opening.

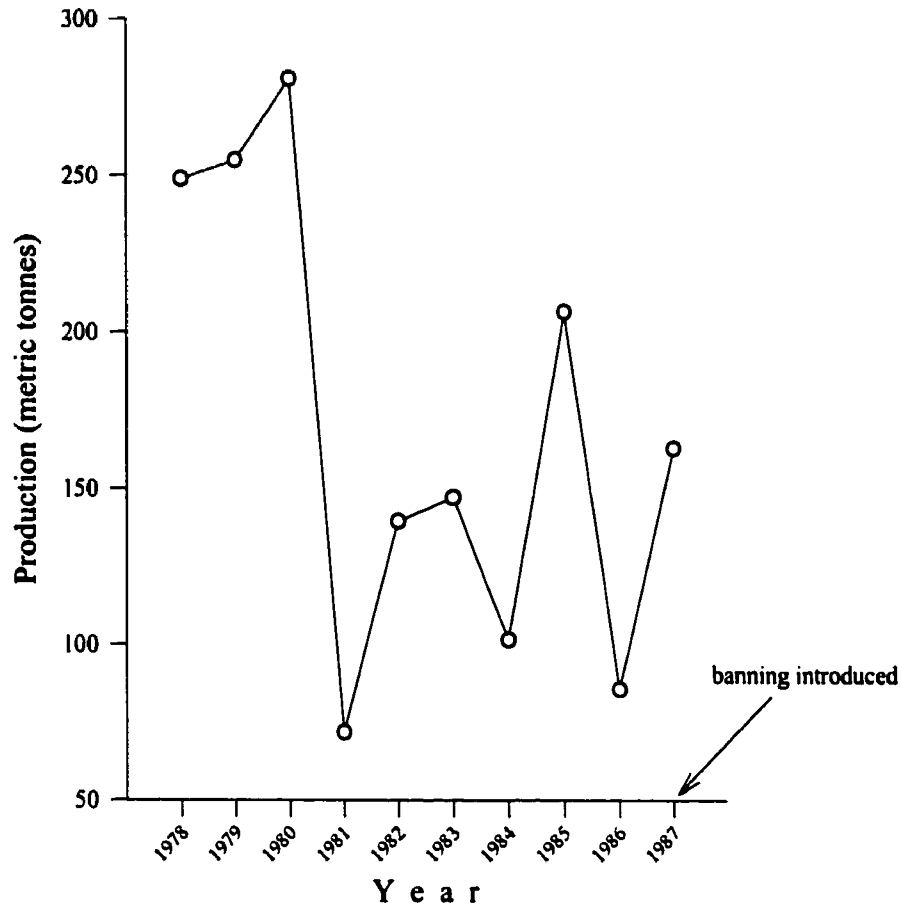

Figure 2.1 Maluku trochus production in ten years prior to banning (from Maluku Provincial Fisheries Statistics)

The inadequacy of the *sasi* system in preventing the depletion of trochus stock eventually prompted the central government to take stricter, largely unpopular measures for resource management. In 1987, the National Department of Forestry released a regulation in which trochus and several other non-fish marine species were declared to be protected resources and any further exploitation of them was prohibited[6].

Unfortunately, this regulation collided directly with strong local pressures to maintain harvests. In general, it appears that total banning on trochus exploitation is unrealistic. Good prices, low exploitation/handling costs, and limited economic alternatives give local economic actors, including villagers, local traders and local authorities an incentive to ignore the regulation. In addition, an issue that works even further against the centrally-designed resource management control policy is its incompatibility with the socio-cultural tradition of the region. Malukuans had been practicing resource management in a democratic way through their own traditional system for hundreds of years. Therefore, it has been not easy for them to accept a top-down style of state regulation that comes from outside their community. From the outset, it was felt by local observers that the application of such a strict policy of prohibition would be extremely difficult to enforce and that efforts to implement such outside controls would undoubtedly raise enforcement costs.

Acknowledging these problems, the government later introduced a complementary regulation by which a limited selective harvest was permitted. An individual or private company could obtain a license from the Department of Forestry to commercially culture trochus. Commercial culture in this case means that the culturists / trochus farmers were allowed to use trochus production for trading purposes. Instead of promoting conservation, however, the regulation has led to even more serious exploitation problems and the complementary regulation has had little or no positive

[6] Dept. of Forestry decree no. 12/Kpts-II/1987

effect. This problem will be discussed more fully in Chapter 4.

Several problems have emerged in the nine-year period since the implementation of the two policies. Probably the most notable negative issue is undetected harvest and data fouling. Arifin (1991) exposed false documentation of illegal trochus harvest where the number taken was simply added to production data on other shell-fish species. An obvious serious consequence is that the unreliable data created by this practice has made it difficult to monitor stocks and construct a management strategy for the future.

Another problem with the state regulation in Maluku, as is often the case for archipelagic regions, is the difficulty in monitoring the harvest of resources due to the wide spread geography of the province. As stated earlier, the region consists of not less than one thousand islands, and communications and transportation between the islands is still limited. Thus, any centralized management policy is costly and difficult to enforce.

2.5. An opportunity to improve *sasi* management through a co-management scheme

It could be argued that lack of a well-formulated alternative has forced the government to take the safest possible action, i.e., the prohibitive regulation. Accordingly, part of the responsibility for the present state of depletion of the resource rests with the scientific community, which might have provided more detailed information on how the resource could be better managed.

Local scientists who recognized the challenge and opportunities, undertook considerable effort in tackling the problem. For example, Arifin and Purwati (1993), and Suwartana *et al* (1985) conducted research to uncover a number of biological characteristics of the species. These researchers approached the problem by suggesting that an appropriate harvest period should be based on a biological criterion, i.e., the age of every cohort, to ensure that each individual trochus has spawned at least twice prior to harvest, which was believed to be enough to perpetuate restocking.

While their findings provide a significant contribution to the resolution of the over-harvesting problem, they represent only a partial solution which needs to be combined with other relevant factors to seek a more general solution. Since the problem of sustainability is complex, approaches to it should not rely solely on biological criterion. Sub-optimal exploitation will continue to occur unless economic, social, and institutional aspects also are taken into consideration.

By incorporating biological information with these other factors, the *sasi* management tradition could be made more effective. As Fong (1984) suggests, the most credible solution is the "*wedding between the science and the tradition*". This approach offers an opportunity to incorporate modern science into the management system so that community can make proper responses to economic and ecological changes. What is proposed here, then, is that some of the practical aspects of the *sasi* tradition should be adjusted to allow for the inclusion of external variables beyond their control. So, while use-right might be assigned to the community through the *sasi system*, the harvest pattern would be limited by scientific predictions of stock dynamics. In such a solution, the *sasi period* would no longer be determined merely by the community's judgment. Instead, it should reflect a compromise with various inputs, including those from outsiders. This can be brought forward through the establishment of collaboration between co-management agents, such as government scientists, and local community people. It is hoped that through this collaboration, the positive values and knowledge of local practices can be merged with those that come from outsiders.

We offer this proposal because as a long-practiced tradition, *sasi* carries a set of proven features typically characterizing a community-based management scheme. Zerner (1990), for example, points to several of the positive characteristics of the *sasi* tradition as a resource management system; including inexpensiveness, effectiveness, environmental appropriateness, and modifiability. As is the case with most community-based management systems, *sasi* in Maluku is practiced by people who live and conduct daily activities in a location close to or within the managed areas so that monitoring is by and large inexpensive. The system is effective because the potential benefits that are secured through the agreement facilitated by the system give people an incentive to respect the imposed regulations. It is considered environmentally appropriate because there is incentive to preserve the resource, which for villagers is usually used to satisfy their subsistence needs. And, by relying on their traditions of consultation and consensus, villagers can simplify any bureaucratic process associated with any necessary attempts to modify the rules/regulations.

The proposal then is for the development of a co-management scheme that is based on the *sasi* system. Despite the shortcomings mentioned above, the long existence of the *sasi* tradition in Malukuan communities might provide the basis for the development of co-management system well-suited to the local physical and cultural environments. The proposal, in fact, is in accordance with Pomeroy and Williams' (1994) assertion that a strong community-based arrangement is necessary for the success of a resource co-management scheme. Therefore, what is studied in this thesis is expanding the *sasi* tradition into a co-management system through its incorporation with other complementary arrangements, such as those mentioned above.

The above discussion suggests that to develop a *sasi*-based co-management scheme for the trochus fishery, a number of questions still need to be investigated. These include 'what lessons from past *sasi* systems are worth learning to support the co-management scheme being considered'; 'what is the optimal harvest rate'; and 'what are the current environmental, social, and economic conditions that possibly have an effect on the development of the co-management model'.

2.6. Optimum harvest

The phrase optimum harvest rate or optimum yield refers to the objective of achieving the highest possible level of sustainable harvest (MSY), followed by the introduction of a maximum net benefit concept (MEY) and socially optimum yield (OSY) (see Cunningham, 1985; Copes, 1981; Christy, 1973). The most common underlying objectives associated with these concepts are biological, economic, and social (Healey, 1984). However, several writers mention other objectives including political (Beddington and Rettig, 1983), cultural (Charles, 1994), and interests unrelated to fisheries, such as nationalism (Christy, 1973). As stated by Charles (1994), the optimum yields are those where all of the existing goals are taken into account so that the total of the benefits is maximized.

The biological optimum (Schaefer, 1954) is the earliest version of the meaning of optimum. In his report, Schaefer referred to an optimum catch, or a maximum equilibrium catch as he prefers to name it. This optimum is determined according to a model of natural population growth, where it is assumed that for every level of population there is a certain corresponding growth rate which will be available for a sustainable rate of harvest. Normally, a natural net growth model assumes that growth increases up to a certain level of population and diminishes afterwards. The highest value of growth rate is then considered as the maximum potential yield or maximum potential harvest (MSY). Such an optimum is determined solely by the biological goal (Healey, 1984), or as Christy (1973) describes it, based on the resource itself.

The economic optimum was developed later by economists to take into account factors other than biological ones. Starting with biological growth models similar to those employed in the determination of MSY, the concept, which was known later as the bioeconomic model, introduces the inclusion of the notion of costs and benefits. The inclusion of costs into the model is to recognize the existence of inputs necessary to transform the potential into actual harvests. The significant difference in this model as opposed to that in the MSY concept is that it is the net, not the gross benefits that have to be maximized. The yield corresponding to the maximum net benefit is called the maximum economic yield (MEY). With reasons advanced by scientists (Christy, 1973 and Healey, 1984), the concept was the best available at that period. Economists at that time asserted that optimum yield was MEY (see Healey, 1984)

As fisheries problems have become more complex, there has been a growing concern about the need to establish a better concept for determining optimum yield. For example, the importance of social factors not captured by MEY have been advanced by several social scientists, e.g., Crutchfield (1975), Roedel (1975), and Healey (1984). Despite being a proponent of MEY, another scientists (Christy, 1977) acknowledges the problems associated with defining economic & social values, especially where it is said that definition of these values may differ quite widely, and might be in conflict, such as for example, between net return versus employment. Healey stated that the optimum yield is an amalgam of biological, economic, and social goals, while the MEY concept focuses only on the importance of the value of the net benefit. And, although it might be argued that the MEY is sufficient to indicate optimum yield as long as techniques are available to include all costs and benefits, or in other words if the social benefit cost analysis is done properly (Copes, 1981), practicality remains a significant issue (Healey, 1984). Pollnac & Littlefield (in Healey, 1984) came up with the term "job satisfaction" to refer to a type of non-market benefit of the fishery. It is likely that there are yet other benefits that should be taken into account.

Ethics, as discussed in Sears (1965), is another example of aspect that should be accounted for in determining the optimum. The discussion of ethics in general seems to suggest that there should be a balance in nature. Rees (1990), for example states that resource utilization by people should not sacrifice the order of nature; e.g., development for economic purposes should avoid degrading the beauty and bounty of nature. On the other hand, other literature (e.g., WECD, 1987 and Brown, 1995) warns the importance of human existence in advancing preservation of nature. One important message of this view is that it is not appropriate to deprive a group of poor community people of their traditional harvest of a particular resource in the name of a potential benefit, such as its existence, which might be enjoyed only by a group of wealthy urban community people. Controversy regarding 'balance' may go on forever because as indicated by Cunningham (1985) the optimum is actually dependent on who is trying to optimize it.

To accommodate aspects not accounted for in the MEY concept, Healey (1984) introduces an approach called multiattribute analysis. His technique may constitute a compromise approach, where management criteria are weighted by the subjective scores given by all stakeholders. These are scores which reflect their concerns over the biological, economic, and social aspects of harvest of the managed resource. This technique is adopted in this study and will be discussed in more detail in the methodology section.

2.7. Summary

The magnitude of problems associated with the ineffectiveness of two management schemes currently adopted in the Maluku trochus fisheries, the *sasi* community-based system and the central government banning policy, provides an opportunity for designing research aiming at the development of a viable alternative. In this thesis, co-management is proposed on the premise that its characteristics might be able to mitigate currently existing problems. These include the issues of conservation and non-optimal use of the resource, and villagers' needs for subsistence support. Based on the concept of optimality as discussed above, the research also includes development of a computer simulation model which is able to accommodate consideration of three relevant optimization criteria: biological, social, and economic criteria.

CHAPTER 3. METHODOLOGY

3.1. Conceptual framework

The research framework developed here starts with an idea that an alternative resource management policy might be established in the Malukuan trochus fishery by combining the positive elements of the traditional *sasi* resource use system with existing government management policy. Practically, this suggestion is consistent with the belief of local interest groups that lifting the current harvest ban on trochus might result in some potential net benefits. Theoretically, an opportunity to adopt alternative use scenarios exists if these benefits can be generated through an exploitation rate not exceeding the maximum sustainable yield. Therefore it should be possible to identify a specific management strategy which will maximize long-term rents. This strategy should be the one that, based on the relevant management objectives, has the most favorable overall characteristics. As stated in Chapter 1, my hypothesis is that co-management or, more precisely, a co-operative arrangement between community, government, and other relevant parties is the option that can best facilitate the establishment of an optimum use scenario. Based on this hypothesis, a research framework was designed and implemented in the field. A brief summary of this research framework is presented below in Figure 3.1.

Literature review of state-designed-
and community-based fisheries management and the concept of optimum exploitation

↓

Theoretical basis by which an alternative policy solution is considered

↓

- revisiting past *sasi* applications to identify experiences necessary to support the development of a co-management regime
- constructing a simulation model to predict tradeoffs among various harvest rationalization scenarios
- assessing current circumstances to predict the operational feasibility of the proposed co-management regime

↓

⇒ is there opportunity to improve the pattern of exploitation ?
⇒ what is the optimum harvest arrangement ?
⇒ do the current circumstances allow it ?

Figure 3.1. Diagrammatic representation of the research outline

3.2. Methods for identifying the experiences of past *sasi* applications

Knowledge about past *sasi* applications was drawn from a review on historical events of *sasi* practices. Freeman and Sherwood's (1970) analytical framework[7] was employed to disclose the possible linkage between the arrangements contained and / or events encountered by the system and the resulting performances. This analysis is

[7] Freeman and Sherwood's specific framework adopted in this study is the causal analysis, where explanations of a certain phenomenon are emphasized more on the causal nature than on a correlation of variables. This framework is reflected precisely in the method of data gathering as described later in Section 5.3.1 in this chapter

presented in Chapter 4, which consists of two parts. The first part focuses on identifying specific factors that influenced the effectiveness of the tradition in the past. The second part is intended to draw lessons from the comparison of more recent *sasi* practices and the government management policy.

3.3. Methods for predicting and comparing tradeoffs among various harvest arrangements

In this study, the assessment of the tradeoffs among specific harvest arrangements was carried out using a computer simulation model, which was developed in three steps. In the first step, a model was constructed to simulate the biological dynamics of the resource. In the next step, economic parameters were introduced to the biological model to form a bioeconomic model, which was able to predict outcomes that were measured in monetary terms, i.e., net present values (NPVs). Finally, a multiattribute analysis was applied to the bioeconomic model to weight tradeoffs and to determine the optimal solution.

3.3.1. The '*sasi*' simulation model

To predict the biological dynamics of trochus resources exploited under the traditional *sasi* or a *sasi*-based management system, a model was developed following the principal framework of the multiple cohort simulation model as outlined by Beverton and Holt (1957). In this *sasi* multiple cohort model, the proposed scenario was stated as that 'once a determined duration of closing is reached, all eligible harvesters as a group are given authority to catch a certain portion of harvestable sized individuals.

In this study, three harvest restriction modes, namely limitations on duration of closing, the actual-potential harvest proportion (equivalent to the duration of opening), and age at first capture (equivalent to the size at first capture), were introduced as the model's variables. Restrictions on the mesh size of fishing nets such as that discussed in Beverton and Holt (1957) and restriction on the size of fishing fleet such as that adopted by Padilla and Copes (1994), are normally used more often than the duration of closing in the models of this type. But in *sasi*, as modeled in this study, varying the duration of the season closure (*sasi duration*) is considered the more important variable because it constitutes one of the accepted techniques commonly practiced in this Malukuan tradition. In fact, this technique appears to be the tradition's most recognizable feature.

Figure 3.2 Dynamics of a fish stock (from Royce, 1984)

The basic dynamic model of a fish stock as usually depicted in the literature is shown in Figure 3.2. This model argues that in the absence of fishing there are three factors that determine the dynamics of the stock, i.e., recruitment, growth, and natural mortality. When fishing activity takes place, then, the three natural factors interact with fishing mortality, affecting the level of stock over time. Based on this, Beverton and Holt

(1957) suggest that in an exploited fishery, a multiple cohort model for fishery dynamics should include four factors, namely recruitment, natural mortality, growth, and fishing mortality. Thus, the result of all inputs and outputs is the size of usable stock, a measure of the magnitude of the fish biomass in a particular area. In biological terminology, stock size might connote "the number of individuals or the weight of stock at a given time" (Royce, 1984). Terms that are closely related to stock size are 'abundance' and 'density'. These terms, as cited from Royce (1984), normally refer to "the total number of individuals per unit of area or unit of fishing effort". In our case, in the trochus *sasi* model, stock is defined as the weight of trochus individuals inhabiting a particular village's territorial water. As described later in Chapter 5., the value of the stock size is estimated from the recorded trochus production of the village being modeled, regardless from which particular area of that village the production is actually generated.

The first of the factors that determine the dynamics of fish stock size in this model is recruitment. In the literature, recruitment is generally defined as the number of new fish of fishable age that are joining the stock (Ricker, 1968; Beverton and Holt, 1957; Royce, 1984). In some cases, the definition needs to be made more precise to recognize the significance of the 'age limitation' factor. Since the age at first capture is often used as a regulating tool, a tool that is also relevant in the *sasi* model developed in this study, it is sometimes necessary that the age of recruitment and the age of first capture differ. This is particularly true in the *sasi* model. In this case the period between recruitment age and the maximum attainable age (longevity) is divided into two parts, i.e., pre-exploited phase and exploited phases as depicted in Figure 3.3. (see Beverton and Holt, 1957).

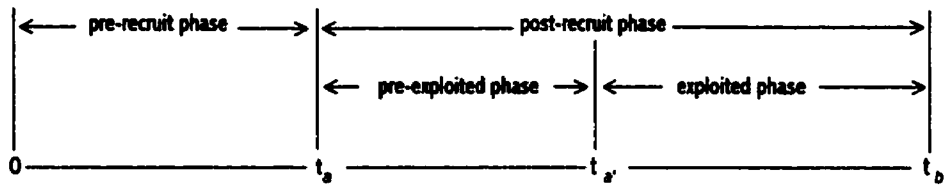

Figure 3.3 Classification of ages with respect to recruitment (from Beverton and Holt, 1957)

In practice, there is no simple means of estimating the number of trochus recruits; therefore, in this study recruitment is predicted[8] from the number of eggs of all cohorts that reach mature size (see Chapter 5).

The second of the inputs determining the dynamics of stock size is individual growth, which is commonly defined as "a gradual increase over time in size or mass or some kind of a living unit" (Royce, 1984). Naturally, size (or weight) of an aquatic animal increases following biological processes, wherein the relationship between size and time can be represented by a certain mathematical function. That is, size and weight will increase to reach a certain limit, where they become essentially constant. However, the nature of such processes is determined by a set of factors, both endogenous and exogenous. Rate of growth is intrinsically dependent on other endogenous factors such as sex and senility (Royce, 1984), where hormones are the controlling factor. This endogenous mechanism, however, cannot work optimally unless favorable external conditions exist, such as the support of a sufficient quantity and quality of food, and the appropriate water temperature and salinity levels (Royce, 1984).

[8] The easiest way to estimate the number of hatched eggs is by multiplying fecundity with the predicted number of mature trochus.

Based on the assumption that age and individual size of aquatic resource animals are more or less correlated, biologists have carried out observations aimed at establishing a statistical relationship between age and increases in growth. One result which follows from their observations is that a common relationship between age and size of various species is exponential (see Ricker, 1968). Biological studies also have revealed that the age-size relationship is transformable to an age-weight relationship because weight and size are correlated. For convenience, the model developed in this study uses the age measurement in its design to indicate the stages of individual development, since most other variables and parameters cited in the literature can be associated with age. For operational purposes[9], however, this age measurement should be transformed into the size units, i.e., the diameter of the shell's base, to provide a more understandable measurement unit.

The next factor determining the size of a fish stock is natural mortality, which works in the opposite direction to growth and recruitment. Ricker (1968) states that natural mortality is usually defined as "deaths from all causes except man's fishing". He also notes that a number of factors influencing the rates of recruitment and growth also play a role in determining the rate of natural mortality. These factors are senility, pollution, epidemics, and predators. In many cases, mortality is stated in an annual term, (m_a) which basically means the number or weight of fish which die during a year (X_t-X_{t-1}) divided by the initial number or weight at the beginning of the year (X_{t-1}) (Ricker, 1968). Accordingly, its counterpart, the annual survival, (s_a) is the fraction of fish that survive

[9] Size can be aggregated to give a single measure of the biomass and economic value.

during a year divided by the initial number at the beginning of the year.

In some models, growth, recruitment, and mortality rates are stated as an instantaneous form. The instantaneous rate of recruitment is "the number of fish which grow to catchable size per short interval of time divided by the number of catchable fish already present at that time" (see Ricker, 1968). This permits the use of continuous functions, such as the relationship of $X_t=X_o.e^{it}$, where t is the elapsed time; X_t and X_o are the values of the dependent variable X, at time = t and time = 0, respectively; e is the base of the natural logarithm (≈ 2.71828); and i is the instantaneous rate of changes in X, or the change in X due to a very small change in time, t (Note: a negative sign is given to i if the rate is negative, such as in the case of mortality). In our *sasi* model, annual rates are regarded as more appropriate because the model deals with a simulation which is run on annual discrete time increments.

In a regulated fishery, an artificial factor enters the dynamic system. According to Beddington and Rettig (1984), regulating strategy in any fisheries management scheme essentially means imposing a technique, or a combination of several techniques, to regulate fishing mortality, and this can be done directly or indirectly. An example of the direct technique is total allowable catch (TAC), while examples of indirect techniques are controlling effort through season closing, area closing, mesh regulation, etc. Various other techniques frequently cited in the literature include license restrictions, monetary measures (fees, taxes, subsidies), and assignment of property rights (territorial use right) (Beddington and Rettig, 1984; Anderson, 1986; and Cunningham, 1985).

The model developed in this study is basically meant to put into practice strategies that are likely to be compatible with the *sasi* tradition as well as with several other relevant local circumstances. These include limitations on season closing, season opening, size/age regulation, and the assignment of territorial use rights. The use of *sasi* as the base for the proposed co-management scheme developed in this study is parallel to the assignment of use rights to people who are traditionally dependent on the resource. In order that fisheries regulation attempts can be made more effective, area closing, time closing, and size regulation are adopted as complements to the rights assignment in order that the optimal use of the resource can be established. These complementary tools are chosen, not only because they are the most compatible to the tradition, but also because of their relevance to the trochus vulnerability to capture. Rights assignment without harvest limitation can easily lead to overfishing of this low motility species.

The biological scenario of the *sasi* model developed in this research starts with an assumed number of trochus belonging to several cohorts, which have been purposely allowed to escape from the most recent harvest and are therefore available for the beginning of the simulation of dynamic process of stock development. The scenario is then controlled by the introduction of a closure time called the *sasi duration*, *d*, which allows these individuals to reproduce and grow at their natural rates for a period *d* after which the next period of harvest (*sasi opening*) takes place. During the closure (*sasi*), mature, individual trochus aged a_k years or older spawn and produce a cohort which will grow to be a new group of recruits.

Besides continually receiving new recruits, the stock is subject to change in its number of individuals due to natural mortality. The notion of longevity, a_z, refers to the highest attainable age or the longest normal life span of a trochus individual. Natural mortality, on the other hand, refers to the annual fraction of the population that dies from natural causes before the individuals reach a_z.

The model is also designed to allow for the prediction of the effects of size and time limitations on harvests. In this respect, the variable a_f, which denotes the youngest age of trochus that reaches legal size, and variable *percent*, which denotes the fraction of the actual harvest relative to the maximum potential harvest, are introduced. The introduction of these two forms of limitation provide an additional means for adjusting the stock in a manner which is sustainable.

Given this scenario, an appropriate model can be illustrated diagrammatically as in Figure 3.4.

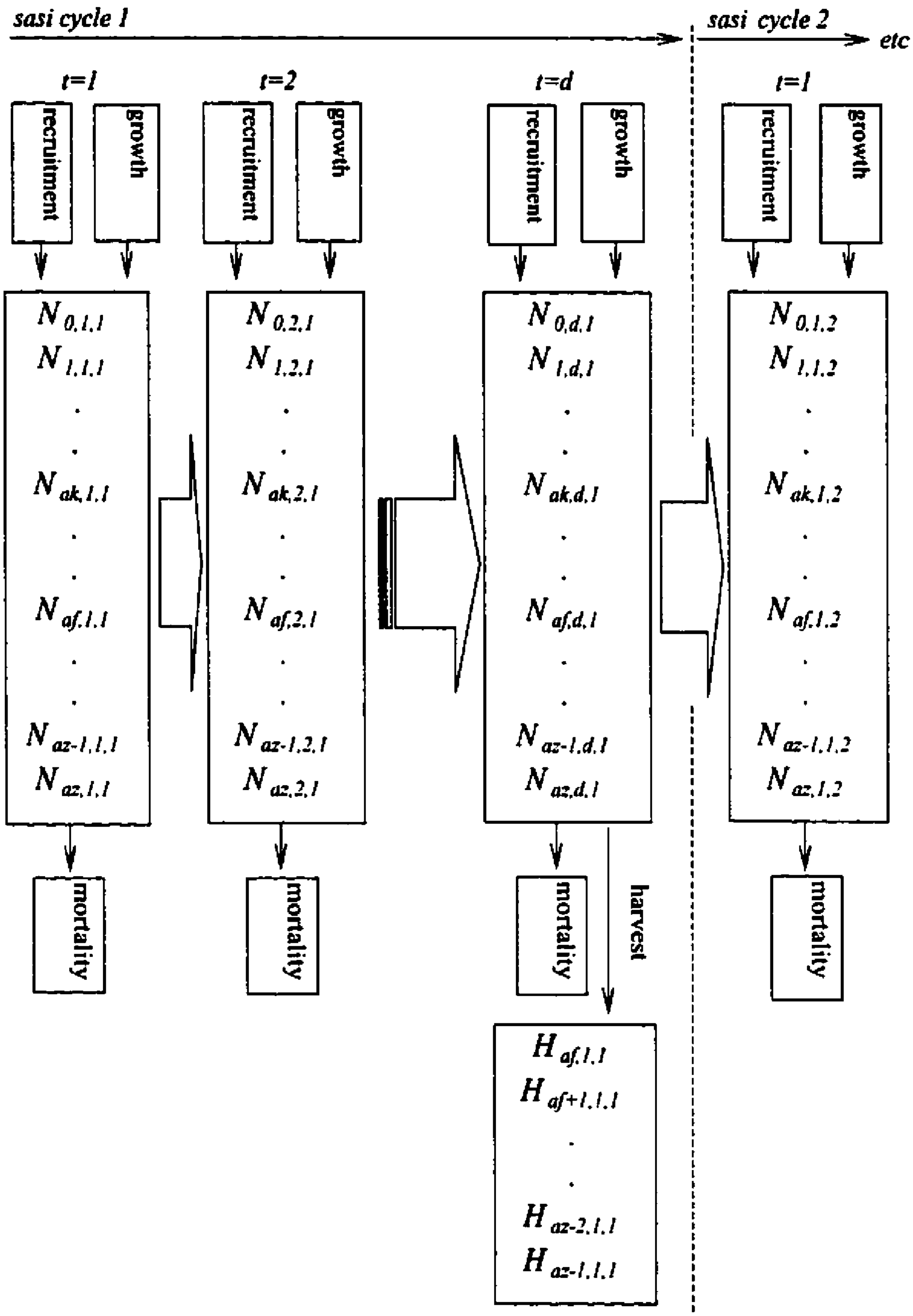

Figure 3.4. Diagrammatic sasi simulation model

Remark : 1. $N_{a,t,p}$ *isthe number of trochus aged 'a' at year 't' of sasi cycle 'p'*

2. *The numbers of trochus at the first year of a cycle are those let to escape from the harvest taken place in the preceeding cycle*

The next step is to incorporate economic parameters into the biological model outlined above, resulting in a bioeconomic model which transforms the dynamics model's predictions into economic terms. The introduction of economic components to a fisheries model was originally accomplished by Gordon in the 1950s (Beddington and Rettig, 1984). Gordon (1954) developed a bioeconomic model which was based on the surplus production biological model. He argued that the important economic parameters in a bioeconomic model are price and fishing costs. The interest rate is also applied when the time preference for money is considered significant.

As discussed in the literature review chapter above, the bioeconomic model often ignores too many social factors in its calculations. Therefore, in this study, it is considered to be necessary to incorporate a technique which can reduce the problem of omitting socially important factors. The method adopted here is multiattribute analysis, which is discussed in the following section.

3.3.2. The multiattribute analysis

The bioeconomic model discussed in the previous section is capable of generating predictions about the relationship between various sets of harvest regulating techniques and the resulting proxies for social, biological, and economic management performance. However, the model is not sufficient to indicate the differences in the overall performance of each harvest regulating arrangement.

A method called multiattribute analysis or multiattribute evaluation (Bell *et al* 1977; Edwards and Newman, 1982; Healey, 1984), is used to compare the overall performance of various sets of harvest regulating techniques by means of taking into account priorities facing relevant stakeholders. Thus in this study, this method is employed to amalgamate the values of proxies representing social, biological, and economic concerns generated through the *sasi* dynamics simulation model (objective scores) and the preferences provided by selected stakeholder representatives interviewed in the field (subjective scores)

Researchers such as Bell *et al* (1977), Edwards and Newman, (1982), and Healey (1984) provide the fundamental idea as to how the analytical technique is developed. The method starts from the assumption that utility is somehow composed of several attributes. For example, the total utility of a stakeholder representative from the existence of a particular kind of resource is a function of his or her concern over the resource's biological, economic, and social functions. In multiattribute analysis, utility is normally developed by weighting the values of all relevant attributes (objective scores) to produce an overall score for each outcome of the sets of harvest regulating techniques. This then permits a comparison of several scenarios. In this case, it is all of the stakeholders or competent parties who put weights (subjective scores) on these attributes.

As noted earlier, the determination of the best strategy option is based on the total/aggregate utility value that characterizes each of the possible options. Even though there are several types of aggregation rules, Edwards (1977) demonstrates that complicated non-linear aggregations bring about approximately the same optimal solution as a linear aggregation does. This is the reason why linear average weighting has become widely applied. Following this finding, the *sasi* model developed in this study adopts the linear aggregation to determine total scores of the options. The relevant attributes, namely social, economic, and conservation were used to determine the optimum strategy option. Accordingly, the variant of multi-attribute analysis that is employed in this research takes the following form:

$$U_i = \sum_j a_j S_{ij}$$

where:

U_i = aggregate score of the i^{th} set of harvest regulating techniques (e.g., the score for a three-day yearly opening with minimum trochus size of 6 cm)

a_j = preference weight associated with the j^{th} attribute

S_{ij} = measure of performance of the i^{th} solution against j^{th} attribute

As outlined by Healey (1984) a multiattribute analysis usually consists of six steps, including bounding the problem, setting up policy alternatives, selecting attributes of the problem, weighting the attributes, scoring the policies, and applying the decision rule.

In the first step, i.e., bounding the problem, the stakeholders to be considered in developing the model are determined. For the Maluku trochus fishery, there are several groups of stakeholders, including community people, local traders, environmentalists, scientific societies, and local government. These groups constitute those that have the most significant interest in the resource. As each group will differ as to which criteria is of the greatest concern, each group will provide different weights for each of the relevant criteria. If so, according to Edwards and Newman (1982), and as reiterated by Healey

(1944), an averaging of the values given by different groups of stakeholders is required.

In the second step, i.e., setting up policy alternatives, the range of strategies or control variables within which the optimum strategies must lie is established. Regarding the variable 'duration of closing', it seems realistic to set a range between the longest bearable closure duration and the most frequent harvest based on practical consideration. Based on interviews with stakeholder representatives, 'four years' is the longest bearable closure duration. On the other hand, 'one year' is considered the shortest possible duration because the harvest (season opening, *buka sasi*) is usually done at the time when average weather conditions allow it, which in fact occurs in an annual cycle. In addition, the adoption an even shorter time interval is avoided because it might cause the model to be inaccurate due to the unmeasurable monthly variation in spawning intensity.

The next harvesting control variable is the age at first capture. An age at first capture between one year and two years is considered feasible for two reasons. The first is associated with the stage of maturity, while the second is associated with the quality of the product. As noted in an earlier chapter, trochus spawn for the first time when their basal diameter reaches 5.5 cm (Arifin and Purwati, 1993), which happens when their age approaches one year. Thus an age of first capture of less than one year would not be associated with sustainable fishing. The second reason is associated with its commercial value. Setting an age standard lower than one year is not a viable option commercially because there is a big difference in price between trochus aged one year and those younger. Setting a standard higher than two years, on the other hand, is not considered appropriate because it would mean sacrificing the opportunity to harvest trochus at the best age. For example, Clarke and Ianelly (1995) argue that for quality reasons, buyers prefer trochus shells with a basal diameter sized 6.4 to 11 cm, which is normally obtained at the age of one to two years.

The final regulating technique is the actual-to-potential harvest ratio. A range for the actual-to-potential harvest ratio of between 40% and 80% is considered realistic. This is mainly based on observations in Wattlaar Village, where researchers (Antunes and Dwiono, 1998) found that harvest within a season opening normally takes approximately 40% up to 70%[10] of the potential trochus individuals. Moreover, based on the claims of divers, production could have been increased if the duration of opening was not limited, as in the case of some other villages. Therefore, it seems realistic to assume that 80% harvest is possible if maximum effort is applied. A 100% harvest was considered unlikely because the traditional method that is applied in the harvest still allows a significant amount of escapement.

Another important part of the analysis is selecting attributes, i.e., deciding what the relevant attributes are. Logically, a number of attributes can be associated with the economic, social and ecological/biological objectives discussed in Chapter 2. The biological objectives for example, are not only associated with the stock level attribute as assumed in this study, but also include the ecological balance of the habitat. However, in practice it is extremely difficult to elicit a consistent response concerning preference when respondents are asked to prioritize too many different attributes. A proxy is chosen

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[10]In the case of Wattlaar village, these percentages are associated with a harvest time ranging from two to four days. The relationship between such percentages and the level of effort logically is unique for every village's trochus bed. Therefore, a conversion factor should be determined prior to the application of the simulation model in each village trochus bed.

to represent each of these attributes. Interviews which asked opinion regarding the importance of trochus exploitation were conducted in the field with respondents representing stakeholders determined earlier in the first step, to establish the appropriate proxies.

The economic attribute:

Beddington and Rettig (1984) argue that the economic objective for managing a fishery in general is efficiency. This means that the net revenue, the difference between the gross revenue and the sum of all relevant costs, should be as high as possible. To compare the effect of variation in harvest arrangements, the only relevant costs are those related to harvest activities during the season opening (*buka sasi*). The same amount of enforcement costs, if any, would occur in all periods regardless of the frequency of opening. For villagers, however, opportunity costs of participating in the season opening are insignificant because they, in fact, sacrifice basically nothing by being involved in such activities. This leaves the gross revenue as the only significant factor in the benefit-cost calculation; and therefore, gross revenue equals net revenue.

The *sasi*-based management model in this study is developed to evaluate options for a given time horizon; therefore, the term net present value is relevant. A deflation factor value is introduced to take into account inflation rate so that all the net revenues associated with all harvest arrangements can be compared on the basis of a common year. Total net present value is then the sum of discounted values of these revenue flows:

$$PVN = \sum_{p=1}^{q} V_p(1+i)^{-pd}$$

where i = annual interest rate

V_p= current value net revenue of of cycle p

p = sasi cycle

q = total number of sasi cycles within the time horizon

d = length of of the cycles

The social attribute:

Interviews with key persons[11] indicate that the most significant social concern in the Malukuan trochus fishery is the perpetuity of the harvest of the product. While recognizing the importance of conserving the resource, these respondents also point out the need for allowing more frequent harvests. They refer to the difficulties that villagers might have to face when the season closings are postponed because an alternative source for their perpetual need for cash is lacking. Moreover, a shorter *sasi duration* is also preferable because season opening feasts are always anxiously awaited, as alternative entertainment is rare in the villages. Based on this feedback, perpetuity is used as a proxy to represent the social attributes. Perpetuity in this model is then defined to be the number of harvests per year. Therefore, perpetuity is equal to one for a *sasi* that is opened every year; it equals to 0.25 if the *sasi* is opened every four years; and it equals to zero if total harvest banning is applied.

[11] Village leaders, traders, and local fisheries officers

The Biological / ecological attribute:

Beddington and Rettig (1984) argue that the biological objective of fisheries management is to assure that the stock can be maintained in perpetuity. And Mc Gowan (1993) states that in the case of trochus, the size of the population in the future depends on how much the size of the population is reduced by the fishing activities now. This is because recruitment is assumed to be dependent on the size of the parent stock. This argument is confirmed in a report by Clarke and Ianelly (1995), wherein they show that if the stock drops too low, the existing population will not be able to replace itself. Therefore, it can be implied that size of the population is crucial for stock sustainability. Accordingly, this factor represents a good proxy for the biological attribute in the multiattribute analysis of the *sasi* model.

The next step in the analysis as indicated in the formula determining the aggregate score of an option, is to determine the weight to be given to every attribute. Weighing the attributes is done by standardizing relative priorities given by the relevant stakeholders and actors. Following Healey (1984), all respondents representing a particular group of stakeholders/actors are asked to assign ordinal and cardinal rankings to the attributes based on their perception. The cardinal rankings are standardized such that the sum of all weights is equal to one (or any other positive value as long as it is done consistently). The standardized values of the weights given by individual respondents are then averaged to provide values to be applied to weighing the values of attributes of all options. The effect of variation in weights among groups, if any, can be seen in the sensitivity analysis carried out in Chapter 5.

3.4. A method to assess the operational feasibility of the co-management solution

After determining the the optimal sasi arrangement, the last step of the analysis is to assess the operational feasibility of a co-management scheme based on the current circumstances. This assessment focuses on two major stages of development: planning and implementation.

The evaluation of the planning process is accomplished by probing the attitudes of relevant stakeholders and actors involved in the management scheme. Public involvement is crucial in determining the success of a management project (Chambers, 1983). Therefore, in this research, the attitude of community members and other relevant groups toward the proposed plan was elicited.

The relevant circumstances at the implementation stage comprise a wide range of factors that might interfere directly or indirectly with the proposed scheme. Oakerson (1992) suggests a relationship between a set of influential factors, incentives to cooperate, and the corresponding management outcomes. Based on Oakerson's framework, Pomeroy *et al* (1996) constructed an operational evaluation technique[12] for community-based coastal resource management projects. The categorization of factors as outlined by Pomeroy's technique was adapted to this study to carry out the assessment.

3.5. Data gathering and analysis

Considering the objectives of the study listed above, three groups of data were gathered through a combination of library and field research. These include information

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[12] This technique proposes a set of variables as shown in Appendix 2 as the observable factors that influence the success of community based coastal resource management projects.

on parameters required for the simulation of the resource dynamics, historical data concerning the past practice of the *sasi* tradition, and demographic data required for assessing the operational feasibility of the proposed co-management. Data concerning the simulation model parameters were gathered through a literature review while other types of data were gathered in the field using interviewing techniques during the period of March 1997 to January 1998.

3.5.1. Data on historical *sasi* application and performance

Several key informants served as the primary sources of information regarding the events that occurred, the arrangements that existed, and the performance of the *sasi* of the past. The sampling procedure used follows the 'reasoned selection design' (Taylor, 1994) with groupings made with respect to the exposure of the *sasi* tradition to economic development, which appears to be associated with the distance between the locations and the province's capital. This is to anticipate possible variation due to differences in the economic circumstances. Six village heads and three customary elders were selected from communities in Kei Besar Island to represent those respondents with a minimum of exposure to economic development. Then four village heads were selected from Banda Islands to represent those with moderate economic exposure, and two village heads and two customary elders were selected from Lease Islands to represent those with maximum economic exposure.

In-depth interviews were employed as the main mode of data gathering. The reason for adopting this method is that one of the objectives of this study is to identify the underlying factors that influenced the performances of *sasi* practices of the past. As stated by Simon (1969), understanding forces that underlie a process leading to a specific trend constitutes the basis for extrapolating an observable trend into the future. For that purpose, in depth interviews were seen as being the best way to determine the underlying forces. Freeman and Sherwood (1970), for example, note that this method can stimulate interviewees so that the free responses that occur will result in more valid arguments. Following this key point questions were prepared, but the phrasing and sequence actually used in the interviews did not necessarily follow a formal questionnaire. These include questions concerning philosophies underlying the establishment of the tradition, the practical arrangements that were used to attempt to accomplish the goal, and records on violations / compliance. In addition, the interview also discussed recent attempts to maintain the *sasi* practices as related to their concerns about the current government management approach. Validation of the information provided by these primary sources was done through crosschecks with alternative sources including ordinary citizens, traders, and other knowledgeable informants. When available, documented sources of information, as well as reports of previous researchers were collected in the villages to obtain further confirmation of the information.

Finally, information was obtained from feedback offered by participants in two seminars presented by the author, and from his participation in studies on *sasi* conducted by other research groups. The first seminar was at the International Research Conference on Maluku held at the Pattimura University, Ambon in July 1996, where interest groups of various disciplines were present; and the second was at the Ambon Assessment Institute for Agricultural Technology in March 1997, where the audience was mostly biologists from Pattimura University, Ambon Station of the National Institute of Science, and the Assessment Institute for Agricultural Technology. Information was also accumulated from the author's personal exposure to the life traditions and values of people in Maluku, where the study was conducted and where the author has been a resident for 15 years.

Descriptive analysis (Simon, 1969) was performed on the data that were collected through the methods described above. The inferences and discussion recorded in Chapter 6 are based on this descriptive data presentation.

3.5.2. Data required in optimization of the harvest arrangement

Information on the biological and economic parameters necessary to construct the simulation model was taken from a review of the literature. In cases where information was not available in the literature, expert opinion was solicited. Data from the various sources were then compared to obtain a best value, and the data were used to run the bionomic simulation model as presented in Chapter 5.

The information on preferences of stakeholders required to analyze the tradeoffs provided by the bionomic model was drawn from the interviews using pre-designed questionnaires adapted from Edwards and Newman (1982). They are included in Appendix 3. Respondents[13] were selected from those individuals relevant to the case study sites. These included 8 village heads, 7 customary elders, two district fisheries officers, one provincial fisheries officer, two local scientists, three local traders, three

[13]The competence of these respondents in this particular part of the research was based on the feedback offered by the audience of various disciplines at the two seminars (see Section 3.5.1) that were held preceding the fieldwork

provincial-level traders, and three representatives of NGOs. As noted earlier, averaging was done on the values of preferences given by the various stakeholders. The result of this survey is presented in Chapter 5. The averaged values were then incorporated in the multiattribute analysis that is based on the bioeconomic model.

3.5.3. Data necessary for assessment of the feasibility of the co-management scheme

Data relevant to the planning process

A list of questions compiled in questionnaire forms was prepared and administered in the field to reveal the attitudes of potential participants. Appendix 1 includes a sample of the questionnaire that guided the survey. Questions in the list are mainly concerned with soliciting the opinions of the respondents regarding issues related to the trochus management plan. A set of questions regarding the contribution that each participant might be able to provide to a co-operative management arrangement was also administered to non-community potential participants[14].

Samples were taken from respondents in seven villages in order to take into account possible data variations due to differences in religion, relative economic conditions, *sasi* compliance, and the level of trochus production. The seven villages were Kilwat, Weduar, Ohoirenan, Yamtel, Hollath, Wattlaar, and Banda Effaruan, which geographically lie from the south to the north on the east cost of the Kei Besar Island, where trochus production is concentrated (see Fig. 1.1). Within each village, samples were taken so as to capture any variation in the existing castes, economic status, and their

[14]Potential participants are groups or individuals that might be considered to be involved in a co-operative arrangement with communities

educational achievement levels. All family groups within all castes were included. Names of members provided by the head of each family group[15] were then selected randomly. All together, 186 questionnaires were administered in the seven villages. Respondents in the non-community category include officers or representatives of various institutions, such as the head of the sub-district government (*kecamatan*), the head of the sub-district police department, traders, staff of research institutions, and members of non-government organizations.

Data relevant to the assessment of implementation process

The data required to carry out the assessment of the implementation stage were collected from a variety of sources, depending on the category of questions. Visual inspections, reviews of secondary documents, and additional questionnaire surveys were employed (Appendix 2). Responses to the questions compiled in Appendix 2 were solicited from three groups of sources:

- Information concerning the circumstances at the supra-community level was gathered from various institutions, including the head of the sub-district government, the head of the sub-district police department, traders, staff of research institutions, members of non-government organizations, and the agent of the PHPA office.
- Information concerning circumstances at the community level was provided by village heads and elders, and other knowledgeable persons in the seven villages that were previously selected. Additional information was collected through site visit observations (e.g., re. environmental features) and reviews of the statistics available

[15]A family group (*mata rumah*) is a customary social categorization normally consisting of members having the same family name

at the sub-district office (e.g., re. the level of the development of villages in the sub-district domain).

- Information concerning circumstances at the individual / household level was collected from the same respondents that were selected to assess the planning process. Therefore, in all, 186 respondents were involved in providing answers for questions regarding individual / household conditions.

Descriptive statistics were used to summarize and analyze the data. This statistical presentation formed the basis from which the inferences and the discussion presented in Chapter 6 were developed on the operational feasibility of the proposed co-management scheme.

CHAPTER 4. LESSONS LEARNED FROM *SASI* PRACTICES

4.1. Historical Evaluation of Successful *Sasi* Management Systems

The fact that *sasi* was, and in several cases still is an effective resource management system suggests that there is something important to learn from its use to support the development of a new, alternative management system. In Chapter 3 a set of contextual factors were introduced to assess the applicability of the management system proposed in this dissertation. However, there also is a set of values-based factors or cultural characteristics that influence individual behavior in a community. These are factors that play an essential part in encouraging, or alternatively discouraging, the acceptance and observance of regulations established by community members. As cited in the literature, factors such as beliefs (Wilson, 1982 and Mc Namara and Tempenis, 1999) and variations in the way local rulings are determined and handed down by leaders (Edgerton, 1985) are among these important cultural characteristics.

These factors have been identified in the literature and through field observations in the villages as being significant in encouraging acceptance of regulations employed in *sasi* management. Further, these are elements that are important to the formation and observance of local regulations. Following Wilson (1982) and Mc Namara & Tempenis (1999), we evaluate three previously identified elements that characterize Malukuan culture. These are customs, religion/belief systems, and respect for the wisdom of leaders. For the most part, these are factors manifested in a form of a moral power or understanding that encourage both leaders and citizens to commit to the regulations they have agreed upon in common. Therefore, the initial phase of this evaluation is to verify whether or not the influence of these forces in natural resource management actually exists. That is, we will see how these three elements are connected to the development of *sasi*. Then we will observe the actual importance of these traditional forces in the field.

The role of customs

In the dictionary of Purwadarminta (1952), customs are defined as a community's standardized inter-generation ways, or ethical codes of behavior. Further, Rader (1964) says that such codes, often referred to in the literature as morality, are usually maintained by individuals in a community to balance an individual's personal attitudes with community interests or objectives. Since some interests and objectives may be unique for each community, customs also may vary from place to place. Spaemann (1989), for example, notes that there is no one fixed morality standard that applies to all communities. Following from this then, the type of social order which exists in a Malukuan community is arguably the product of its local customs, and *sasi* regulations present there may reflect these customs. Therefore, it is relevant here to see how customs adopted by the Maluku peoples have played a role in *sasi* development and observance.

The role of religion

Rader (1964) argues that in religious communities people believe that God is their moral law giver. Thus religion is an important factor in promoting social order. Wilson (1982) extends Raders work by arguing that followers in all religions are taught behavioral principles not only for their benefit in the hereafter, but also to help them cope with life in the present world. He also notes that religion is not only important in traditional communities but in modern societies as well. McNamara and Tempenis (1999) and Day and Laufer (1987) support these findings by noting that religion plays a significant role in law enforcement practices in the modern societies of North America.

Considering that most people living in Maluku are either Christian or Moslem, the literature cited above provides justification for the presumption that religious teachings are relevant to the social life of Maluku people. Thus, in this chapter we will address the role of religion in determining the acceptance of *sasi* rules by communities. As discussed in McNamara and Tempenis (1999), however, it is not just because a religion exists in a community that social order may be established; the religious quality, or religiosity, as these authors call it, is the key. For example, they cite a report which finds that religious participation of prison inmates makes them more compliant to rules and regulations. Therefore, the discussion in this chapter will give particular attention to the quality side of religious practices.

The role of wisdom of leaders

Our review of the literature also supports our other presumption that the manner in which rules and regulations are applied by respected leaders have helped make the *sasi* system work in the villages of Maluku. According to Edgerton (1985), variations in the application of specific regulations are particularly relevant in situations where there is social stratification. What's interesting about his findings is that exceptions to rules are practiced extensively all around the world. And more importantly, he found that practicing flexibility in the adjudication of rules in particular circumstance often works better than maintaining strict application of the letter of the law in all conditions. In this chapter, we will consider several examples of such exceptions, and show how this works quite effectively in promoting compliance to the *sasi* regulations.

Regional variations in sasi

One of the interesting discoveries made during my field work was that some *sasi*es are present and functioning in some villages but not in other, neighboring villages. My hypothesis is that these variations in the use of *sasi* are caused by regional differences in the way the three cultural variables mentioned above are present and perceived by villagers in various locations. To test this hypothesis, communities on Kei Besar Island were selected as case study sites to investigate the causes of variation in the use of *sasi* in the region. In addition, where appropriate, case study examples from other parts of Maluku also are presented to complement the information collected from Kei Besar. In each case a description of local customs, religious practices, and the role of and respect for leaders will be cited to illustrate how they have influenced the performance of *sasi*.

4.1.1. How customs have affected the way people perceive the value of *sasi* in resource exploitation

Some basic customary principles: an inspiration for sasi

As stated in Chapter 1, the origin of *sasi* is not clear. However, regardless of the origin of *sasi*, previous researchers seem to agree on one thing, i.e., that in the past *sasi* worked well in most Malukuan communities. In our case, the important issue is whether or not the cultural characteristics of these communities have been accommodative to the *sasi* system because this will indicate whether or not *sasi* may be an appropriate basis for future management.

Below, we discuss local customs as understood by Maluku villagers themselves, and evaluate how they have influenced the development of *sasi* practice in the past. The description of these customs varies, depending on the sources. The villagers themselves describe customs as principles, norms, regulations, means, and all other practices that have developed over time as a reaction to the physical and cultural ecology of the region (Kissya and Rahail, pers. comms.). Furthermore, these sources argue that the essence of customs of Maluku people is the close association between them and three important subjects, nature, kinship, and the Supreme Being or supra natural objects. For example, in an interview with Rahail, the Rajah of the village of Wattlaar, it was mentioned that a written document exists which describes seven principles underlying customs in his community. In the following discussion we will observe where various aspects of *sasi* practices link with the principles he mentioned, which include:

i. We dwell in the village where we live and eat from its water/soil.
ii. We occupy our place and will always defend our share
iii. We always carry out our public matters according to customary laws
iv. We live as honestly as possible and always go on the straight path
v. And, customary laws will protect us
vi. And, ancestors protect and love us
vii. And, God protects us

The following cases are presented to illustrate where the influences of values can be observed in various resource management practices of Malukuan communities. One of the most notable examples is belief in super natural power, something beyond human capacity to fully understand, which can be used to help individuals or groups protect their properties. While in some places it is not unusual to hire a person to guard personal property, people in many villages find it more convenient to adopt a form of a supernatural mode of property protection. In other cases, both approaches may be used simultaneously.

Property protection involving mystical belief is widely practiced by Maluku peoples. While this system was initially adopted by their early ancestors, present day villagers still employ it in many locations. For example, in Ler Ohoilim, in the eastern part of Maluku, one can observe bottles of water tied up with a piece of ribbon-like fabric, generally red in color, hanging about one meter above the ground on palm trees. The people there have a devout person pray over the bottles in the hope that his/her blessing would protect the tree from robbers. And in Hatta, in the central part of the province, many villagers believe that one will have his or her stomach inflated and deflated following the rise and the fall of the sea tide if he or she ever disturbs a 'protected' object. They believe that a prayer delivered by an *orangpintar* (lit.: a capable person) that makes such an occurrence possible. Further to the west, another example of belief in supernatural powers can be found in the Lease Islands, where the word *pakatang* is quite popular. This word refers to black magic, which is normally used by a person to take revenge or to punish someone whom he or she believes has somehow upset him or her. In some cases, however, people simply use it as a means of protecting their property. Apparently due to its 'black-side' nature, *pakatang* is less practiced these days than it once was.

The influence described here is not limited to local mystical beliefs but also is applicable to modern religions. Prayers delivered by a religious leader, even though rarely including a wish for specific punishments, are often believed to have a magical power too. So it is not just a coincidence that such practices reflect underlying customary principles. Such practices are a manifestation of custom as stated in the philosophical words, 'God and the ancestors protect us'.

There are differences among these practices, and the above examples represent only few of the beliefs that were and still are alive in the communities of Maluku. Yet they all imply a similar phenomenon; i.e., that the values, especially belief in the Supreme Being or a supernatural power, makes a nonphysical, spiritual, control system effective. What this suggests is that people have found that property protection which takes advantage of people's belief in supernatural power is more practical than employing watchmen to guard their property. Thus, what is being argued here is that the adoption of a supernatural property protection technique has been perceived by Maluku property owners to provide higher assurance of protection at less cost. Generally speaking, then, it is clear that mystical and/or religious beliefs have strongly influenced the kind of property protection system that the communities have developed, and that they are important in the case of *sasi* collective management systems.

Manifestation of customary values in sasi designs

Depending on whether property belongs to a private individual, a particular group, or the public, there are three main categories of *sasi*. First is *sasi umum* (public *sasi*), the most commonly known form of *sasi*, which deals with the interest of all the community members. The second is *sasi gereja* (church *sasi*) and *sasi masjid* (mosque *sasi*), which deal with the safety of group properties. This second *sasi* category is proposed, established, and administered by members of recognized religious groups within a community, such as *jamaah masjid* (mosque congregation) for the case of *sasi masjid* or *jemaat gereja* (church congregation) for the case of *sasi gereja.*

The third category is *sasi perseorangan* (individual *sasi).* In this case, a person who wishes to place a *sasi* on his or her property (usually agricultural commodities) has to declare the plan to a person who is assigned to implement it, usually a member of the *saniri* (the village traditional deliberation council which consists of village's prominent persons). Signs usually believed to have a sort of magical power are placed to notify public that a property is being *sasied.* A portion of harvest has to be given up by the property owner in return to such an arrangement made by this village institution.

In addition, there is a fourth important variant of *sasi,* i.e., *sasi negeri* (village *sasi),* which is imposed under a specific circumstances such as when there is dispute between neighboring villages. In this case, *a kepala desa* (village head) might decide it is necessary to make an interim agreement with the neighboring village to establish a temporary *sasi* for the disputed territory or the appropriation of the harvest of a particular land or seabed resource while the ownership case is pending. This kind of *sasi*, is meant to allow talks on the disputed matter to take place. Until a settlement is reached, no harvest or utilization of the resource is allowed. During this period, the disputed area is usually guarded intensely by people of both villages. A recent example of *sasi negeri* is the one being implemented for a territorial dispute between Upper Hollath and Lower Hollath. Written documentation on agreements of this type are rare. However, one might find them in songs created as reminders to the people about the events. The songs sometimes may be sung to the parties that commit the violation.

Some aspects of *sasi* are similar while some others vary. A *sasi* almost always connotes a prohibition that follows a certain customary formality, and is assumed to be observed by every single individual who happens to be in the village, either temporarily or permanently. However, the actual forms of customary influence may vary from one *sasi* practice to another. These variations are apparently associated with differences in the way people of different localities adapt their customary laws into *sasi* formulation and implementation. Thus *sasi* practice may differ from village to village even though they may face similar circumstances.

The following discussion describes how customs are interpreted within *sasi* formulation. It will be followed by a review of the control mechanisms developed in several localities (e.g., what types of control or rules are adopted and what messages are contained in the rituals marking the opening and closing) while at the same time comparing the outcomes.

A common characteristic of communities that have depended on *sasi* in the past is their dependence on natural environment for their sustenance. This has created a situation wherein they have had to manage their resources for the common good. Thus all resources that exist within the village domain are perceived to be the common property for all members of the community. This means that every individual also has the potential to participate in determining collective actions aimed at maximizing collective benefits. Consultative meetings facilitating the formulation process of *sasi* are an example of the result of the perceived need of collective action. Ideas and arguments are advanced by people, who are the stakeholders of the resource. Because of such meetings, many village communities in Maluku end up accepting the idea of *sasi*.

Although spatial and temporal variations might occur, the essence of such collective action remains the same in all cases. In the old days, when the population of a village was generally small and their economic activities were limited, all members of the community might easily attend such meetings. However, now that the population has increased, holding an all-community meeting is quite a challenge. Instead, most villages in Maluku have adopted a representative system, where only members of the *saniri negeri* (lit: the village's customary deliberation council), are present at the meeting. There is some variation amongst villages with regard to the composition of a *saniri negeri*. But it normally is composed of *margas* (clans) or *soas* (groups of several clans). For more important cases, the meetings are attended by members of *saniri besar* (the village's customary consultative assembly), which includes all members of *saniri negeri,* village executives, customary elders, and other distinguished persons of the village.

Another important feature that characterizes *sasi* is the influence of either religious or local mystical belief systems, or both. This feature is not surprising because as is indicated by the mystical property-protection-practices of the past, people find if effective to involve supernatural power in the *sasi* system. Evidence of this influence can be found in the prayers delivered in ritual ceremonies marking the closing or opening of *sasi.* Even though the types of prayer vary depending on the religions or beliefs that are found in the different villages, their main message is similar; i.e., an expression of gratitude for the blessings of the year that passed, and a call for more blessings for the future years. In some villages, prayers also include a request for punishment for those who break a *sasi* rule (e.g., in Wattlaar and Hollath). But for most other villages this kind of a request is not normally included.

Our research also discovered that while religions embrace different prayer contents, the general messages they deliver are similar. In the case of most *sasi*es of the past and many *sasi umum* of the present, rituals often include an offering to mystical objects. But, now that religions have penetrated into the people's social lives, inappropriate ritual segments have been revised. For example, in cases of *sasi mesjid and sasi gereja,* beliefs that are inconsistent with religious teachings are put aside. And, no mystical practices are maintained in *sasi gereja* or *sasi masjid.* On the contrary, prayers that are more appropriate to modern religion have been adapted. In these cases, no offerings to spirits thought to be inhabiting spooky rocks, stones, or trees are performed.

Two additional features are worth mentioning concerning place to place variations. The first is the popularity of private *sasi* in Southeast Maluku as compared to that in Central Maluku. Even though private *sasi* is found just about everywhere in Maluku, its prevalence seems to be greater in the Southeast. This apparently has something to do with the availability of more clearly stated individual rights in SE Maluku communities: *'hira i ni fo i ni, it did fo it did.'* (Theirs are theirs and ours are ours). What this suggests is that the people of Southeast Maluku are more likely to develop a private *sasi*. The other feature is associated with the past record of property rights transfers, which were common in many locations of Southeast Maluku. Granting pieces of land to groups of people belonging to another community was practiced extensively by early inhabitants of Southeast Maluku villages, including many in Kei Besar Island, with the hope that the newcomers would be able to guide the earlier inhabitants to a better life.

Traces of customs in the primary control mechanisms that were developed to sustain sasi:

In the field work of this study, I was able to confirm an important message, which was repeatedly stated by the villagers and their leaders. This message is that sanctions and other forms of control mechanisms are not meant by the community to intimidate people or to collect revenue from the ones who get caught committing violations. Instead, respondents asserted that sanctions were established to persuade people not to betray the common interest. The possibility that they learned such a view from an external source is small because they are generally isolated. Thus, most of the principles they follow must have come from something that they have acquired from internal sources, such as customary laws and religious values. Besides, as also emphasized by elders, this view is not a new invention. It is a *pusaka* (an heirloom), as they like to call it, which they have inherited from their predecessors. The principle that says 'we carry out public matters according to customary laws' supports their claim. Thus, it can be argued that this message is a reflection of their principles, which for the villagers comes from their customs or religious values.

The following are several case illustrations as to how sanctions are carried out in practice in the *sasi* system. In general, the sanctions seem to be flexible because it is their effect which is actually the main concern. What is meant here is that a person who gets caught violating a law has the potential to face the most severe punishment / sanction, as stated by customary law. However, a moderate sanction might be considered when there is indication that the person is helpless and requires access to the resources to survive. Sometimes, circumstances might even prompt the leading decision-maker in the village to grant amnesty or pardon. More details on amnesty and other types of tolerance will be provided later. In this section, we limit our discussion to primary / basic control mechanisms; i.e., those that are actually agreed upon, either written or verbally and maintained in the villages.

The primary tools or control mechanisms normally consist of various moral sanctions, alienation, physical sanctions and fines of various kinds. Table 4.1 lists the types of sanctions that have been adopted by the village communities.

Table 4.1. Various types of sanction introduced by selected villages

	Shame		Harvest right revocation		Valuable item fines		Labor fines		Physical punish-ment		Cash fines		Performance
	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present	
Ohoirenan	√	-	-	-	√	√	√	√	√	√	-	√	*medium*
Weduar	√	-	-	-	-	√	√	√	-	√	-	√	*low*
Hollath	√	-	-	√	√	√	-	√	-	-	-	-	*high*
Wattlaar	√	-	-	-	-	√	√	√	-	-	-	√	*high*
Banda Effaruan	-	-	-	-	-	√	-	√	√	√	-	√	*low*
Kilwat	√	-	-	-	√	√	√	√	-	-	-	√	*medium*
Yamtel	√	-	-	-	-	-	-	-	√	-	-	√	*medium*
Hatta	√	-	-	√	-	-	√	√	-	-	-	√	*low*
Nolloth	√	-	-		-	-	√	√	√	√	-	√	*low*
Haruku	-	-	-		-	-	-	√	√	√	√	√	*medium*

Note:

1. Common valuable items are *lela* (a small antique cannon from the Portuguese colonial era, priced at approximately Rp 300,000 each), some other antiques, and gold
2. Cash is normally charged for the cost of the case process and fines, for which the amount is based on the level of the violation.
3. Performance: this category is based on the frequency of the violation within the past ten years, where low performance is associated with more than ten violations; medium performance is associated with five and ten violations; high performance is associated with less than five violations.
4. 'Present' denotes the periods after the year of 1970.

One way to identify the types of rules or regulations imposed is by looking at what is contained in the ritual procession marking the *sasi* opening or closing. A typical form of ritual procession usually includes a formal sequence of ceremonial events that are carried out both in the village and on the seashore. The in-the-village ceremony is normally carried out in the church and/or mosque, or the village civic hall or village office. In the church and/or mosque, prayers are the major theme. The most important segment of the by-the-sea procession, on the other hand, is a restatement of the rules of *sasi*, a reminder about the effect of rules breaking, and a restatement of the reasons for *sasi*.

Although different villages may introduce similar lists of sanctions, the workability of these sanctions may not necessarily be the same in all cases. Given this, effective enforcement is a crucial issue. In general, there are two distinct methods of enforcing *sasi*. One method relies on the effectiveness of the traditional police, called *kewang*; while the other is built on the premise of an effective 'community watch' system. Through either one of the two systems a violation might be discovered and a report handed in to an assembly meeting for action.

On Lease Islands, in Central Maluku, most responsibilities for control and enforcement are given to the *Kewang*, whose job is to monitor the implementation of all of the regulations, to apply sanctions against violators, to control territorial boundaries, to place signs of *sasi*, and to arrange and hold both periodic and emergency meetings.

To carry out its function, a *kewang* organization normally has the following structure: two *kepala kewangs* (leading *kewangs), kepala kewang darat* (for land resources*)* and *kepala kewang laut* (for marine resources*)*. One of them also acts as the coordinator for both. Each of them, assisted by a *kewang pembantu* (assistant *kewang)* and several *anggota kewang (kewang* members), is responsible for their assigned tasks. In addition, the organization is also equipped with a secretary and a treasurer.

In Southeast Maluku, *sasi* control is based on the effectiveness of each individual reminding others about the importance of everyone participation in protecting their common resource. In some ways, this resembles a community watch system in western societies. There also is a strong indication that caste stratification characterizes enforcement mechanism in this particular part of Maluku. The history of Eastern Maluku community development has made them acknowledge the existence of two[16] major caste categories, *mel* and *ren*. In the old days, outsiders were often invited by the original inhabitants of many villages to help them manage their natural resources. The consequence of this was that the outsiders, later called *mel*, became the first class in the social structure. The first inhabitants, later called *ren*, on the other hand, become the second class. Within this class arrangement, however, villagers prefer to use brotherly terms such as *adik* (younger brother) for the *mel* and *kakak* (older brother) for the *ren*. One implication of this is that, even though the *mel*s for all practical purposes are the ruling class, the *ren*s have a position by which their advice must be listened to by the *mels*.

An implication of this social stratification is that given the authority to rule the *ren*s, the *mel*s have the opportunity to maximize their benefit share by performing a more active management role over the resource and by taking advantage of their position. Their *sasi* arrangement shows that this opportunity has been implemented in practice. In Figure 4.1, it is shown that a portion of the revenue obtained by divers from the village collective

[16] There is another category of caste called *iri*, but it is not discussed in this section here due to its insignificant relevance

sale, has to be surendered to the village for common purposes including for redistribution. Table 4.2 shows that the redistribution is to secure the right of those who can not dive such as children and woman. However, this table also shows that the marginal benefit is higher for the *mel* than for the *ren*. For example, the ruling group receives a larger share of the benefit generated from the resource harvest. Therefore, it can be argued that, given the *mel*'s social position, there is a tendency for this caste to increase its share even higher, by deceitfully taking some of the benefits which should go to the *ren*. This tendency, however is somewhat neutralized by the elder brotherhood status of *ren*, who will always be in the position of giving advice (read: reminders) in case the younger brother attempts some irresponsible action. This is possible because monitoring everyone's actions with respect to the resource is not very difficult in many Southeast Maluku village communities. Whose *kole-kole* (Malukuan traditional canoes) are in the sea and what and how much is being collected from the ocean are easily observable. An outboard motor boat leaving the village will be readily recognized by practically everyone in the village. So, there is little chance that a person would be able to leave and take anything from the village without other villagers knowing.

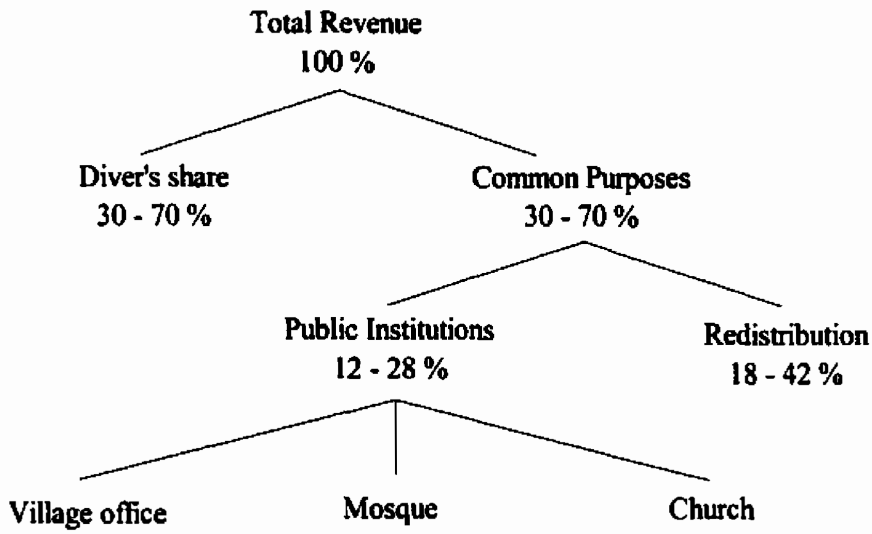

Figure 4.1. Diagram of revenue distribution in a sasi opening
Remark: - Village institutions receive equal shares
- Redistribution to villlagers is carried out according to a plan as shown in Table 4.2

Table 4.2. The Ohoirenan's revenue redistribution (fixed share) scheme

Social category (i)	**Share factor (f_i)**
Village head	5
Village secretary	4
Soa chief	3
Clan chief	2
Household head / widow	1
Unmarried aged 18^+	.75
School out-drop	.50

Notes :

- The benefit share received by a person of social category i is calculated as: $IR_i = RR \times \frac{f_i}{\sum f_i n_i}$, where IR_i, RR, and n_i, are individual share, total redistributed revenue, and number of person within category I, respectively.

Another implication of the existing caste system is that control is also carried out among the members of each group because they understand that reputation of the group, and hence its credibility in the eyes of other groups, depends on the behavior of each individual member. Many respondents indicated that it would be a shame to have a violation perpetrated by a member of their group or clan. A quote from a respondent demonstrates this: 'Several years ago, I opted not to report a case of poaching which involved my clan member. Instead, I had him return the stolen trochus to the village, and told him not to poach again'. This indicates that from one point of view, the intense kinship relationships of the villagers could have an adverse effect on enforcement of regulations. In their society, however, individual homes are almost always open to everyone in the community, particularly those of the same caste or the same clan. Therefore it is not surprising that, as they emphasized in the interviews, monitoring other's behavior, both at home and at sea, is functioning well.

In Kei Besar, a good lesson that can be derived from the community watch system is that the system allows the development of awareness among villagers about the importance of observing rules. A friendlier atmosphere exists because 'community watch' is not a system where a guard watches for violations. Instead, it is, as understood by villagers, a system in which everyone is supposed to remind others not to violate local regulations. However, within this system, there are also potential drawbacks associated with the moral condition of the people. The example presented earlier where an individual was unwilling to disclose poaching because the poacher was a close family member is a case in point.

The *kewang system*, on the other hand, is a good alternative when the community watch system is unable to function well. But certain conditions need to exist for the *kewang* corps to be fully effective. For example, despite the prestige of being assigned to the corps, a *kewang* member still needs a sufficient source of income to support his family. Recently, many *kewang* members have experienced inadequate incomes due to declines in revenue associated with depreciation in the price of agricultural products. So, becoming a *kewang* member is not as attractive as it once was. Recently, the idea of providing a government subsidy to revive the *kewang system* was introduced(Haulussy, pers.comm.). However, this proposal will not be feasible because the costs that have to go to all *kewang* members may exceed the total revenue of harvest normally received by a village.

4.1.2. Other intangibles in *sasi* implementation

Do religious practices matter?

It is not unusual for Maluku people to characterize a village by looking at the prevalence of religious followers. A village is referred to as Christian (loc: *Kampung Kristen)* because the majority of its citizens are Christian, and it is called Moslem (loc: *Kampung Islam)* if most of the citizens follow Islamic teaching. When comparing the effectiveness of *sasi* in a number of villages of Kei Besar, in general it looks like the Christian villages were able to maintain *sasi* practices better than their neighboring Moslem villages. Wattlaar (a Catholic village), Ohoirenan (a Protestant village), and Hollath (a Catholic/Protestant village) are villages where the *sasi* management system has been sustained quite successfully while in Banda Efaruan (Moslem village) and Weduar (Protestant/Islam village), *sasi* is not functioning very well.

On the other hand, *sasi* practices in Saparua of Central Maluku provide evidence that it is not the type of religion *per se* that contributes to the performance of *sasi*. The fact that *sasi*es are functioning better in Christian villages of Kei Besar and in Moslem villages of Saparua appears to be an inconsistency. Wilson (1982) and McNamara and Tempenis (1999)'s argument regarding the role of religiousness in law enforcement might provide a plausible explanation to these inconsistencies. Therefore, in the following paragraphs we will examine these religious aspects. Based on my field observation, special attention will be given to the leadership / organizational structure and the comprehension and practice of religious teachings amongst the people.

A distinction in terms of leadership and organizational structure is recognizable between the two major religions in Maluku, Islam and Christianity. The Christians have a more formal / coordinated type of organization, while the Moslems maintain a relatively loose structure. The Christian community form of governance which is very effective because each member is associated with one of the zonal groupings of the community. As a result, messages from a local Christian leader can be transmitted to virtually every member of the congregation within the respective village. A continuing flow of financial contributions necessary to sustain the religious services can also be encouraged. The Moslems organizational style, on the other hand, does not have a solid structure. Consequently, Moslem villages do not have the opportunity to mobilize any kind of common action that Christian ones do.

Despite the fact that most Moslem communities are not traditionally well equipped with a solid administrative organization, there are cases where a devoted Moslem is quite influential in carrying out effective organizational functions for his fellows. The head of the religiously mixed village of Weduar, for example, notes that there has been a period when leaders of the Moslem society in his village were able to establish good interaction with their community so that coordination could still work well. Furthermore, the village head elaborated that this situation will be present as long as religious leaders have a good appreciation of local history and customs; especially an appreciation of the fact that people in the village have a common heritage. He noted that a priest was expelled from the community recently because he had failed to recognize local customs and history. On the Moslem side, the same community also is facing difficulty because their leader is 'too young', and too immature to understand the customs and history of the village.

These illustrations carry two important messages. The first is that the efficient organizational arrangement featured by the Christian communities has the potential to contribute to the effective communication and administration necessary to mobilize support for public affairs. This may include support for the development of a co-management program such as is proposed in this study. However, the second advises that the actual effect of Christian organizational styles depends on how customary values are recognized. Because, to villagers, customs and religions are both important. What this means is that the highly organized administration such as that shown in the Malukuan Christian model, could fail to result in good coordination in the absence of an appreciation of local customs. Conversely, the loose organization common to the Moslems can be sufficient to mobilize people as long as customs are respected. So, it is clear that the significance of the organizational aspect of religions is subject to the incorporation of local customs and values.

Another important aspect of religion, is comprehension and practice of religious teachings. In Maluku, religious teachings clearly can promote the social behaviors necessary to sustain the collective regulation of common use resources such as *sasi*, because they instruct people to be considerate of each other, a fundamental condition for a collective regulation. However, the extent of the penetration of the religious teaching in the life of its adherents often reflect a gap between the teachings and peoples actual behavior. More specifically, what matters is whether or not people incorporate religious teachings to their lives. In fact, in several Christian and Moslem villages, only few people practice what is taught by their religious leaders.

Ay is an village in the Banda Islands where a trochus fishery is a potential venture. In the past, trochus harvests generated a considerable amount of revenue for the village. However, because of poor management in the past, trochus harvest has generated little revenue for the past two decades. Several attempts to rebuild the trochus resource potential were made by villagers who realized the potential of adopting the *sasi* system, but none of them was successful. A distinguished Moslem educator of the village argued that there could not be a functioning *sasi* system until the people practiced the religion more thoroughly. To emphasize his contention, he pointed to the poor attendance of the village mosque. The statement of Dullah, a citizen of the neighboring island village of Kampung Baru, confirmed the educator's claim: 'The villagers of Ay are frequent champions of the *Kora* boat race held each year in the Banda Islands, but their victory celebrations do not conform to their religious beliefs because liquor consumption is associated with the celebrations, and this is forbidden by the Islamic teaching'.

Wisdom, the leader's improvised approaches

A story of a forgiven trochus poacher has become a legend for the people of Wattlaar Village. It is a story that shows a Rajah's wisdom in using a non-physical, yet effective,punishment on a *sasi* violation. *Bapak Raja* Rahail of Wattlaar is a seventy-year-old, respected leader who has been serving in the traditional role as a Rajah in Wattaar, a 'kingdom' that reigns over 46 kampongs (11 *desas*/ villages) in the northern part of the Kei Besar Island. Even though more stringent alternatives are available, his approach to various cases has been and still is mostly persuasive. Most of the villagers recall a specific case, the theft of *sasied* trochus by a poor woman. Some buried shells were found by a sand gatherer, who reported his find to the Rajah. The buried shells were taken to be the proof of a theft. The Rajah had a respected elder pray that the guilty thief would not escape punishment and announced a three-day grace period during which the thief could confess to committing the crime. The day before the deadline a poor woman admitted that she had stolen the trochus and said that she was prepared for whatever punishment the customary law stated she should receive. Wisely, the Rajah forgave the woman on the condition that she not repeat the offence, and the villagers agreed with his decision. The people in the village believe that a prayer like the one mentioned in this case would affect the poacher by causing sickness or even death.

Another example of a leaders' effective approach to violation cases can be found in Haruku, in Central Maluku. For those who have violated *sasi* or any other regulation, *kewang* members will consider total forgiveness or at most some moderate penalty such as a gentle lash of a rattan whip, for violators who show remorse over having committed the crime. (Kissya, pers. com.). Usually, the convicted person himself has to pick the whip. Kissya believes that it is not severe punishments that make a person respect rules.

Instead, at times forgiveness is the more effective way to prevent him/her from doing the same in the future.

The kind of approach illustrated above works in many cases. A violator, either motivated by guilty feelings or by regret at having misused the patience shown by his / her leaders, might opt to voluntarily confess because of the positive benefits of doing so. However, because some individuals are different from others, complementary mechanisms are still necessary. For example, people who might not be discouraged by mystical curses might respond positively to actual punishment.

Lessons learned:

Several features that exist in *sasi* are essential for the formulation of an alternative management system:

1. Two local customs have inspired the development and contributed to the effectiveness of *sasi*. These are recognition on the importance of the interdependence between people and nature; and belief in supernatural powers.
2. Although several forms of sanctions have been applied, a leader's wisdom in using leniency often has worked better than other harsher forms of punishment.
3. The two existing enforcement models, the *kewang* and community watch models, both have potential advantages. The *kewang* model is a credible option as long as the sustenance of all *kewang* members is satisfied while the community watch model works well provided that people are able to avoid the kinship trap.
4. Respected leadership is provided by individuals who have a good appreciation of local customs, particularly common heritage.
5. Religion, in terms of the level of commitment is a relevant factor making *sasi* observance possible.
6. Attempts to involve resource use right transfers to outside parties within a *sasi* arrangement do not succeed because local custom perceives the nature to be an essential part of human existence.

4.2. Lessons from trochus fishery management: the arrangements and relative performances of *sasi* and commercial aquaculture

In this section we evaluate the characteristics of *sasi* and those of its alternative, the government's commercial aquaculture policy, and we compare their performances in trochus management. That is, it will be shown 'to what degree these two schemes have and have not performed their functions'. Each will be judged according to criteria taken from various reports by previous researchers (Jentoft, 1989; Charles, 1994; Kuperan and Abdullah, 1994). These criteria include compatibility with real problems, ability to promote conservation, enforceability, efficiency, and distributional effect.

4.2.1. The arrangements and compatibility with problems

Despite their common goals, the *sasi* system and central government's policy show significant differences in the strategic arrangements they employ to achieve their goals. Several researchers have shown that both schemes aim at resource sustainability and revenue generation; but *sasi* also carries with it an equity goal (Rahail, 1993; Kissya, 1993; Anon., 1987; Anon., 1989; Anon., 1988, Anon., 1990a; Anon., 1990b). Moreover, the *sasi* system is based on recognition of the rights and responsibilities of villagers to exploit natural stocks. On the other hand, the government plan functions through banning all natural stock exploitation, and the advancement of commercial-aquaculture operations.

For the trochus fishery in Maluku, these goals and arrangements were established at the outset to deal with the most prevailing issue; i.e., that the resource was under threat because of local people's lack of alternative economic opportunities. The main reason for reemphasizing this issue here is the physically close association of population to the resources. Thus, events that occur and the situation that prevails among the people will affect significantly the fate of the resource. Furthermore, the fact that villagers' sovereignty over their resources has long been recognized makes it necessary for managers to recognize the villagers' potential role in a management scheme. Being the *de facto* owner of the resource, villagers are in a position to make an immediate response to any external impetus, including externally imposed regulations.

Recent developments have shown that although it was proven to be quite effective to sustain harvest in the past, *sasi* appears not to have worked very well recently because of the complex economic issues that have emerged. *Sasi* arrangements appear to be insufficient to encourage people to make appropriate management decisions on harvest rate in cases where markets develop rapidly. As noted in the introductory chapter, this is mainly due to the fact that adjustments in *sasi* usually are based on a long-learned experience of the village people, and the system is less effective when a drastic external change occurs, which requires quick reactions. For example, recent events in the trochus fishery indicate that the system lacks a mechanism that would enable producers to include resource sustainability considerations while developing responses to the rapidly changing market. As the result, when commodity prices increased sharply, many village communities came up with responses which, despite the substantial increase in the short run benefits, resulted in questionable long run sustainability.

The government commercial-aquaculture plan, which was introduced to replace the *sasi* system, also failed to recognize the issue of revenue generation necessary to sustain a village economy. This is a policy that provides an opportunity for the trading of an endangered / protected species, including trochus, as long as the traded items are harvested from a licensed aquaculture operation. With this plan, the government expected that the decline in trochus population could be halted, while at the same time an opportunity for activities aimed at revenue generation could be made possible. My field observations show that this policy seems to have benefited only a few trochus traders, and helped no other market players. This policy was unsuccessful because it failed to consider the economic problems of local communities. The government policy does not contain an arrangement that allows the community to enjoy benefits which are sufficient to stop them from endangering the resource.

Villagers are unable to compete with established entrepreneurs under the government's policy because of lack of capital, lack of technological knowledge, and incomplete comprehension of the existing rules. Both lack of capital and technological knowledge prevent villagers from establishing an aquaculture operation as required by the regulation. On the other hand, because of access to capital, private entrepreneurs are able to take advantage of the villagers' lack of awareness of the existing regulations.

The following is an example of what has happened as the result of these inequities. An entrepreneur, with the assistance of a conservation agent, applied for a license[17] to run a commercial trochus aquaculture[18] operation. Since the process of issuing the license is slow, a large sum of money was paid to the agent to ensure that a quick decision would be made. When the entrepreneur received the license, he took advantage of the backing of the conservation agent and the villagers' lack of awareness of the existing rules, to gain control of the harvest. This case suggests that the villagers' competitiveness must be improved if they are to survive.

What can be learned from the above discussion is that the effective performance of both *sasi* and the government policy has been low because the local human capital issue has been ignored. Consequently, future attempts to adopt a management alternative for this region should place more attention on this issue. This means that viable alternatives would be those where exploitation by the villagers is permitted, while at the same time a better harvest control method is imposed. Alternatively, or complementarily, a policy might be developed which has an emphasis on economic diversification, so that the incentive to exploit the resource can be reduced.

4.2.2. Ability to promote conservation

The short time period within which the government commercial aquaculture policy has been operating does not allow for an accurate assessment of its conservation

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[17] This is a permit necessary for individuals to run a commercial aquaculture operation as described in the government scheme

[18] Commercial aquacultures for a protected species are defined as all aquaculture activities including culturing, processing, and marketing

effect. However, several indicators mentioned below should enable us to evaluate the performance of the policy as compared to that of *sasi*. In general, it will be shown that apart from the problem described in the preceding section, the arrangement contained in *sasi* will make the system be a relatively more dependable conservation means than the commercial aquaculture scheme. As noted at the end of this section, however, aquaculture is very important in the conservation effort, especially in cases where the natural stocks are so weak that they can not produce a large enough number of recruits to perpetuate themselves.

An important factor that would allow *sasi* to promote conservation better than the commercial aquaculture policy is the fact that its arrangement generates a sense of ownership among the immediate users. To villagers, applying *sasi* to maintain the existence of a type of natural resource is not just a matter of economic urgency. Non-economic motivations are involved as well. Ruttan (1995b), for example, notes that villagers have a tendency to be proud of the natural wealth of their village. This pride of ownership gives them incentive to preserve all the resource endowment existing in the village, something that a private aquaculturist is lacking. Consequently, even when the existence of the commodity is no longer of concern to a private aquaculturist, it might still be considered important by villagers.

Like other resource management systems, however, *sasi* would only function well as a resource-conserving system under certain circumstances. As noted in the introductory chapter, the implementation of *sasi* in trochus fishery was inadequate to prevent depletion of trochus in many locations in the past. And, as indicated in Chapter 2, this situation is primarily due to inadequate knowledge of the biological consequences of harvest adjustments they have made in response to the changing economic circumstances. Therefore, experience in many villages indicates that it is only if communities succeeds in adopting appropriate complementary harvest control mechanisms that the effect of the economic pressure on *sasi* can be neutralized, and a stable harvest can be maintained. An example of successful adoption of complementary harvest control mechanisms can be found in Ohoirenan Village. It is not a coincidence that the decrease in trochus depletion in this village is not as severe as that in other villages.

The government commercial aquaculture plan also faces problems, most significantly those related to its enforceability. The commercial-aquaculture scenario, which follows a harvest banning policy, puts the natural stocks at a higher risk. Insufficient enforcement capability has spurred uncontrolled harvests on natural stocks that used to be under the responsibility of *sasi* enforcing instruments. Aquaculture, also faces many technical problems, including high set up costs. A fisheries officer interviewed noted that only one aquaculturist has taken up the opportunity of the government's plan in his district. Unfortunately, as the officer pointed out further, this aquaculturist is maintaining his trading activities not by producing trochus but by receiving supplies from illegal harvest natural stocks. This suggests that lacking effective enforcement, the commercial-aquaculture policy merely increases the chance of the depletion the resource.

Another factor that has caused the conservation performance of the commercial-aquaculture solution to be lower than the *sasi* system is the flexibility of the aquaculturists in moving from one business activity to another. There is indeed a possibility that efforts to boost aquaculture production will eventually reduce the risk of depletion, in which case the perceived value of conserving the natural stocks becomes relatively lower. If this is the case, there will be good reason for the government enforcers to loosen the prohibition of the harvest of natural stocks, and this will endanger natural stocks. On the other hand, the aquaculturists, because of their ability to move from one activity to another, will maintain their operation only as long as there is no better business alternative. When a more profitable business opportunity comes along, aquaculturists might choose to leave the operation. When the aquaculture operation stops and if the control on harvesting the natural stock has grown too loose, then a disaster is likely.

Despite its drawbacks, it is undeniable that development of aquaculture has made a significant contribution to trochus conservation. Dwiyono (1996) notes that research on the artificial restocking of trochus that he has been conducting in Maluku has so far been shown to be a positive development. However, this does not necessarily mean that replacing natural stock with a cultured breed is an appropriate decision because an aquaculture breed is usually less resistant to external disturbances than the natural breeds. Clarke and Ianelly (1995), for example, have observed that the response of natural trochus stocks to environmental pressures is better than the transplanted ones. Given all of this, the best situation for the introduction of aquaculture might be where the natural stock is unable to halt its depletion.

4.2.3. Enforcement arrangements and their performance

It was indicated earlier that the enforcement arrangements developed for *sasi* are one of the system's most notable features. As discussed in section 4.1., Maluku people rely on two main mechanisms to maintain the *sasi* resource management system. Some *sasi*es are effectively maintained by the *kewang* system, while some others are maintained through a community watch mechanism. In addition to these two mechanisms, operated mainly to avoid poaching for the duration of the close-season time, villagers also normally respect an agreed-upon set of practical arrangements[19] issued at the time of the season opening and managed by a committee[20] established for that purpose.

In the government's commercial-aquaculture operational framework, enforcement is mainly carried out by the *jagawana*, conservation enforcing agents belonging to the Ministry of Forestry. These agents are located at the market gates from where illegal harvests are expected to be shipped out to destinations outside the region. At the time of my field-work, two *jagawana*s were located in Tual, the capital of South East Maluku district, and six others were placed on Ambon Island, the capital of the province. Whenever necessary, coordinated action involving military personnel, the police, and the *jagawana* itself, may carry out a surprise operation on suspected stock-piling of illegal harvested trochus.

[19] An example of an additional practical arrangement is control of the process of measuring the size of harvested trochus as found in many villages.

[20] This committee usually includes all the village's customary elders, which in most cases also constitute the members of the LKMD, the Village Security Council.

The governments commercial-aquaculture policy is very difficult to enforce. The continued pressure on villagers to exploit the wild stocks is the most significant problem. The implementation of the government commercial-aquaculture solution simply brought out several perverse implications on the villagers. Within the *sasi* system, the *kewang* members and the villagers were motivated to guard the resource because this action would result in a direct benefit for them. The design of the government scheme, which aimed at the prevention of all the natural harvest, on the contrary, lacks consideration of the villager's concerns. Consequently, people lose interest in supporting the government program as there is no direct benefit for them that can be expected from doing so. And, under the pressure of an urgent need for income, villagers have continued harvesting the resource. In fact, they have found themselves encouraged to find ways to escape the constraining regulations.

The enforcement instrument that has been established to enforce government regulations appears to be inadequate to counter such pressures. At the moment, apparently constrained by the limited available budget, the government is unable to provide an adequate number of enforcement officers, making it difficult to perform the necessary surveillance. In fact, monitoring of potential smuggling can only be focused on activity around major seaports. Constrained by this lack of personnel, the enforcers have applied a rule of thumb wherein as long as the trading is arranged by an authorized license holder, it will be considered legal. Illegal practices that occur beyond the major ports, including illicit supplies for a legal trader, are practically impossible to control. In Ambon, for example, there are about fifty small trochus collectors that are freely buying and selling trochus from illegal harvests. An interviewed enforcement agent stated that there are too many places where people can do illegal transactions, so that monitoring has become very difficult.

In general then, because of limited government funding, the geographical setting, and the partially maintained *sasi* tradition, the enforcement mechanism of the government plan is less reliable than its alternative, the *sasi* system. Village based enforcers such as the *kewangs* and the observing neighbors in the *sasi* arrangement, while not perfect, work better.

4.2.4. The arrangements and the efficiency

Even if both the *sasi* and the government scenarios were to function as expected, the *sasi* arrangements would likely generate a larger amount of benefit to the villagers. The notion of 'functioning' as used here is meant to imply that the sustainability of the resource can be maintained. Furthermore, this implies that both schemes can preserve equally well the benefits of alternative or future uses. Given this, the difference in benefits between the two schemes depends merely on those of current uses, which are associated with the level of trochus production. Therefore, it is only if the size of the aquaculture industry expands significantly that its production can match that of the natural stock. Referring to the conditions of aquaculture development in the region in general, it seems realistic to assume that within the range of time considered in this study, it will remain more likely that the production under the commercial aquaculture policy will be lower than that under the *sasi* scheme.

The government's scheme also incurs more costs, including cost of preventing illegal harvest. Clearly, the government will need more enforcement agents if the illegal harvest of trochus is to be reduced. While Ambon is only one of many areas where trochus can be shipped out of the province, an enforcement agent at Ambon seaport asserted that there are approximately five major points in the Ambon area alone that need constant surveillance to eliminate smuggling. This number, which reflects the need for additional enforcement, will certainly become much bigger considering that there are several other places like Ambon, where inter-island boats go directly in and out of the region. The monetary value of recruiting these additional enforcers indicates clearly that the funding necessary to strengthen the enforcement under this policy is very high.

In addition to enforcement costs, an aquaculture operation also involves costs associated with the prevention of vandalism on the aquacuture sites. Based on what has been experienced by the only operating license holder, guards are necessary. In this case, the operator hires one local villager to be responsible for the safety of its two-hectare aquaculture site in the village of Ler Ohoilim. When it finally begins to run at full-capacity, the company will likely need more guards. In fact, similar aquaculture operations in shrimp farms usually employ at least three persons to cover the same area.

In the case of *sasi*, on the other hand, even if the *kewang* members were to receive payment, the level of compensation would most likely be less than that of an aquaculture operation. This is primarily because *kewang* members also have a personal interest in the expected benefits from protecting the resource. A *kewang* member would likely be willing to accept a lesser payment to monitor his common property. As described by a *kewang* member in Haruku Island, it is not the bigger share of the benefit but the non-monetary return, such as his pride in being a *kewang* member that makes him stay in such a job.

There are other additional expenses associated with trochus commercial aquaculture that do not exist in the *sasi* system. These include costs normally spent in the development and operation of an aquaculture venture, such as training of operators and the purchase of spawners. Adding up all the costs associated with the government plan, and then comparing them to those of the practically costless *sasi* arrangement, it is clear that the government plan is less efficient than the *sasi* system.

To improve the efficiency of the government plan, it was proposed by several stakeholders that a rights transfer mechanism be established from a village to a private company. Based on this idea, the resources are to be managed as a commercial aquaculture venture, but with an enforcement system like that of a *sasi* system. However, the case cited below makes it clear that this option has serious potential drawbacks. The case referred to took place in Pelau, Central Maluku, where harvest rights to the local sea cucumber resource were transferred to a private company. This arrangement came with an agreement that the village accept compensation for giving up its rights to the resource, while maintaining a *sasi* enforcement system for monitoring the closing. One immediate problem of this arrangement is that given time-limited rights, the buyer has the incentive to attempt to use all possible means to maximize its profit in the short run, including harvesting undersized sea cucumbers. These situations suggest that instead of improving efficiency, such an arrangement has the potential to result in a higher risk in terms of resource depletion.

4.2.5. Distributional effect

Despite its failure to promote a sustainable harvest recently, *sasi* still represents one of the management systems that is effective in distributing economic benefits. Provided that all the problems are manageable, at least two of the most important stakeholders, the villagers and the small retailers would be directly helped by the flow of revenues made possible by the arrangements that are found in *sasi*. In every *sasi*, there is always a mode of revenue distribution that allows the allocation of different portions of the benefit to different people depending on the standing of the person within the village's customary structure. The village head and its staff for example, receive a larger share of rents, a discrimination that seems to be acceptable to the villagers. For the traders, who buy the harvest from the villages, the benefit is allocated equally among them through a mutual understanding: a trader is not supposed to get an access traditionally belonging to another trader. Thus, in terms of relative performance, the distribution effect of the *sasi* system is at least better that the alternative plan proposed by the government.

From the beginning, the government scheme has involved indirect discrimination against the majority of traditional stakeholders. The promotion of the government's commercial-aquaculture plan has resulted in the accumulation of power in the hands of a few market players. This has been related to the inability of the villagers or small private entrepreneurs to bear the high establishment and operational costs of an aquaculture project. The issuance of the license has empowered the holder with the opportunity to dominate the market. As the result, villagers and small buyers are defeated before competition has even begun.

The benefit share discrepancy will become even greater when the plan is fully implemented. When the aquaculture plans work well, all activities are dominated by the aquaculturist. If the natural stocks are to be fully guarded, the villagers will have no chance to supply small buyers with illegal harvests as they might do in the case where low enforcement exists. Accordingly, both the villagers and the small buyers will be deprived of a benefit that would otherwise be flowing from the illegal harvest. Thus the aquaculturists become the big winners. While the government plan assumes that villagers will still be generating revenue by supplying spawners to the aquaculturists[21], in practice this appears to be an insignificant compensation to villagers.

4.2.6. Lessons learned

1. As long as the villagers are economically incapable of participating in a competitive economy, allowing them to exploit the natural stock, such as is found in the *sasi* arrangement, is necessary.
2. If the handicap that prevents communities from determining the optimum harvest is removed, conservation is more assured by the *sasi* system.

[21] see Anonymous, 1988

3. Limited capital, the maintained tradition, and the geographical setting suggest that community enforcement systems as shown in *sasi* are better than the government enforcement system.
4. Given the high costs, the commercial aquaculture policy tends to be economically inefficient when compared to the *sasi* system.
5. The government plan most likely has lower rent distributional performance because only a few individuals would be able to take advantage of it.

Table. 4.3. Summary on comparative analysis of *sasi* and the government plans in trochus management.

	Sasi	**Government plan**	**Relative performance**
1. **Content of regulation**	• Insufficient to deal with resource depletion • Friendlier to community's economic concerns	• Insufficient to deal with resource depletion • Unfriendly to community's economic concerns	➢ Provided that the real problem belongs to villagers, the content of *sasi* model seems to be more appropriate than the government plan
1. **Conservation**	• Conservation will be dependent significantly on the development of social and economic condition of the people	• Conservation might be affected by the private aquaculturist's profit orientation	➢ Low life standard of villagers lower vulnerability of the stock tend to suggest that *sasi* would conserve better than the government plan
1. **Enforcement**	• Village economy and cultural dynamics are significant variables	• Government incapability of providing an adequate number of enforcers is a major constraint	➢ Limited fund, relatively maintained tradition, and geographical setting suggest that *sasi* is more enforceable
1. **Efficiency**	• Capable of generating flows of benefits with insignificant costs	• Most probably would waste resources	➢ Very likely that *sasi* is more efficient
1. **Distributional effect**	• Brings benefit to villagers and small traders	• Brings benefit to those who are able to bear the cost of developing and operating aquaculture projects	➢ The government plan most likely has lower districutional performance because only few individuals are able to take the opportunity

Given the performances of the two management systems and the criteria used to evaluate them, some lessons can be learned:

1. Assuming that the two trochus management scenarios, the *sasi* and the the government versions, can be implemented successfully, *sasi* is superior in many aspects, most importantly in the efficiency and the distributional aspects.
2. Even so, as is indicated by recent circumstances, improvements are necessary for *sasi* in order for it to be able to meet the challenge of the contemporary development.
3. Given point 1 and point 2, it seems reasonable to develop a trochus management alternative which is based on *sasi*.

CHAPTER 5. MODELING THE IMPLICATIONS OF HARVEST RESTRICTIONS IN TROCHUS *SASI*-BASED MANAGEMENT

5.1. The computer simulation programming

This computer simulation model is designed to be a tool capable of predicting the likely outcomes associated with various sets of regulations imposed on three harvest rate determinants[22] that are relevant to *sasi* management of a trochus resource: duration of closing, duration of opening, and size at first capture. To pursue the best regulation set, the model treats these regulations as variables so that the outcomes of various combinations can be compared on the basis of several criteria and the optimum configuration can be determined. Three criteria relevant for Maluku trochus management, namely annual average revenue, which represents the economic concern; perpetuity, which represents the social concern; and stock level, which represents the biological concern, are included in the model. As normally appears in a model, a systematic approximation, particularly of the relevant parameters, is also performed in several steps for this *sasi* modeling, and a calibration is carried out on the juvenile mortality and carrying capacity parameters to make the model predictions conform to the actual values.

[22]See discussion in Chapter 3. Harvest effort, which is dependent on the number of divers, is not included because the sasi tradition usually does not exclude any adult who can dive from participating in the openings. This factor, however, should be taken into account in formulating the operational interpretation of the term actual-to-potential harvest ratio that is used in the simulation model.

5.1.1. Formulation of the model's mathematical equations

To implement the scenario described in Chapter 3, the following mathematical formulations are necessary to build an appropriate model.

- Let d denote the evaluated *sasi* duration, i.e., the designated number of years of closure per *sasi* cycle
- Let T denote the time range in which the evaluation will be carried out
- Let p, $1 \leq p \leq q$, denote the number of cycles, i.e., how many times the closure/*sasi* has been put in place. Note that $q = T/d$
- Let t, $1 \leq t \leq d$, denote the time, in years, during which the water has been closed to harvest within a particular *sasi* cycle.
- Let a, $0 \leq a \leq a_z$, be the age of trochus. Then a_Z is the normal trochus longevity and 0 represents the age of newly hatched individuals. Then let a_k, $a_k \geq 1$ be the age at which the trochus spawn for the first time and a_f, $a_f \geq a_k$, be the age of first capture.
- Let r_a and m_a denote respectively the fecundity[23] and the mortality rate of individuals aged a
- The number of trochus of age class a at the beginning of t^{th} year of the p^{th} cycle will be written as $N^{beg}_{a,t,p}$ and that at the end of that particular year it will be written as $N^{end}_{a,t,p}$, where $N^{end}_{a,t,p} = (1 - m_a)N^{beg}_{a,t,p}$

Given the initial number of trochus and through a simulation of the reproduction and

[23] Fecundity is measured as the number of eggs released by a female annually.

mortality processes, the number of trochus individuals for various closure times in a given cycle can be determined. Using the notations introduced above, the following are the mathematical equations that are applicable for calculating different states of the variables.

5.1.1.1. Simulation of trochus population in the absence[24] of harvest

For $t \neq 1$, all individuals aged one year or older that exist at the beginning of the year t are survivors of those that existed at the beginning of year t-1. On the other hand, the number of trochus aged zero at the beginning of the year is modeled by the number of eggs released by all the mature females of these survivors. Therefore the number of individuals for a particular cohort in this situation can be determined by Equations 1 and 2.

$$N_{a,t,p}^{beg} = (1 - m_{a-1}) N_{a-1,t-1,p}^{beg} \qquad a \neq 0 \qquad (1)$$

$$N_{0,t,p}^{beg} = \sum_{a_k - 1}^{a_{\infty} - 1} r_a (1 - m_{a-1}) N_{a-1,t-1,p}^{beg} \qquad a = 0 \qquad (2)$$

Using a similar argument, Equations 3 and 4 show the mathematical notation for the number of individuals when t = 1.

$$N_{a,1,p}^{beg} = N_{a-1,d,p-1}^{end} \qquad a \neq 0 \qquad (3)$$

$$N_{0,1,p}^{beg} = \sum_{a_k}^{a_{\infty}} r_a N_{a-1,d,p-1}^{end} \qquad a = 0 \qquad (4)$$

[24] To make notations consistent, it is assumed that there are *sasi* which maintain a zero harvest at every opening

5.1.1.2. Simulation in the presence of harvest

After some iteration, the simulation will generate a prediction on the number of trochus at the designated closure time, *d*, for all existing age-classes, and provide predicted values of the potential harvest level. According to the model, the harvest is done at the end of d^{th} year of every *sasi* cycle. If all individuals aged a_f and above are to be harvested, the yield from an age class for that particular cycle would be:

$$H_{a,p} = N^{end}_{a,d,p} = (1 - m_a)N^{beg}_{a,d,p} \qquad (a_f \leq a \leq a_z)$$

The total harvest of a particular *sasi* cycle would then be

$$H_p = \sum_{a_f}^{a_z} N^{end}_{a,d,p}$$

When the actual harvest is only a portion of the maximum potential, a factor of % applies. In that case,

$$H_{a,p} = \%N^{end}_{a,d,p} = (1 - m_a)\%N^{beg}_{a,d,p}, \qquad \text{and,}$$

$$H_p = \%\sum_{a_f}^{a_z} N^{end}_{a,d,p}$$ (% is the fraction of the potential harvest that is actually taken).

In the presence of harvest, the population equations for $t \neq 1$ do not change but those with t=1 and $a \geq a_f$ have to be corrected by $H_{a,p}$. In this case, $N^{beg}_{a,1,p} = (1 - \%)(1 - m_{a-1})N^{beg}_{a,d,p-1}$

Thus far, the model is capable of generating information regarding the number (count) of trochus of different cohorts for different values of the variables *d* (duration of closing), a_f (which is associated with size standard) and % (which is associated with duration of opening). However, for the purpose of calculating the value of harvest, the harvest should be converted to a weight[25] basis. This conversion is carried out using the normal diameter-weight conversion factor that is given by a formula described in a later section, in which growth parameters are discussed. The total biomass at a particular time is then calculated as the sum of the biomass of all existing cohorts. The conversion formula also applies to the numbers of the harvested trochus individuals to give a weight figure for the harvest at a particular *sasi* opening. This figure can then be multiplied by a price to give a prediction of revenue from a harvest according to:

$B_p = \sum_{a_f}^{a_L} H_{a,p} \times w_a \times h$, where h = the price of one kg of trochus, in Indonesian Rupiahs and w_a is the count-weight conversion factor of the cohort aged a. Subtracting harvesting costs from the gross revenue will yield the net benefit,

$V_p = B_p - C$, where C = the opportunity cost of the harvest of one opening.

Since the comparison of the lengths of closure (*masa sasi*) involves different time periods, the net revenue, should be adjusted by a discounting factor, i. The present value of the net benefit is calculated accordingly as,

$$PVN = \sum_{p=1}^{q} V_p (1+i)^{-pd}$$

The above mathematical equations are used in the formulation of a computer program[26], whose flowchart is depicted in Figure 5.1. The actual program, which is written in *Quick Basic*, can be seen in Appendix 4.

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[25] Ttrochus is sold on the basis of its shell's weight

[26] Ranges of control variables are explained in Section 3.3.2 of Chapter 3.

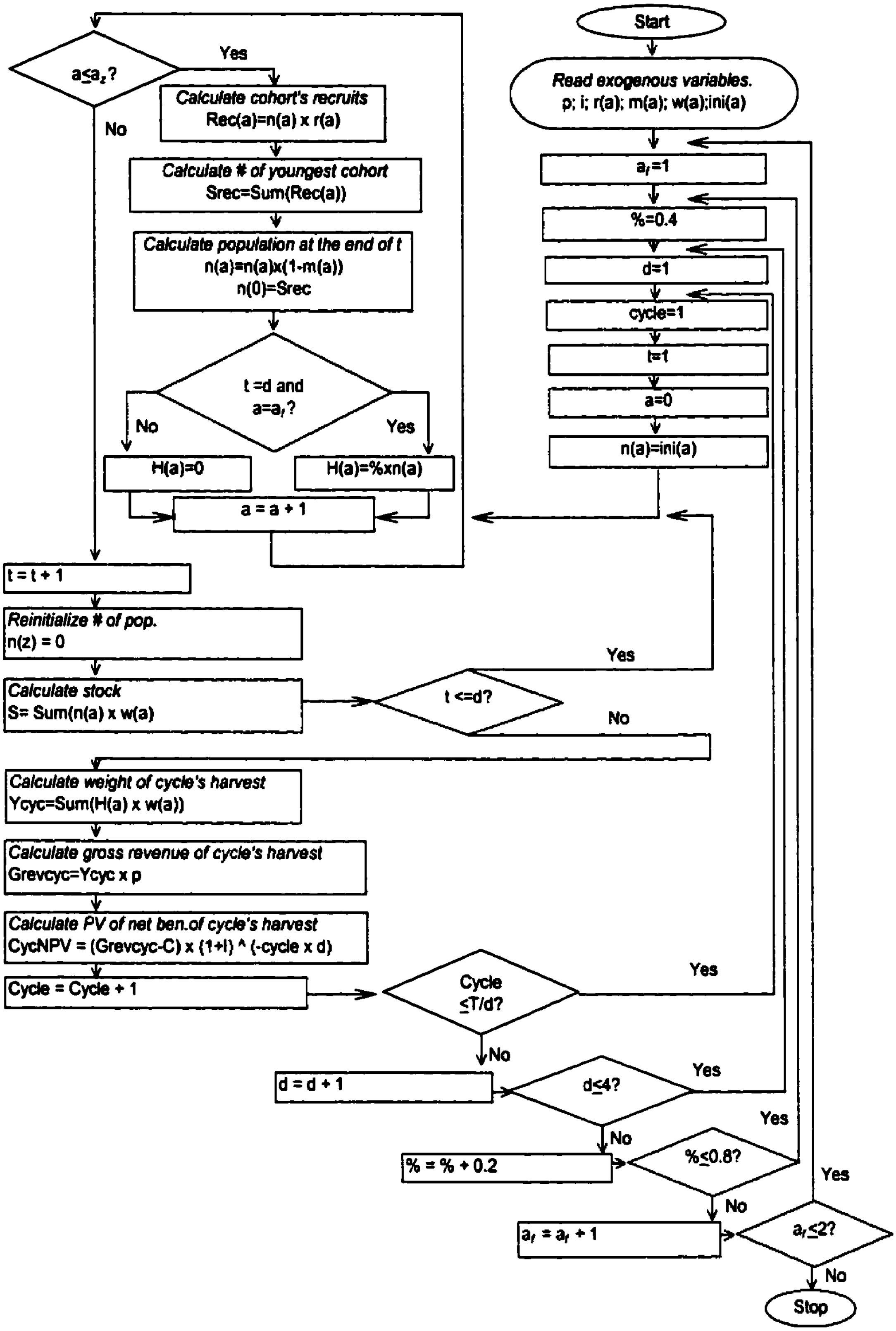

Figure. 5.1 Flowchart of Sasi Computer Simulation Program

5.1.2. Parameterization

The two groups of parameters relevant to this model are the biological and economic parameters. The biological parameters include recruitment, size growth, natural mortality, longevity, carrying capacity, and the stock effect. The relevant economic parameters are price, opportunity cost of harvest, and the discount rate. While information on several of the parameters, such as the growth parameters, can be derived directly from the existing literature, several others such as carrying capacity, recruitment, early mortality rates, and density effects have to be deduced through approximation.

5.1.2.1. Recruitment: fecundity and sex ratio

A critical factor in determining the level of the potential harvest in the *sasi* simulation model is the recruitment rate, which indicates the capability of parent stock to produce new trochus individuals to join the stock. The definition of recruitment might take several forms, but normally it is associated with numbers of individuals reaching the size at first capture. Recruitment is difficult to measure. On the other hand, information on fecundity and natural mortality rates is easier to obtain. Therefore, in our *sasi* simulation model, recruits are calculated from the predicted number of the eggs that reach the legal size or age. Based on this, four parameter determinants are relevant, i.e., mortality rates up to the age of legal capture, the sex ratio, the individual fecundity of the parent stock, and the female annual spawning frequency. Mortality rates are discussed separately in more detail Section 5.1.2.3.

With respect to the sex ratio, all cited research reports seem to suggest an approximately balanced male-to-female proportion. Evidence for this proposition is, for example, found in reports by Arifin (1993); Pradina *et al* (1997); Gimin and Lee (1997a); and Kikutani and Patris (1991). This proposition is strengthened by other research findings that indicate that there is no evidence that would lead to the conclusion that a sex change in trochus is possible, as is observed in some other mollusks (Bour, 1991). These scientific findings justify the inclusion of a factor of 0.5 into the *sasi* simulation model to take into account the productivity of the stock in terms of the likely portion of females to total population.

Concerning the fecundity value to be used in the model, studies by other researchers provide empirical information required to construct a statistical relationship between the size or age of a trochus female and the number of eggs it can produce. For example Heslinga Murakoshi (1991), Nash (1985), Amos (1991), Dwiono *et al* (97) report values of trochus fecundity of certain shell diameter sizes. Furthermore, Bour (1991) provides fecundity values associated with a range of sizes from 70 mm to 130 mm.

Other information relevant to the selection of the fecundity parameter is found in the studies of Clarke and Ianelli (1995), and Hahn (1998). Clarke and Ianelli (1995) propose that fecundity among trochus females increases at a geometric rate with diameter. A parallel finding by Hahn (1998), suggests that a 12-cm female has the potential to produce 14 times as many eggs as a 6-cm female can produce annually, even though not all of them are viable.

Following from Clarke and Ianelly's conclusion, in this analysis an estimator for an age/size dependent fecundity function was obtained by loading the empirical figures provided by Bour (1991) (see Table 5.1) into a geometric regression model. Following such a framework, the estimation function for the relationship is modeled as:

$$Y = c.e^{n.X}$$

where, Y = fecundity (number of eggs)

X = diameter

c ; n = constants

For reasons of convenience in performing the regression, the formula was then converted into a linear function[27], where $\ln Y = \ln c.e^{nX}$

or $\ln Y = \ln c + nX$

The predicted value of ln c is given by the intercept of the regression while the predicted value of n is given by its slope; hence, the predicted value of c can be determined by the antilog of the intercept.

The empirical figure given by scanning of various reports of previous studies shows a wide variation. Finding or Bour (1991), on the other hand is more consistent, and this is then used in our model. The empirical data based on Bour's work is presented in Table 5.1.

Table 5.1. Fecundity of different shell diameters

Diameter (mm)	70	80	90	100	110	120	130
No. of eggs (x1000)	511	562	592	660	690	974	3003

Source: Bour (1991)

[27] The best estimates are those that result in the highest value of coefficient of correlation

The regression's predicted values were of c = 1394; n = 0.05834; therefore the predicted age-dependent fecundity function can be written as:

$$Y = 1394\, e^{0.05834x}$$

The relationship is shown graphically in Figure 5.2.

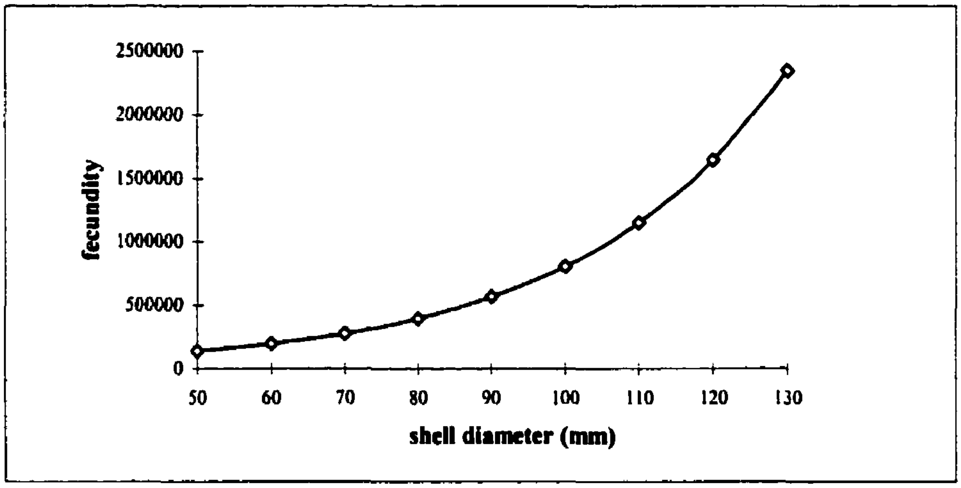

Figure 5.2. Relationship between fecundity and shell diameter

Another recruitment parameter – the annual spawning frequency – is introduced into the model to take account of the fact that each female usually spawns more than once in a year. This fact explains Amos' (1991) statement, who says that the actual female reproduction contribution might be larger than the numbers given by the fecundity figures. Nash (1985) believes that each female spawns every 2 to 4 months or 3 to 6 times annually. Given this, an introduction of a 3.0 spawning frequency factor seems to be reasonable as a conservative estimate.

5.1.2.2. Size growth

Studies on growth parameters for trochus have been carried out extensively in various locations (e.g., Nash, 1985; Smith, 1986). To make better predictions for the specific case mentioned in this study, however, only research findings for Maluku were used. In Maluku, information on these parameters can be found in the work of several authors, such as Arifin (1993), Suwartana *et al* (1985), and Yusron *et al* (1987).

The normal growth function of a trochus is given by $L = L_\infty(1 - e^{-K(a-a_o)})$. Some authors such as Yusron *et al* (1987) measure the size, L in terms of the shell height, while the others measure it in terms of the shell basal diameter. As seen in its mathematical formulation, L is determined by a time variable i.e., the age of trochus in years, a, together with three parameters: the theoretical asymptotic value of L, L_∞, the coefficient determining the rate of growth, K, and the theoretical age for which L is zero, a_o (Bour, 1991). Since basal diameter is a more common measurement for trochus management and trade, the model adopts the parameter values given for this measurement. Summing up findings of other researchers, Bour (1991) gives ranges of 8.7 cm to 16.1 cm for L_∞; 0.11 to 0.66 for K, and 1.2 to 4.1 months for a_o. For Maluku conditions and using the basal diameter, Arifin (1993) gives values of 12.3 cm for L_∞; 0.621 for K and assumes that the value of a_o is equal to zero. These values are used in this study as they are consistent with Bour's findings.

Studies on growth also normally provide information on the diameter-weight relationship so that the length growth function can be converted into a weight growth function. Referring to trochus in the Maluku region, Arifin (1993) reports the relationship between shell diameter and total weight to be:

$$\text{Log}_{10} W = 2.6798 \log_{10} L - 2.836 \text{ or } W = 1.45 \times 10^{-3} L^{2.6798}$$

where: W = total weight, in grams

L = shell diameter, in mm

Furthermore Arifin (1993) finds that Maluku trochus shells comprise 85% shell of the total weight. Based on this, the formula for shell weight is:

$$w = 0.85\ W = 1.24 \times 10^{-3}\ L^{2.6798}$$

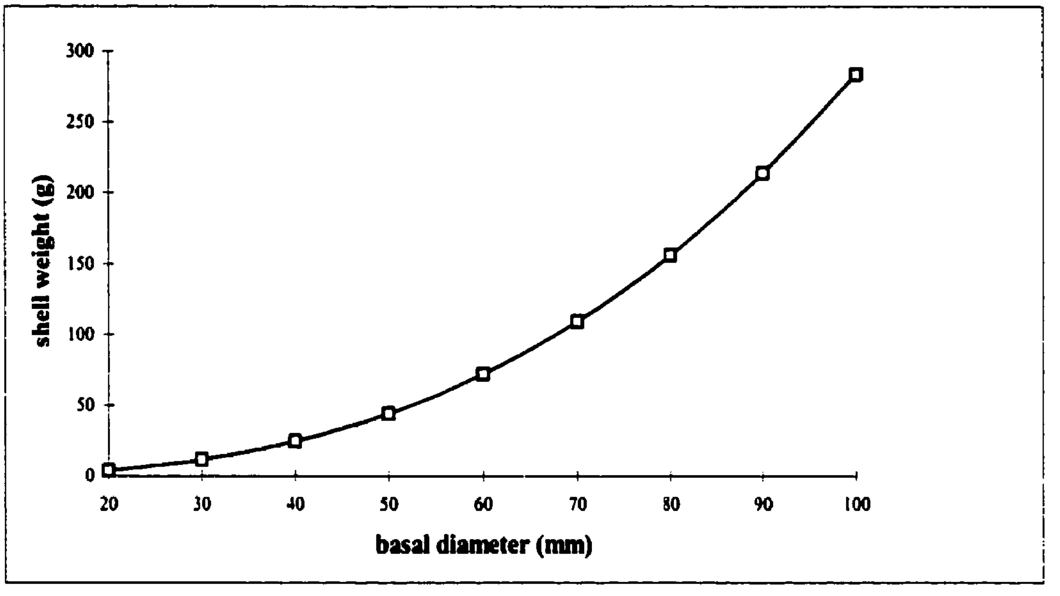

Figure 5.2.a. Relationship between basal diameter and shell weight

5.1.2.3. Mortality

In the absence of information on natural mortality of young trochus (aged one year or less), an estimate was deduced from aquaculture studies where the controlled environment allows the trochus to grow in favorable conditions, conditions which presumably resemble natural growth when space and food constraints are at a minimum. This mortality figure is then used in the model as a lower bound for the early mortality value. Murakoshi (1981) authored a detailed study that includes observations on the mortality of aquacultured trochus at the very early stage of development[28]. He reported that from 548,000 eggs 272,000 veliger larvae (49.6%) were obtained. Of the number of veliger larvae that he was able to collect, 51.8 % of them were found to successfully develop into crawling larvae. Forty five percent of the crawling larvae continued to develop to reach a juvenile stage size of 3 mm. Based on his work, it can be calculated that the survival of eggs to 3-mm juveniles is 49,6% x 51.8% x 45.5% = 11.6%. It is worth noting that from other observations, Murakoshi (1981) found early survival rates which ranged from 0.1% to 14.2 %.

A study of how the early stage mortality figure is affected by the salinity level was done by Gimin and Lee (1997). Among the results that have a relevance to the *sasi* simulation model, the two researchers came up with a range of survival percentages that seems to validate the numbers given by Murakoshi. Calculations based on stage-by-stage observation of the survival of eggs to the 2-month-age juvenile stage (± 3mm) give rates of 1 %, 1.5 %, and 2.24 % for salinity levels of 25, 30, and 35 ppt respectively. These results are sufficiently reliable to use as a basis for assuming a value of egg survival in Maluku waters, where the salinity is in the range of 34 ppt to 34.4 ppt (Arifin, 1993 and Yusron et al, 1989).

Summing up the results of these two studies and taking into account the above information on the average salinity of the water in the trochus production centers in

[28] The terminology describing the development at early stages comprises cleavage, gastrulation, hatching, veliger larvae, methamorphosis (crawling larvae), and young (2 months) juveniles (Gimin and CL Lee, 1997; Bour, 1991)

Maluku, it is quite safe to assert a maximum pre-juvenile survival rate of 2 % for the *sasi* simulation model.

Another critical stage in trochus development is during the juvenile age where they are at maximum vulnerability to predators. As in the case of the very early stages of trochus development, the selection of an estimate on the survival at the juvenile stage was based on aquaculture studies. Empirical data on survival are available at various ages for young trochus ranging up to one year. Table 5.2 presents a summary of the information on the survival of trochus included in these studies. As in many cases, the reports do not provide information on the ages of the trochus under observation; so in the model the sizes or the ranges of size are presented for these cases. For the purpose of constructing the relationship between survival and age, the information was then converted into age figures using an inversed[29] growth function. The growth function given by Nash (1985) for trochus is $D_a = 123(1-e^{-0.344a})$, where D_a is diameter (in mm) and a is age (in year). This inversion function is used for this conversion because it represents a conservative[30] prediction, meaning that a particular size of trochus is associated with an age that is longer than the actual time required to reach the size. Therefore, this conversion tends to provide a higher mortality rate at a particular age of trochus. When the size of trochus is

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[29] The Nash growth function is transformed into $a = \frac{12\ln(1-D_a/123}{0.344}$ to give age values in month.

[30] Conservative prediction is meant here that the model should result in outcomes which follow a precautionary principle, in which stock sustainability is a prime concern. This principle has been adopted here because the goal of this research is to convince the government, which has currently shown concern on conservation, e.g., by exercising harvest banning

stated in terms of a range, the size is taken as being the average of the upper and lower bounds of the range. The results of this size to age conversion are included in Column d. of Table 5.2.

Since the data in these reports is available for the total survival of the trochus over various lengths of observation and was made on different ages of the first observation, standardization was necessary to make it useful for the simulation model. Since the model requires an estimate of survival rates of trochus up to one year old, it is found convenient to convert these data values, into a monthly survival figure, which is referred to hereafter as 'observation monthly survival'. Based on these figures, it is possible to compare the information from the different data sources used in this analysis. Observation monthly survival (OMS) is calculated from the formula $OMS^{LO} = OTS$, where

OTS = observation total survival, i.e., the percentage of trochus that survive within the duration of observation

LO = length of observation (months)

Table 5.2. Mortality from juvenile to one year-old trochus.

Source		Size of trochus	Initial Age / predicted age equivalent (month)	Length of observation (LO) (month)	Observation total survival (OTS)	Observation monthly survival
No.	Author					
a	b	c	d	e	f	g
1	Gimin and Lee (1997b)		1	2.4 (72 days)	65%	0.8357
2	Gimin and Lee (1997b		1	2.4 (72 days)	45%	0.7170
3	Gimin and Lee (1997b)		1	2.4 (72 days)	66%	0.8410
4	Castel, 1993	± 9.5 mm *(range: 5-14 mm)*	2.80	6	0.13 %	0.7117
5	Amos (1995) *in* Crowe *et al* (1997)	± 10 mm *(range: 8-12)*	2.95	6.7 (200 days)	32 %	0.8436
6	Murakoshi (1991)	± 15 mm (range: 16-18)	4.53	2.67 (80days)	43.00 %	0.7290
7	Chauvet *et al* (1997)	19 mm	5.85	0.5 (2 weeks)	20 %	0.04*
8	Chauvet *et al* (1997)	19 mm	5.85	2	10 %	0.3162
9	Chauvet *et al* (1997)	19 mm	5.85	3	8.4 %	0.4380
10	Chauvet *et al* (1997)	19 mm	5.85	12	0.33 %	0.6212
11	Amos (1992)	± 20 mm (<20 and > 20)	6.19	1.67 (49 days)	44.20 %	0.6133
12	Amos (1995) *in* Crowe *et al* (1997)	± 23.5 mm *(range: 12-35)*	7.40	6.7 (200 days)	88 %	0.9811
13	Castel, 1995 *in* Crowe *et al* (1997)	± 28.5 mm (range: 13-44)	9.20	1 (30 days)	26 %	0.26*
13	Castel, 1995 *in* Crowe *et al* (1997)	± 28.5 mm *(range: 13-44)*	9.20	3.7 (111 days)	12.4 %	0.5688
16	Castel, 1995 *in* Crowe *et al* (1997)	30 mm	9.75	3.3 (40 days)	6.7 %	0.4408

These numbers are presented in Column g. of Table 5.2. The studies are listed in order of the initial age. The observed monthly survival rates then are grouped[31] and averaged to provide estimates of average monthly survival rates of juveniles at each initial age, as is shown in Table 5.3. The results are referred to hereafter as the 'averaged point survival'. The approximate cumulative survival is then the product of the averaged

[31]Data which was far below or above the average observation are not used. This data is marked by an asterisk.

point survivals up to the age (months) being referred to; e.g., the cumulative survival of the 3-month-old juvenile (after a month of development) would be the product of the average point survival of 2-month olds with that of 3-month old juveniles.

Table 5.3. Survival rates of different ages

Age (month)	Monthly survival given by different sources*)[32]	Averaged point survival (%)	Approximated cumulative survival (%)
A	B	C	D
2	0.88(1); 0.72(2); 0.84(3)	0.81 ± 0.0833	0.8133
3	0.88(1); 0.72(2); 0.84(3); 0.71(4); 0.84(5)	0.80 ± 0.0775	0.6490
4	0.71(4); 0.84(5); 0.73(6)	0.76 ± 0.0700	0.4932
5	0.71(4); 0.84(5); 0.73(6)	0.76 ± 0.2684	0.3748
6	0.71(4); 0.84(5); 0.73(6); 0.32(8);0.44(9); 0.62(10); 0.61(11)	0.66 ± 0.1865	0.2474
7	0.71(4); 0.84(5); 0.73(6); 0.32(8);0.44(9); 0.62(10); 0.61(11)	0.61 ± 0.1781	0.1509
8	0.71(4); 0.84(5); 0.73(6); 0.32(8);0.44(9); 0.62(10); 0.61(11); 0.98(12)	0.66 ± 0.2105	0.0990
9	0.71(4); 0.84(5); 0.44(9); 0.62(10); 0.98(12); 0.57 (14)	0.69 ± 0.1942	0.0686
10	0.62(10); 0.98(12); 0.57 (14); 0.44 (15)	0.65 ± 0.2311	0.0446
11	0.62(10); 0.98(12); 0.57 (14); 0.44 (15)	0.65 ± 0.2311	0.0289

An approximate cumulative survival rate of 0.0289 (≈ 3%) is then obtained for juveniles to one year old trochus. Given a maximum survival rate of 0.02 (2%) at the early stages and 3% at the juvenile ages, the maximum survival rate of eggs up to one-year-old trochus is 2%x3% = 0.06%. Another way of expressing this rate is in terms of mortality, which is equal to 99.94 %.

5.1.2.4. Longevity:

Some reports cited indicate that some trochus might live as long as 15 or even 20

[32] The numbers in parenthesis indicate the source of information as referred to in Column a of Table 5.2.

years. Bour (1985), for example, reported that a trochus estimated to be aged 20 years old was taken from Ouvea, New Caledonia. Given the environmental conditions of Maluku waters, however, local scientists (Dwiono and Arifin, pers. comms.) have suggested that the eight-year longevity figure is realistic. Therefore, the model developed in study assumes an average longevity of eight years.

5.1.2.5. Carrying capacity, maximum mortalities, and maximum member of cohorts

To minimize technical complications and to improve its practicality, the model developed here introduces an approximation for carrying capacity that relies on data which is relatively easy to obtain. The approximation is based on the recorded maximum harvest. It is assumed that maximum harvest is associated with a long period of sasi, so that the stock of trochus is at a biological equilibrium or at its carrying capacity. Given an age-independent adult natural mortality[33] rate, m, the relationship between the numbers in the various cohorts is: $N_a = (1-m)N_{a-1}$ where a (the age of the cohort) = $1,\ldots\ldots,a_z$; then the weight of the maximum yield is:

$$Yield\max = N_{a_f} w_{a_f} + N_{a_f+1} w_{a_f+1} + \ldots\ldots\ldots + N_{a_z} w_{a_z}$$

$$= N_{a_f} \left(\sum_{a=a_f}^{a_z} (1-m)^{a-a_f} w_a\right)$$

Therefore, the number of individuals of a cohort aged a_f can be determined using

[33] Nash (1993) suggests a range of annual mortality value between 0.1 to 0.78. Based on this information, an average value of 0.45 is then employed

the equation:

$$N_{a_f} = \frac{Yield\max}{\sum_{a=a_f}^{a_z}(1-m)^{(a-a_f)} w_a}$$

And, the general equation for determining the number of individuals of a cohort aged a is:

$$N_a = \frac{(1-m)^{(a-a_f)} Yield\max}{\sum_{a=a_f}^{a_z}(1-m)^{(a-a_f)} w_a}$$

This formula assumes all individuals of age a_f or above were harvested. If the recorded maximum yield represents only a part of the potentially harvestable individuals, a parameter *percent*[34] which is equivalent to duration of opening for a given number of divers, is applied and the equation[35] becomes:

$$N_a = \frac{(1-m)^{a-a_f} Yield\max}{\% \sum_{a=a_f}^{a_z}(1-m)^{(a-a_f)} w_a}$$

where % = the actual to potential harvest ratio, which is included to equip the model with a mode to simulate a *sasi* scenario which allows for a certain level of escapement.

The above mathematical function was then adopted to construct a sub-model and transformed into a computer-program such as flow-charted in Figure 5.3, and was written

[34] It was assumed that a zero marginal capture rate per unit effort was associated with a 80 % harvest level. A justification for this number can be seen in Section 3.2.2 of Chapter 3..

[35] In the computer program as shown in Appendix 4, the denominator of this equation is stated as 'factor'

in a computer language as indicated in Appendix 4. This model will predict the maximum number of trochus for each cohort (*n*max), the values of maximum stock[36] (*stock*max), the maximum number of released eggs (*r*max), and the maximum early-mortality rate (*m0*max).

The maximum number of released eggs is calculated as: $r\max = f\sum_{a=ak}^{a_*} N_a F_a$

where:

f = a constant denoting the multiplication product of average annual and average female proportion in trochus population

F_a = fecundity of a trochus aged a

The maximum early mortality rate is calculated as: $m0\max = 1 - \frac{N_{1\max}}{r\max}$ where:

N_{1max} = the steady-state number of trochus aged 1

r_{max} = the steady-state rate of egg production

The maximum stock level is calculated as: $stock\max = \sum_{a=1}^{a_*} N_{a\max} w_a$ where:

N_{amax} = the steady-state number of trochus aged a

w_a = the number-weight conversion factor

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[36] maximum stock is referred to as carrying capacity

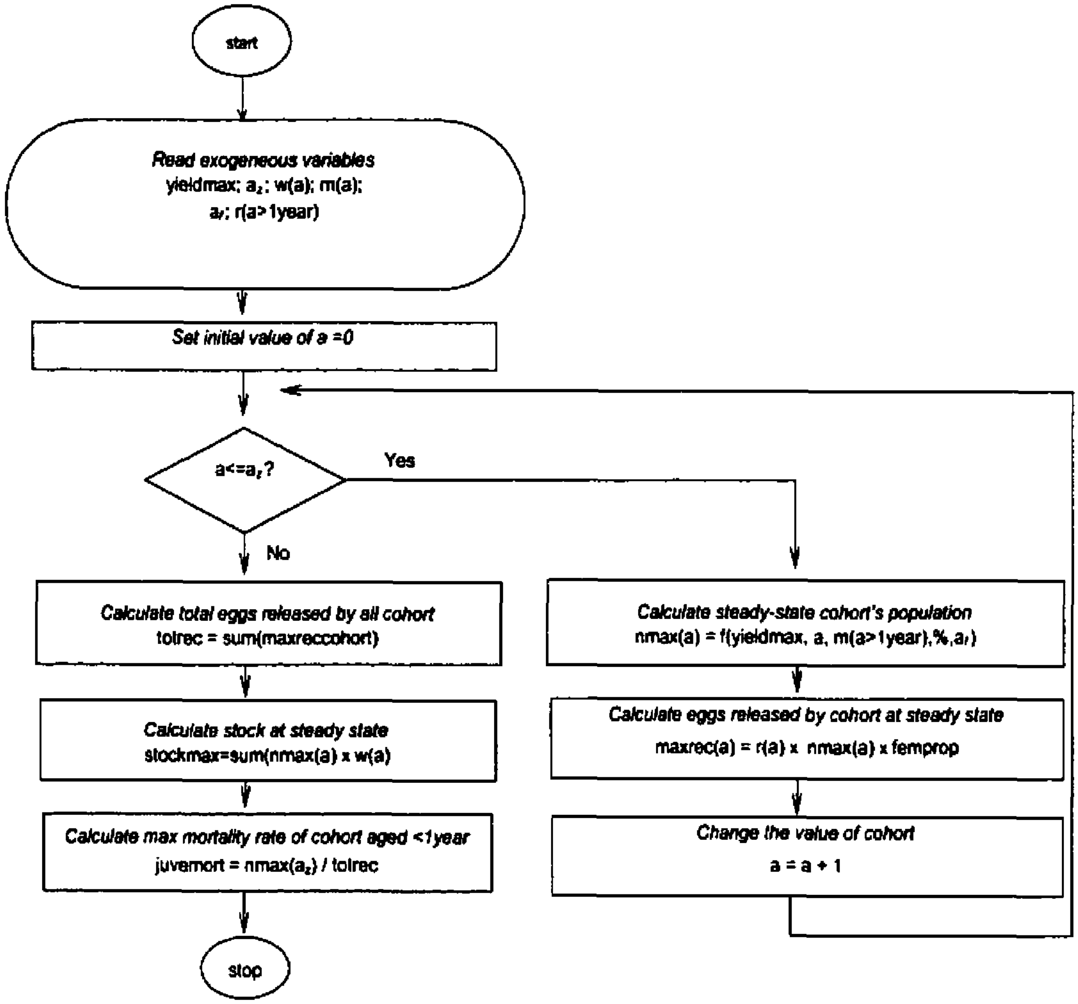

Figure 5.3 Flowchart of program for approximation of maximum values of , member of cohorts, stock and mortality

5.1.2.6. Density / stock effect

In theory, environmental carrying capacity exists as the result of the limited supply of natural elements required for further growth and reproduction, especially food and space. As the density of trochus inhabiting an area increases, the supply of food and space become limited causing a biological reaction in terms of a decrease in growth and recruitment rates, and/or an increase in mortality rates. As far as our model objective is concerned, the inclusion of the density effect is proposed to make biomass-growth model more realistic. Based on the cited literature (Pauly, 1980 and Dwiono *et al*, 1987), the density-effect model proposed here assumes that it is trivial whether the mortality or growth is actually most significant in limiting biomass-growth. Pauly (1980) proposed the use of parameters determining growth rate to make an approximation of mortality because the values of recruitment and mortality rates are dependent on the same variables. The inclusion of the density effect in the growth model here will be focussed on the mortality rate of trochus individuals aged one year or less. For trochus aged more than one year, a constant, density-independent, mortality, as mentioned in Section 5.1.2.5, is assumed in the model.

The first attempt to incorporate such a density and biomass growth relationship into the model used a linear function[37]. Based on the minimum and maximum mortality values as discussed in Section 5.1.2.3 and Section 5.1.2.5, the relationship between mortality and stock can be modeled. The following is an expression of the mortality density relationship for a particular cohort in a linear version:

$m = \alpha + \beta\,\text{stock}$,

where: m = mortality rate

α = $m$min = mortality rate associated to the zero stock level

β = ($m$max - $m$min) / *stock*max

$m$max = the mortality rate at the steady state condition

*stock*max = maximum stock

[37] the validity of a linear relationship has been assumed for a long time (e.g., Beverton and Holt, 1957)

The model takes the mortality value determined earlier in section 5.1.2.3 as the minimum (99.94 %), and the value determined according to the framework discussed in Section 5.1.2.5 as the maximum[38]. It is then assumed that the lower bound of the range corresponds to a condition where the density is significantly low compared to the availability of food and space, so that its effect on mortality might be assumed to be minimum. The upper bound of the range, on the other hand, is taken as associated with the condition where the effect of these factors reaches its maximum, so that it prevents further growth of the biomass. To obtain a prediction of the biomass growth rate which is close to the actual relationship of the *sasi* timing and the resulting yields, a space is reserved in the modeling process for fine tuning. This is carried out by adjusting the rate of increase of the modeled growth function.

The problem with the linear function is that it lacks the flexibility necessary for fine tuning. In the linear model, an adjustment in the rate of the increase of the function can not be made without violating the basic assumptions:

$m = m\text{min}$ when $stock = 0$

$m = m\text{max}$ when $stock = stock\text{max}$

The following curvilinear function, in which a constant, *c*, is introduced to allow an adjustment on the rate of increase of the stock-dependent mortality function, represents an approach that meets these required properties. For various values of *c*, the corresponding stock-mortality relationships are depicted in Figure 5.4.

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[38] The value is modeled as unique for every trochus, depending on exogenous variables explained in Section 5.1.2.5.

$$m = \frac{[m\max x m\min]}{m\min + [m\max - m\min]x\left[\frac{m\min}{m\max - m\min}\right]^{\frac{c.stock}{stock\max}}}$$

where $m$min = minimum mortality rate

$m$max = maximum mortality rate

*stock*max = maximum attainable stock size (carrying mortality)

c = a constant that determines the rate of change in mortality rate as the stock changes (in tons)

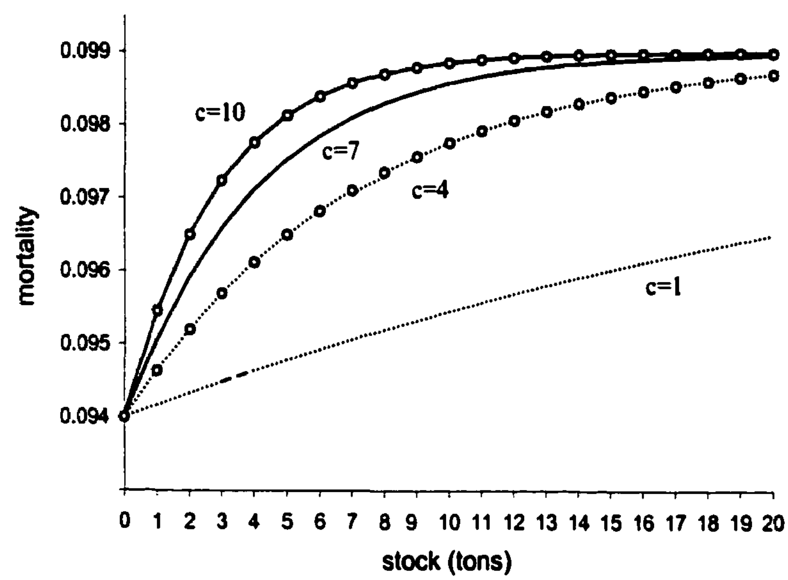

Figure 5.4 Relationship between stock-dependent mortality function and the value of c

Depending on the value of c, the steepness of the curve varies. As shown in Figure 5.4, however, only a certain range of c values will result in curves that satisfy the assumptions stated earlier. Accordingly, the correct c value will be selected from among these values.

5.1.2.7. Price

There are two sets of data from which a value to represent trochus price and price trends can be deduced. However, one data set seems to be more reliable than the other. The first data set carries information on prices at the producer level, while the other contains prices at the exporter level. However, producer prices are less reliable because they are often influenced by variations that are not easy to measure. In particular, these variations are due to differences in transportation costs and differences in the binding relationship between middlemen (local buyers) and villages. Although the transportation cost is quantifiable, explanation on the effect of the middlemen-village relationship on price would require comprehensive research. On the other hand, the ultimate destination of the products is the international market and export prices are unaffected by this variation. Therefore, our model will rely on the export price figures.

Trends in export price were based on the international market outlook, whose two major determinants are world production and consumer appreciation. On the production side, the most observable cause of changes in trends would be the development of aquaculture. Aquaculture technology for trochus is advancing. However this growth should not be seen as a threat for demand for naturally bred trochus, because of the significantly higher cost of aquaculturally produced shells. Lee (1997) reported that the costs of producing 1-3 mm juveniles ranged from 0.7 to 3.3 USD cents/juvenile and the cost of producing 6-10 mm-juveniles ranged from USD 29 cents to 71 USD cents/juvenile. Taking the 0.7 cent juvenile production cost, assuming no additional costs, and drawing upon the 3 % survival rate (see section 5.1.2.3), the total production cost of

1 kg of trochus shell (equivalent to approximately 5 one-year-old trochus shells) is at least $1.20, while the cost of naturally bred trochus is zero.

On the consumer side, the most serious threat to trochus price comes from the increased production of substitutes. A competitor for trochus is 'the Port Sudan shell', which is marketed at about half the trochus price (Nash, 1992). However, there is no evidence that the increased availability of substitutes will make the demand for trochus collapse, because these substitutes are inferior in terms of brittleness and coloring factors (ICECON, 1997). In the same report, a designer was quoted as stating that nothing could replace the luxury and the excellence of mother-of-pearl buttons. This perception is equivalent to the high valuation of scarce natural products such as genuine leather or genuine pearls. In addition, because of its quality, the Indonesian trochus command a special price compared to other trochus. These illustrations tend to suggest that extrapolating the current trend to predict the situation over an intermediate time span (25 years) would be reasonable.

If this assumption is correct, the model assumes that the price schedule of Maluku trochus is shown by the values presented in Figure 5.5.b. These values are an extrapolated prediction based on price figures compiled from the past export records from Maluku. An OLS regression was run to obtain the best prediction of the development of price over time.

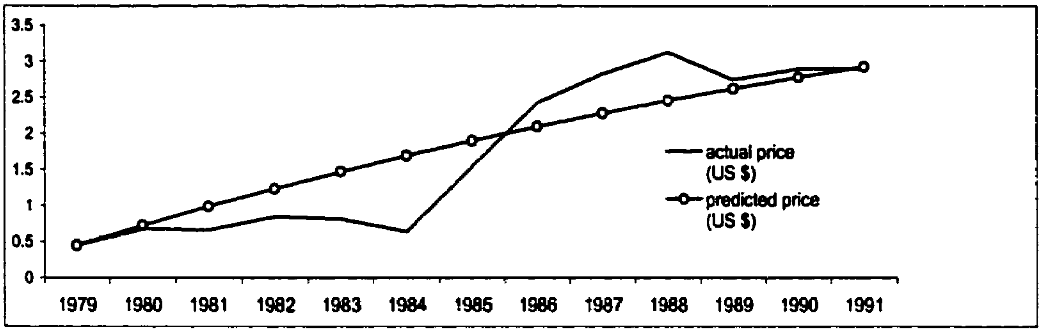

Figure 5.5.a. Actual and regressed past prices

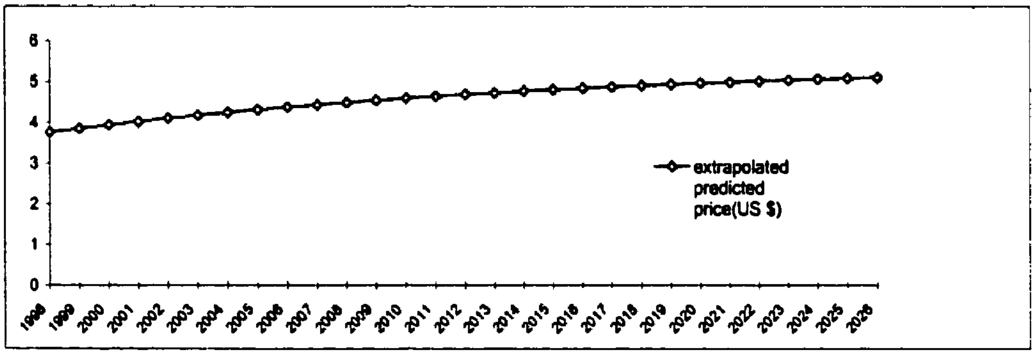

Figure 5.5.b. Extrapolated regression of future prices

5.1.2.8. Harvest cost

The cost of harvest in the *sasi* system is insignificant. Even though most villagers have to leave their daily activities to participate in a *sasi* opening, a zero cost of this action can be assumed. This is because even though for most villagers, participating in the *sasi* opening will mean skipping a few days from clearing their agricultural plots, the impact of this on their agricultural production is insignificant. On the contrary, villagers will receive non-value benefits in terms of the enjoyment of being involved in the *sasi* feast. For this reason, in the model, the cost of harvest is set at zero.

5.1.2.9. Deflation rate

The recent economic crisis in Indonesia has made it quite risky to assume any deflation rate. However, a ten percent discount rate seems to be reasonable as it is close to the annual rate of inflation in the price of primary goods normally purchased by villagers (see Table 5.3.a). Therefore, a deflation rate of 10 % is used in the analysis. This rate is applied calculate values of NPV as discussed in Section 5.1.2.

Table 5.3.a. Price list of villagers' primary goods

Consumption good		1997 Price [a] (Rp)	1993 Price [b] (Rp)	Annual increase [c] (%)
Type	Unit of package			
Rice	kg	1500	1000	10.6
Sago starch	basket	1500	1000	10.6
Sugar	kg	2800	2000	8.8
Kerosene	bottle	500	350	9.3
Salt	kg	700	500	8.8
Cigarette	pack	1750	1100	12.3
Soap	bar	750	500	10.6
Coconut oil	bottle	1000	650	9.0
Egg	piece	500	350	10.7
Dried fish	kg	4000	2500	11.2

Note: a) based on the surveys on village vendors' price lists
b) based on the 1994 Kei Besar Statistics
c) annual price increase is calculated as: $i = \{[(\frac{p_{1997}}{p_{1993}})] - 1\} \times 100\%$

5.2. Past harvest records and the calibration of the model

Historical records reflecting the relationship between the timing of *sasi*-based harvest arrangements and the associated harvests were taken into account to ensure the validity of the future projection of the simulation model developed in this study. Three samples, namely the trochus beds of Watlaar, Ohoirenan, and Hollath villages were selected on the basis of their geographical representability, the level of *sasi* observance[39], and the existence of variations in timing of the harvests. The three sample locations were selected based on their geographical positions among the major trochus producing villages, which are all located on the Kei Besar's east coast-line. Wattlaar, Ohoirenan, and Hollath respectively were chosen to represent the South, North, and the Central parts of the island. The level of *sasi* observance was also taken into consideration as it is likely that the chance of getting incorrect harvest rate information due to falsification of records or undetected harvests is higher for places where observance is lower, and vice versa. As shown in Table 4.1, *sasi* observance in the three villages can be categorized as moderate or high. Variations in the length of *sasi* periods, on the other hand, were expected to improve the accuracy of the model's predictions by providing increased coverage of the effects of such variation on the resulting yields.

The calibration process of this model has been performed by correcting some of the model parameters so that its prediction most closely matches the recorded yields associated with different closing times that were applied by the communities in these three sample locations. The conformity of actual data and the model prediction is

[39] Level of observance is associated with the number of violations as defined in Chapter 4.

measured in the correlation coefficient[40], r. The parameter values associated with the highest r were then taken as the calibrated values. Following the rationale described in Chapter 3, the parameters that were used as the basis for the calibration were the juvenile mortality rate[41], which was taken to represent the factors influencing the speed of changes in the biomass level; and the maximum yield, which was used as a 'starting point' proxy for the determination of carrying capacity. With respect to carrying capacity, on the other hand, the calibration was done by adjusting the initially-presumed value of the maximum yield to a value that gives a better fit of the model prediction to the actual data (Table 5.4).

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[40] $r = \sqrt{\frac{\Sigma(y-\hat{y})^2 - \Sigma(y-\bar{y})^2}{\Sigma(y-\hat{y})^2}}$, where $y, \bar{y}$, and $\hat{y}$ are, respectively, actual yield, average actual yield, and predicted yield

[41] Given that the existing literature provides a wide range of predictions on the early stage mortality rate, it is considered reasonable that calibration should focus on the values of the mortality rates at this stage.

Table 5.4. Harvest tonnage in three villages

Year	Harvest (tonnes)			Notes
	Wattlaar[a]	Ohoirenan[b]	Hollath[b]	
1978		16.9 ± 0.6 (respondent=13)		
1979				
1980		10.2 ± 0.6 (respondents=14)	11.5 ± 0.3 (respondent=8)	
1981	5.204			
1982	1.057			
1983	0.967	1.25 ± 0.0 (respondents=11)		Sasi was not opened in Ohoirenan, but a light harvest took place
1984		1.25± 0.0 (respondents=14)		Sasi was not opened in Ohoirenan, but another light harvest took place
1985	0.754			
1986		12.0 ± 0.0 (respondents=13)	14.9 ± 0.7 (respondent=8)	
1987			9.0 ± 0.0 (respondent=8)	
1988		10.0 ± 0.0 (respondents=11)		
1989	1.236		11.0 ± 0.4 (respondent=7)	
1990	0.831	10.9 ± 0.8 (respondents=11)		
1991	0.989	4.0 ± 0.0 (respondents=11)	11.0 ± 0.0 (respondent=7)	
1992	0.902			
1993				
1994	1.895	8.0 ± 0.0(respondent=13)		
1995		2.0 ± 0.0(respondent=13)		
1996	0.891			

a) numbers were based on a village's written record

b) numbers were given by several villagers / collectors who were involved actively in *sasi* openings based on their best recollection and standard deviations are to show variation among figures by these respondents

Based on the above, Figures 5.6.a, 5.6.b, and 5.7 show the model predictions as compared to the actual historical harvest data collected from the villages of Wattlaar, Ohoirenan, and Hollath, respectively.

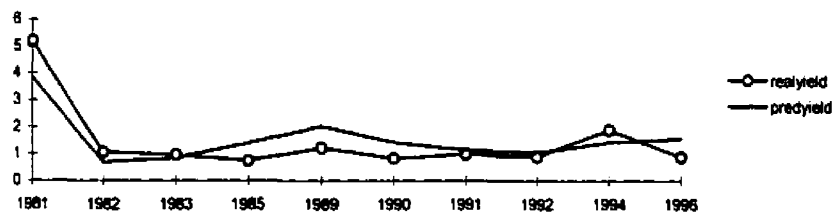

Figure 5.6. Actual and predicted harvests tonnnages resulting from different closing time in Wattlaar

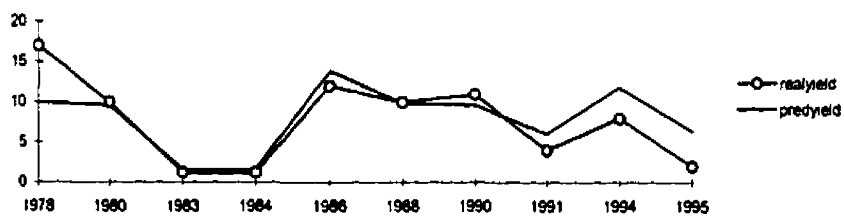

Figure 5.6.a. Actual and predicted harvest tonnages resulting from different closing time in Ohoirenan

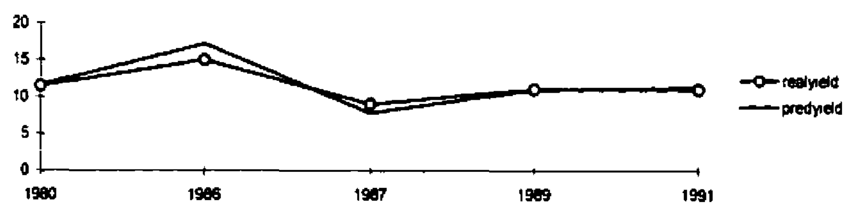

Figure 5.7. Actual and predicted harvest tonnages resulting from different closing time in Hollath

Notes: 1) representing the closeness of the prediction to the actual figures, *r* values for the three predictions are 75.09%, 63.34%, and 66.75%, respectively
2) x axis = year of observation; y axis = actual/predicted yields, in tons
3) realyield = the observed yield; predyield = the predicted yield

Due to the lack of written harvest records and the fact that people encountered difficulty in remembering events that happened more than 20 years ago, most harvest data collected in this study covers a range of time of approximately twenty years. All data having a standard deviation of more than ten percent[42] were excluded and not used in the calibration. It is worth noting here that for the case of Hollath village's trochus beds, the calibration was attempted despite the small number of observable *sasi* cycles in the 20 year period, due to an absence of a harvest since 1991. This village was selected as representative of the central part[43] of the island's trochus producing villages because of the dependability of the data from this village due to its high level of *sasi* observance, even though there were only a limited number of *sasi* cycles. As shown in Figure 5.7, the model prediction has a high correlation with the actual data

5.3. Future projections of the outcomes of various *sasi* arrangements

Using the model parameters obtained from the calibration step, future projections can be made simulating various harvest arrangements such as shown in Figures 5.8.a to Figure 5.10.f. Using the Ohoirenan case as an illustration, the figures delineate various implications associated with modifications in one or more *sasi*-based harvest regulating

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[42] A standard deviation of ten percent was considered to be too big because the *sasi*-duration-driven yield difference often is even smaller than ten percent

[43] A first attempt was made to use data from Yamtel Village, which geographically more representative for the central part of the island but the data shows wide variation. Therefore, data from Hollath Village was considered as an acceptable alternative

techniques, which are referred to in the model as *variables*. To explain the nature of the trends portrayed by such simulation runs, consider the following simple intuition. In the basic multicohort model described earlier in this chapter, the preharvest biomass is affected positively by recruitment and the duration of sasi period. This framework will be used to explain trends in the following paragraphs.

Figures 5.8.a and 5.8.b show that within the range of harvest regulating options, the sustainable pre-harvest stock increases as the duration of *sasi* is extended. The intuition for this result is as follows. If the sizes of the modeled trochus stocks naturally increase at a diminishing rate over time, which in fact they do, it can be said that below carrying capacity, these trochus beds have a positive net-biomass growth-rate (e.g., in terms of tons per year). In the absence of any external influence, the existence of positive net biomass growth implies that the rate of individual growth plus recruitment is greater than the rate of mortality. In such a case, it is clear that below carrying capacity the extension in growth time (e.g., in terms of years) will result in an increase in stock (e.g., in terms of tons) because the time extension magnifies the increase in the accumulated biomass through the positive net growth rate and the increment of growing time. Taking this intuition into the *sasi* simulation, it can be expected that with a longer closing time, applying a constant value of actual-to-potential harvest ratio will result in a larger stock accumulation, and hence a higher yield per *sasi* cycle. This is true because the extended *sasi* not only provides more time for a positive growth, but it also allows the stock to start with a greater number of individuals at the beginning of each cycle. As will be discussed later, this does not necessarily mean that a longer *sasi* is better than a shorter one because one criteria in selecting the management scenario is to total revenue, not revenue per cycle.

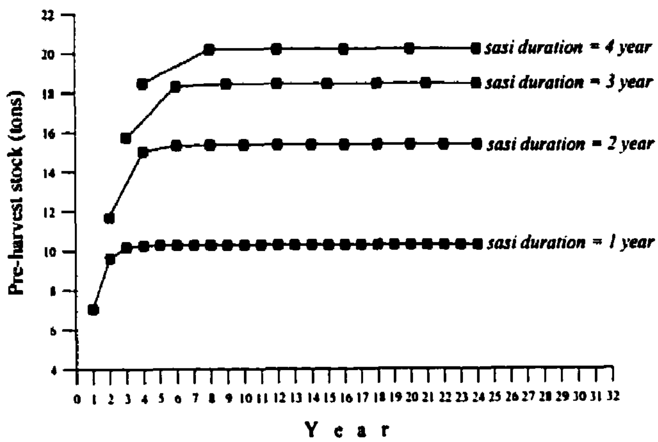

Figure 5.8.a Projected development of pre-harvest stocks for different sasi durations given higher age of first capture (a_f = 2)

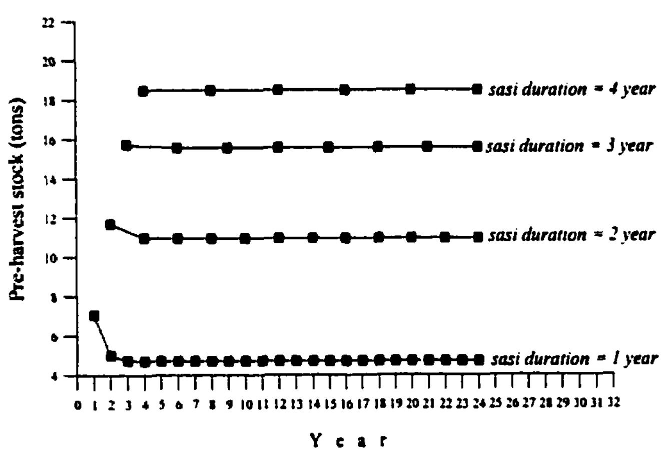

Figure 5.8.b Projected development of pre-harvest stocks for different sasi durations given lower age of first capture (a_f = 1)

Figures 5.8.a and 5.8.b show two different possible curve shapes of the projected development of the stock for ages of first capture of 2 and 1 year, respectively. In the first *sasi* openings for a given *sasi* duration, the two schemes resulted in exactly the same outcomes. This is because the model starts with the same number of individuals at $t = 0$. As shown in these figures, the age at first capture is not the same for the two cases, and this causes a larger harvest and fewer spawners for the next cycle, with a_f=1. In this case stock levels are lower in later cycles.

In Figures[44] 5.9.a to 5.9.f and 5.10.a to 5.10.f, it is shown how changes in the two other harvest regulating techniques will affect the sustainable levels of pre-harvest stock, yield, and the corresponding post-harvest stock. However, unlike extending the time of closing, these two harvest regulating techniques influence the total increase in net biomass by affecting the net growth rate of the stock. Assuming that up to the carrying capacity, the biomass growth is positive for all positive numbers of trochus individuals, the outcomes of the modification in the age of first capture (variable a) or the actual-to-potential catch ratio (variable *percent*) is given by the net effect on mortality and recruitment.

[44] Figures 5.9.a to 5.9.f depict the results of variation in age of first capture for a fixed actual-to-potential catch ratio (*percent* = 0.4) while figures 5.10.a to 5.10.f depict the results of variation in actual-to-potential catch ratio given a fixed age of first capture (a_f = 2). As used in the model algorithm, *percent* = 0.4, percent = 0.6, and *percent* = 0.8 means that the actual-to-potential catch ratio is 40 %, 60% and 80%, respectively.

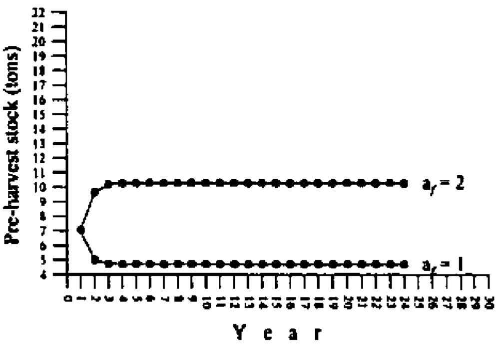

Figure 5.9.a Projected development of pre-harvest stocks for different age limitations given a shorter *sasi* duration ($d = 1$)

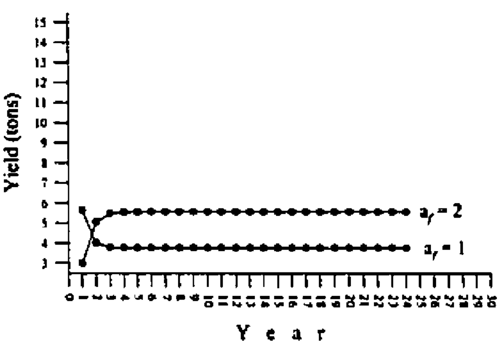

Figure 5.9.b Projected development yields for different levels of age limitation given a shorter *sasi* duration ($d = 1$)

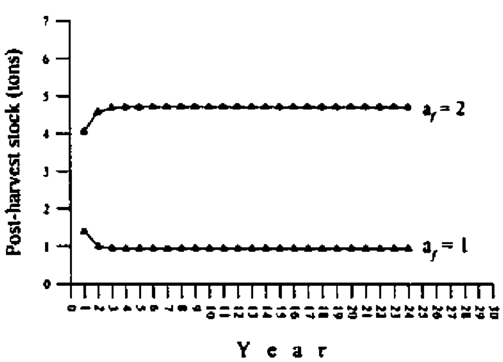

Figure 5.9.c Projected development of post-harvest stocks for different levels of age limtation given a shorter *sasi* duration ($d = 1$)

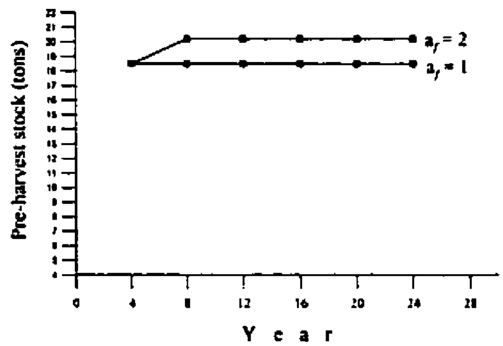

Figure 5.9.d Projected development of pre-harvest stocks for different levels of age limitation given a longer *sasi* duration ($d = 4$)

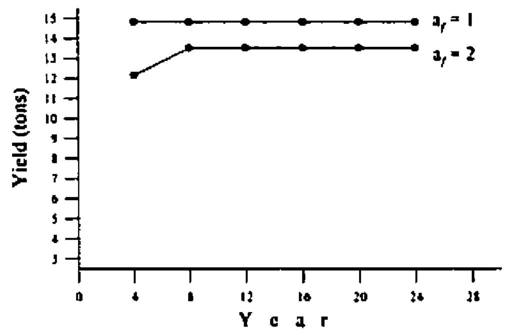

Figure 5.9.e Projected development of yields for different levels of age limtation given a longer*sasi* duration ($d = 4$)

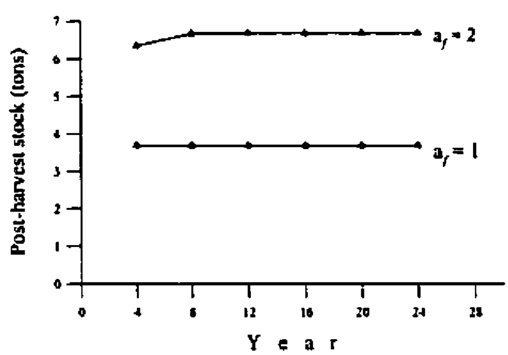

Figure 5.9.f Projected development of post-harvest stocks for different levels of age limtation given a longer*sasi* duration ($d = 4$)

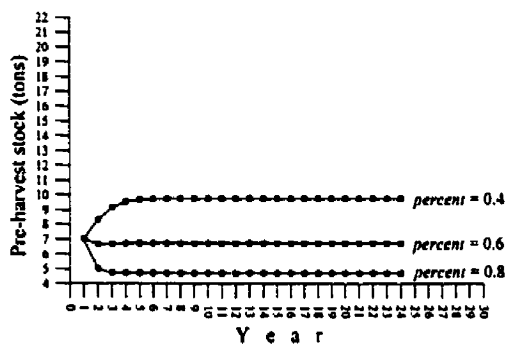

Figure 5.10.a Projected development of pre-harvest stock for different actual-to-potential harvest ratio given a shorter sasi duration (*d* = 1)

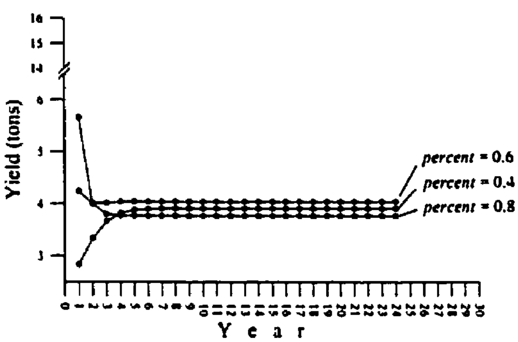

Figure 5.10.b Projected development of yield for different actual-to-potential harvest ratio given a shorter sasi duration (*d* =1)

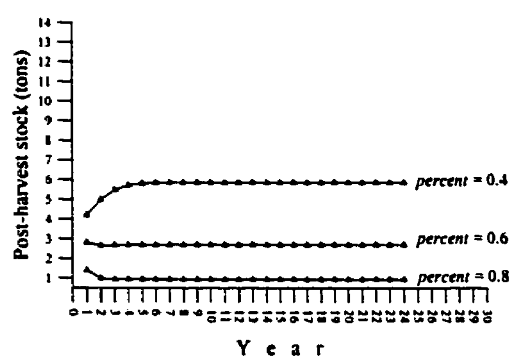

Figure 5.10.c Projected development of post-harvest stock for different actual-to-potential harvest ratio given a shorter sasi duration (*d* = 1)

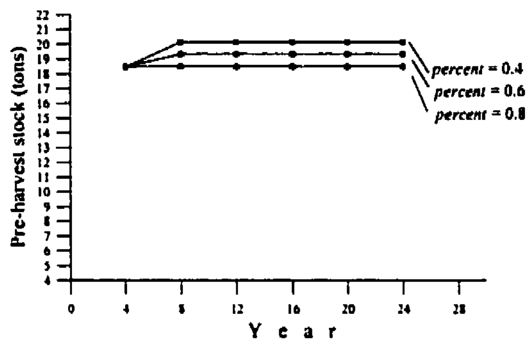

Figure 5.10.d Projected development of pre-harvest stock for different actual-to-potential harvest ratio given a longer sasi duration (*d* = 4)

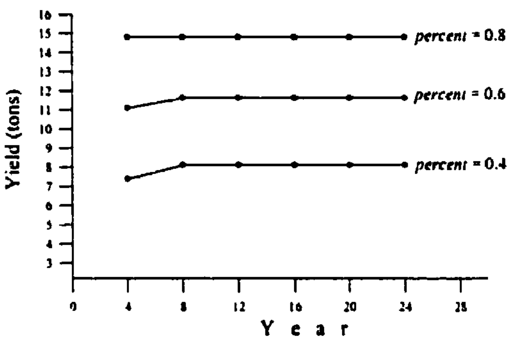

Figure 5.10.e Projected development of yield for different actual-to-potential harvest ratio given a longer sasi duration (*d* = 4)

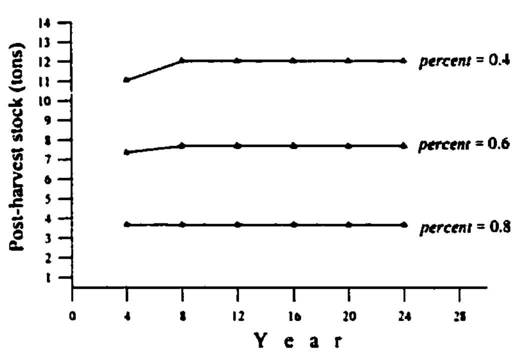

Figure 5.10.f Projected development of pre-harvest stock for different actual-to-potential harvest ratio given a longer sasi duration (*d* = 4)

To some degree, the two regulating tools will lead to the same result in the resource dynamics, i.e., that both will affect recruitment and mortality. Extending the harvest opening has similar effect to lowering the age of first capture. Increasing the value of variable *percent* or lowering the age of first capture both have two implications. They reduce the post-harvest stock and reduce the number of spawners. Reducing the stock will reduce the mortality rate, meaning greater survival. Whether the effect of such variable modification on the rate of biomass increase is positive or negative depends on the tradeoff between the effect on the number of spawners and the effect on mortality. From the simulation results, however, it can be seen that given the range of harvest restriction, increasing the age at first capture and/or decreasing the portion of the harvest on harvestable individuals always leads to a higher sustainable pre-harvest stock. This means that at any given point in time within the closed (*sasi*) period, the net biomass growth rate is higher for a lower value of the variable *percent* or a higher value of the variable a_f.

Due to the carrying capacity limit, the resulting sustainable pre-harvest stock of any setting of variables a_f and *percent* will eventually merge at a certain length of *sasi*; i.e., when the duration is long enough for any setting to approach the maximum attainable sustainable pre-harvest stock. In the case of short *sasi* cycles, a low value of a_f or a higher *percent* will cause a severe reduction in the number of spawners because the short closing time does not allow them to produce a high number of additional spawners. Consequently, the application of a lower a_f or a higher *percent* will not always increase yield on a sustainable basis. Considering that natural mortality of trochus juveniles is extremely high (see Section 5.1.2.3), such a severe reduction in the number of spawners at one time can greatly reduce potential harvest in the future. If this is the case, at a longer *sasi* cycle, sacrificing potential harvest associated with the imposition of a higher age standard or a lower *percent* value will be less meaningful. This is because the extended closing (*sasi*) duration will provide the remaining individuals with enough opportunity to produce more juveniles to ultimately increase recruits to pre-harvest stocks. As a result, the increase in the number of recruits associated with a longer *sasi* cycle more than offsets the sacrifice of potential harvest. This result can be seen in Figure 5.9.e and Figure 5.10.e.

Tables 5.5, and 5.6, and 5.7 present the results obtained from the simulation model. Using a 24-year planning horizon, the figures portray various input-and-outcome relationships of *sasi* in the three sample locations, Wattlaar, Ohoirenan, and Hollath. In management terms, the numbers presented in these tables reflect outcomes of the various options for the harvest regulating techniques. The tradeoffs between these outcomes will be discussed in the next section.

Table 5.5. Matrix of harvest arrangements and the corresponding outcomes of Wattlaar

Age of first capture, a Effort level, %	a_f=1 %=0.4	 %=0.6	 %=0.8	a_f=2 %=0.4	 %=0.6	 %=0.8
duration of closing, d=1 year						
Cummulative NPV (USD 1000)	22.449	24.366	23.826	23.227	28.499	31.718**
Sustainable post-harvest stock level	0.879	0.404	0.141*	1.465	1.011	0.707
Perpetuity	1.00**	1.00**	1.00**	1.00**	1.00**	1.00**
duration of closing, d=2 years						
Cummulative NPV (USD 1000)	17.053	22.167	25.559	15.597	21.389	26.118
Sustainable post-harvest stock level	1.402	0.786	0.329	1.838	1.302	0.86
Perpetuity	0.50	0.50	0.50	0.50	0.50	0.50
duration of closing, d=3 years						
Cummulative NPV (USD 1000)	13.132	18.437	22.974	11.509	16.572	21.199
Sustainable post-harvest stock level	1.666	1.020	0.467	2.005	1.454	0.952
Perpetuity	0.33	0.33	0.33	0.33	0.33	0.33
duration of closing, d=4 years						
Cummulative NPV (USD 1000)	10.406	15.137	19.552	8.9514	13.180	17.243
Sustainable post-harvest stock level	1.805	1.155	0.55	2.081	1.53	1.003
Perpetuity	0.25	0.25	0.25	0.25	0.25	0.25
duration of closing, d=∞						
Cummulative NPV (USD 1000)	0*	(no revenue is accumulated)				
Sustainable post-harvest stock level	3.252**	(equals to carrying capacity)				
Perpetuity	0*	(no harvest takes place)				

Note: perpetuity is defined as the frequency of an opening per-year (e.g., perpetuity is one if opening is every year and it equals to 0.25 if opening is every four years)

Table 5.6. Matrix of harvest arrangements and the corresponding outcomes of Ohoirenen

Age of first capture, a Effort level, %	a_f=1 %=0.4	 %=0.6	 %=0.8	a_f=2 %=0.4	 %=0.6	 %=0.8
duration of closing, d=1 year						
Cummulative NPV (USD 1000)	149.609	162.441	158.841	154.849	189.999	211.451**
Sustainable post-harvest stock level	5.86	2.696	0.943*	9.767	6.739	4.716
Perpetuity	1.00**	1.00**	1.00**	1.00**	1.00**	1.00**
duration of closing, d=2 years						
Cummulative NPV (USD 1000)	113.6866	147.7807	170.3928	103.9821	142.5911	174.1165
Sustainable post-harvest stock level	9.348	5.24	2.191	12.256	8.677	5.731
Perpetuity	0.50	0.50	0.50	0.50	0.50	0.50
duration of closing, d=3 years						
Cummulative NPV (USD 1000)	87.542	122.917	153.159	76.731	110.483	141.325
Sustainable post-harvest stock level	11.104	6.801	3.111	13.364	9.693	6.346
Perpetuity	0.33	0.33	0.33	0.33	0.33	0.33
duration of closing, d=4 years						
Cummulative NPV (USD 1000)	69.376	100.912	130.347	59.677	87.865	114.954
Sustainable post-harvest stock level	12.035	7.698	3.687	13.874	10.202	6.686
Perpetuity	0.25	0.25	0.25	0.25	0.25	0.25
duration of closing, d=∞						
Cummulative NPV (USD 1000)	0*	(no revenue is accumulated)				
Sustainable post-harvest stock level	21.682**	(equals to carrying capacity)				
Perpetuity	0*	(no harvest takes place)				

Table 5.7. Matrix of harvest arrangements and the corresponding outcomes of Hollath

Age of first capture, a	a_f=1			a_f=2		
Effort level, %	%=0.4	%=0.6	%=0.8	%=0.4	%=0.6	%=0.8
duration of closing, d=1 year						
Cummulative NPV (USD 1000)	174.544	189.514	185.314	180.658	221.666	246.693**
Sustainable post-harvest stock level	6.837	3.145	1.100*	11.395	7.863	5.502
Perpetuity	1.00**	1.00**	1.00**	1.00**	1.00**	1.00**
duration of closing, d=2 years						
Cummulative NPV (USD 1000)	132.634	172.411	198.792	121.313	166.356	203.136
Sustainable post-harvest stock level	10.905	6.113	2.556	14.298	10.123	6.686
Perpetuity	0.50	0.50	0.50	0.50	0.50	0.50
duration of closing, d=3 years						
Cummulative NPV (USD 1000)	102.133	143.403	178.686	89.520	128.896	164.879
Sustainable post-harvest stock level	12.955	7.935	3.63	15.592	11.308	7.404
Perpetuity	0.25	0.25	0.25	0.25	0.25	0.25
duration of closing, d=4 years						
Cummulative NPV (USD 1000)	80.939	117.731	152.071	69.622	102.509	134.112
Sustainable post-harvest stock level	14.04	8.981	4.301	16.186	11.903	7.8
Perpetuity	0.33	0.33	0.33	0.33	0.33	0.33
duration of closing, d=∞						
Cummulative NPV (USD 1000)	0*	(no revenue is accumulated)				
Sustainable post-harvest stock level	25.296**	(equals to carrying capacity)				
Perpetuity	0*	(no harvest takes place)				

5.4. Using the model outcomes to optimize *sasi*

Since, as shown in the previous section, the selection between *sasi* regulation options involves tradeoffs among the criteria used to judge *sasi* success, a decision making framework is required for comparing the values of criteria, which in fact are stated in different units. The framework developed by Healey (1984), as described in the methodology section, has been adopted in this analysis.

Table 5.8 contains the model's predicted outcomes which have been standardized using Healey's technique discussed in Chapter 3. Standardization of values given in Table 5.5, 5.6, and 5.7 has resulted in the same matrix of values as shown in Table 5.8. This result is possible because the calibration for the three locations, despite differences in their carrying capacities, creates no differences in the factors influencing the rate of the biomass change. In fact, as long as all of the growth parameters are the same and the critical mass necessary for successful spawning has been passed, carrying capacity in this model functions like a magnifier, in which a trochus bed with a bigger carrying capacity can be regarded as a combination of the trochus beds with a smaller carrying capacity. Thus when comparing the sets of regulating techniques on either of these beds, the same results will be obtained.

Based on the predictions for the three locations, the values for every combination of harvest regulating techniques were standardized according to the minimum and the maximum among all existing prediction values. The maximum values in Tables 5.5, 5.6, and 5.7 are marked by a double star, while the minimum is indicated by a single star. In standardization[45], the maximum is given a score of 100 while the minimum is given a score of zero. For this process, it was determined that the maximum cumulative NPV is given by a combination of a 1-year *sasi* duration, a 2-year age of first capture, and an 80-percent actual-to-potential harvest ratio. No revenue is accrued from total banning; therefore the nil NPV associated with it becomes the minimum of the evaluated NPV values. The maximum stock is also associated with total banning, while the minimum stock occurs for a combination of the regulating techniques of a 1-year *sasi* duration, 1-year age of first capture, and an 80-percent actual-to-potential harvest ratio.

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[45] A standardized value of an indicator x, $X_{std} = \frac{X_{actual} - X_{min}}{X_{max} - X_{min}} \times 100\%$

Table 5.8. Standardized values of outcomes

Age of first capture, a	a_f=1			a_f=2		
Effort level, %	%=0.4	%=0.6	%=0.8	%=0.4	%=0.6	%=0.8
duration of closing, d=1 year						
Cummulative NPV	70.75	76.82	75.12	73.23	89.85	100.00**
Sustainable post-harvest stock level	23.71	8.45	0*	42.54	27.95	18.19
Perpetuity	100.00**	100.00**	100.00**	100.00**	100.00**	100.00**
duration of closing, d=2 years						
Cummulative NPV	53.76	69.89	80.58	49.18	67.43	82.34
Sustainable post-harvest stock level	40.53	20.72	6.02	54.55	37.29	23.09
Perpetuity	50.00	50.00	50.00	50.00	50.00	50.00
duration of closing, d=3 years						
Cummulative NPV	41.40	58.13	72.43	36.29	52.25	66.84
Sustainable post-harvest stock level	48.99	28.25	10.45	59.89	42.19	26.05
Perpetuity	33.33	33.33	33.33	33.33	33.33	33.33
duration of closing, d=4 years						
Cummulative NPV	32.81	47.72	61.64	28.22	41.55	54.36
Sustainable post-harvest stock level	53.48	32.57	13.23	62.35	44.65	26.05
Perpetuity	25.00	25.00	25.00	25.00	25.00	25.00
duration of closing, d=∞						
Cummulative NPV	0**					
Sustainable post-harvest stock level	100**					
Perpetuity	0*					

The values presented in Table 5.8 are sufficient for comparing the harvesting options in the absence of the stakeholders' priorities on management objectives. However, factors representing preferential judgment need to be included if stakeholders have non-neutral preferences concerning these objectives. The priorities of the stakeholders are combined with the values given in Table 5.8 to produce the weighted values of attributes presented in Table 5.9. According to weighting technique discussed in Chapter 3 and the results of the interviews presented in Appendix 2, it was found that the economic concern, whose proxy is NPV, should be weighted[46] 27 %. The biological concern, whose proxy is the sustainable post-harvest stocks, should be weighted 35 %.

[46] A method of weighting is discussed in Chapter 3, and the result is shown in Appendix 2

The social concern, whose proxy is the sustainable perpetuity, should be weighted 38 %.

Table 5.9. Scores for various configurations of harvest regulation techniques

Age of first capture, a		a_f=1			a_f=2	
Effort level, %	**%=0.4**	**%=0.6**	**%=0.8**	**%=0.4**	**%=0.6**	**%=0.8**
			duration of closing, d=1 year			
Score for economic concern	19.10	20.74	20.28	19.77	24.26	27.00**
Score for conservation concern	8.30	2.96	0	14.89	9.78	6.37
Score for social concern	38.00**	38.00**	38.00	38.00**	38.00**	38.00**
Total score	***65.40***	***61.70***	***58.28***	***72.66****	***72.04***	***71.37***
			duration of closing, d=2 years			
Score for economic concern	14.51	18.87	21.76	13.28	18.21	22.23
Score for conservation concern	14.18	7.25	2.11	19.09	13.05	8.08
Score for social concern score	19.00	19.00	19.00	19.00	19.00	19.00
Total score	***47.70***	***45.12***	***42.86***	***51.37***	***50.26***	***49.31***
			duration of closing, d=3 years			
Score for economic concern	11.19	15.70	19.56	9.79	14.11	18.05
Score for conservation concern	17.15	9.89	3.66	20.96	14.77	9.12
Score for social concern	12.67	12.67	12.67	12.67	12.67	12.67
Total score	***40.99***	***38.25***	***35.88***	***43.43***	***41.54***	***39.83***
			duration of closing, d=4 years			
Score for economic concern	8.86	12.89	16.64	7.62	11.22	14.68
Score for conservation concern	18.72	11.40	4.63	21.82	15.63	9.69
Score for social concern	9.50	9.50	9.50	9.50	9.50	9.50
Total score	***37.08***	***33.79***	***30.77***	***38.94***	***36.35***	***33.87***
			duration of closing, d=∞			
Score for economic concern				0*		
Score for conservation concern				35.00**		
Score for social concern				0*		
Total score				***35.00***		

Based on the weighted values shown in Table 5.9, it can be concluded that the optimal outcomes are given by the combination of the regulating techniques of a 1-year period of *sasi*, a 2-year age of first capture, and a 40-percent actual-to-potential harvest ratio. The italic numbers in Table 5.9 are merely the sums of the weighted values of biological (conservation), economic, and social attributes. As it can be seen in the table, the optimal setting gives a value of 72.66, the highest among all relevant options. For Wattlaar, this optimal setting is associated with a net present value of USD 23,000, a sustainable annual harvest of 0.97 tons, and a post-harvest stock of 1.46 tons. For Hollath, this optimal setting is associated with a net present value of USD 180,500, sustainable annual harvest of 7.60 tons, and post harvest stock of 11.40 tons. For Ohoirenan, this optimal setting is associated with a net present value of USD 154,800, sustainable annual harvest of 6.51 tons, and post harvest stock of 9.76 tons.

5.5. Sensitivity analysis

In this study, sensitivity analysis has double significance. The first is associated with adopting the model to areas where the inherent water conditions might be different from those where the calibrations used here were done. The other is associated with changes in external factors which might affect the model's results in the future such as environmental, economic and social circumstances. Through this analysis, the effect of the wrong selection of parameter values is shown so that the implications, if any, can be anticipated.

The inclusion of the two parameters, carrying capacity (represented by the recorded maximum harvest, *Yield*max) and rate of growth (represented by the growth parameter *c* as shown in Figure 5.4) in the analysis can be used to show the effect of slight differences in water conditions. As mentioned earlier, information that meets the criteria are required to perform a calibration is not available for all trochus beds. Thus, relying on calibration carried out in adjacent waters may be appropriate. The rate of change in the biomass can be readily transferable to adjacent waters, assuming that the conditions of the two areas are not significantly different. The carrying capacity approximation, on the other hand, will have to rely on the best available carrying capacity information for the village's trochus bed for which the model is to be adopted. In the analysis, the effect of changes in the growth rate on the outcomes is shown by scaling up the value of c of the stock-dependent mortality function. While the effect of the change in carrying capacity is illustrated in terms of changes in the outcomes as the presumed maximum stock is reduced.

To measure the effect of external changes, a sensitivity analysis was done on selected parameters, including price, the discount rate, and the objective weight. Price and discount rate were included in the analysis to anticipate the effect of a change in economic conditions. The objective weights, on the other hand, are included to take account of the possibility of changes in perception among stakeholders regarding the existence of the resource. Changes in the c are included to take into account the effect of deviation in the mortality value due to external factors such as to environmental degradation and the presence of illegal harvest. Altogether, the analysis considers 13 cases, including the base case. These are listed as follows:

Base case = parameter values are set equal to the result of the calibration

Case 1 = weight[47] of economic concerns increases twice relative to others

Case 2 = weight of biological concerns increases twice relative to others

Case 3 = weight of social concerns increases twice relative to others

Case 4 = weight of economic concerns three times relative to others

Case 5 = weight of biological concerns increases three times relative to others

Case 6 = weight of social concerns increases three times relative to others

Case 7 = the constant that indicates the effect of the stock on the increase of mortality rate, c, is increased by 20 %

Case 8 = the rate of price change is reduced by 20%

Case 9 = the rate of price change is raised by 20 %

Case 10 = discount rate is reduced to 5 %

Case 11 = discount rate is raised to 20 %

Case 12 = carrying capacity is reduced by 20 %

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[47] Letting $C_{old,a}$, $C_{old,b}$, and $C_{old,c}$ be the original weightts of concerns a, b, and c, respectively; and $C_{new,a}$, $C_{new,b}$, and $C_{new,c}$ be the new values of weightt of those respective concerns, then an increase of $C_{old,a}$ by n times relative to other concerns means that:

$$\frac{C_{new,a}}{C_{new,b}} = n \times \frac{C_{old,a}}{C_{old,b}} \text{ and } \frac{C_{new,a}}{C_{new,c}} = n \times \frac{C_{old,a}}{C_{old,c}}. \text{ Then, } C_{new,a} = 1 / \left[1 + \frac{C_{old,b}}{C_{old,a}} + \frac{C_{old,c}}{C_{old,a}} \right]$$

Table 5.10. Sensitivity analysis

	Base Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12
Duration of closing (year)	1	nd	nd	nd	nd	banning	nd	nd	nd	nd	nd	nd	nd
Harvest portion	0.4	0.8	nd	nd	0.8	0	nd	nd	nd	nd	nd	nd	nd
Age of first capture (year)	2	nd	nd	nd	nd	∞	nd	nd	nd	nd	nd	nd	nd
NPV (US$)	154,850	211,450	nd	nd	211,450	0	154,850	nd	126,970	182,725	251,220	76,680	123,880
Stock (ton)	9.747	4.716	nd	nd	4.716	21.682	9.747	nd	nd	nd	nd	nd	7.814
Yield (ton/harvest)	4.302	5.566	nd	nd	5.566	0	4.302	nd	nd	nd	nd	nd	3.442

Note: nd = no difference from the base case

Starting with the base case, it is found in most of the cited cases that the effect of changes of the parameters on the configuration of the harvest regulating technique are insignificant. The only change that may predictably result in a significant effect on the optimal solution is the increase of economic prioritization. As shown in Case 1 and Case 4, such increases would require that a lengthier duration of *sasi* opening be adopted to result in the optimal solution. A double increase in the biological concern (Case 2) will not cause a change in the recommended configuration of the harvest regulating techniques. However, a further increase, such as shown in Case 5, shows that at that stage the model indicates the best harvest arrangement is a total banning on harvesting.

Changes in some parameters cause changes in yield per opening, net present value, and sustainable stock, even though the harvest regulation configuration does not change. This can be seen in cases 7 to 12, where different values of the price, discount rate, and carrying capacity parameters are used as compared to the base case.

The implication of this analysis is that unless there is a significant shift in the parameters used in the model, the optimal solution we predicted based on the current condition is valid. This result also emphasizes that a harvest banning policy is difficult to implement in the near future, i.e., until the time where appreciation in conservation amongst stakeholders is at least tripled.

CHAPTER 6. ASSESSMENT OF THE VARIABLES INFLUENCING THE PROPOSED CO-MANAGEMENT REGIME

The purpose of the following analysis is to build a better intuition on the viability of a *sasi*-based co-management policy for Maluku's most prominent trochus production center, Kei Besar. Therefore, based on criteria suggested by co-management experts, the discussion will determine whether this policy is feasible for this particular location. Many of these experts such as Pinkerton (1989), Ostrom (1994), and Jentoft (1989), drawing on empirical evidence, propose several conditions that are necessary for a co-management scheme to be sustainable. Based on their theoretical framework, Pomeroy (1996) developed a practical research guideline for evaluations of community based coastal resource management policies. This framework is adapted in this study.

As described in the methodology section, Pomeroy's framework was designed to construct a link between management outcomes as the dependent variable and a set of relevant demographic figures as the independent variables. To make this framework appropriate to the nature of the specific case on which this study focuses, the following two modifications were applied. First, considering that the framework was used to assess a management system that is still in the development stage, figures are presented in terms of prediction, given a hypothetical situation. Willingness to participate in the planning process, for example, is used to represent the likely degree of participation if a planning process were actually taking place. Second, due to their important role in the existence of *sasi* management system in the past, several cultural variables are discussed separately in more detail in Chapter 4.

6.1. Assessment of the prospect for planning process

The first issue in the development of a new management proposal is the planning process. A key element here is the incorporation of public consultation and public participation. Previous empirical research (e.g., Chambers, 1983) has shown that resource management projects often fail because of the exclusion of public participation in the planning process; and our field research indicates that such involvement is essential to public acceptance of any management proposal in Kei Besar. Accommodating the opinions of villagers in the planning process will reduce social management costs and will increase the chance that the proposed management regime will be accepted. Unfortunately, in the past the participation of villagers here has not been sought out, resulting in resistance to changes in policy. Therefore, for the purposes of this study an assessment of attitudes in regard to *sasi*-based management was undertaken.

As noted in Chapter 3, a total of 186 interviews were conducted in the field to elicit attitudes of villagers toward the initiation of a planning process leading to the development of the proposed sasi-based management plan. The questions asked and the responses to them are summarized in Table 6.1. The results are encouraging. The majority of those surveyed provided positive responses to almost all of the questions. Those questions receiving the most positive responses were Number 3, willingness to participate in the planning process; and Number 5, willingness to participate in training. These results can be associated with those shown in Table 6.9, which indicate that communities in Kei Besar island are aware that there has been a significant decrease in harvest due to deterioration of stocks. Some of these communities have also acknowledged the link between the introduction of harvest restrictions (e.g., size at first capture) with the improvement occurring in some stocks.

Table 6.1. Responses of community people to question regarding plans for trochus management

NO	CATEGORY	RESPONSES			
		POSITIVE	NEGATIVE	INDIFFERENT	TOTAL
1	Attitude towards arrangement to restrain rate of harvest in order to sustain level of production.	86.02 (160)	13.98 (26)	0	100 (186)
2	Attitude towards an involvement of outside expertise in the process of determination of harvest control within the context of *sasi* practice (e.g., those of research institutions, NGOs, etc).	80.11 (149)	10.21 (19)	9.68 (18)	100 (186)
3	Willingness to participate in planning process to construct better *sasi* arrangements.	95.16 (177)	4.84 (9)	0	100 (186)
4	Attitude towards a majority decision that is not in accordance with individual's view.	68.82 (128)	9.68 (18)	21.50 (40)	100 (186)
5	Willingness to participate in training program to create job opportunity.	94.09 (175)	5.91 (11)	0	100 (186)

Note: the numbers without parentheses are percentages; those within parentheses are the actual numbers of respondents

Responses to question 1, 'restraining harvest to sustain future levels of production'; question 2, 'using outside expertise to determine *sasi*-based harvest controls'; and question 4, 'accepting a majority decision that is not in accordance with individual's view', also were positive. But, while positive, these responses were not as strong as the responses to the other questions. Also, in the case of question 4, a large proportion (21.5%) of the responses were 'indifferent'. Follow-up discussions with respondents indicated that this was due to two factors. First, some villagers felt uncomfortable in expressing their personal views because of a lack of confidence in their ability to articulate contrary arguments; while others did not want to express views which were in conflict with those of family members who had already spoken out on the issue.

Of the interviewed respondents, 80.11% indicated a willingness to involve outsiders in their local management program (question 2). However, follow-up discussions indicated that this response would have been even more positive if the original question would have contained more precise information as to who the outside agents might be. The following transcript of conversation on this issue shows the question of who is to get involved in policy development is relevant for the villagers.

> Q: What would you think if an outsider came with help to manage your village natural resources, or wanted to share knowledge for the good of *sasi*?
>
> A: I am not sure it will be acceptable for most people.
>
> Q: Why?
>
> A: Government agents often cheat people.
>
> Q: Are you positive about the generality of your view?
>
> A: Are you a government agent?
>
> Q: I do work for the government as a researcher to find out if I have anything to contribute to solve the natural resource problem in the villages.
>
> A: There are outsiders who did good jobs; NGO's, for example, also did several good jobs.

Despite the large number of positive responses to all of these questions, another set of data indicates that the interpretation of this information should also take into account the variation in the social strata of the respondents. Table 6.2 shows that a larger number of negative responses were given by respondents that belong to the lower classes; namely lower income, less educated, and lower caste groups. In line with this, Ostrom (1994) has warned of the danger of over-reliance on simple voting, which may result in poor representation of the concerns of lower-class groups. Furthermore, Racelis (1984) suggests that there should be a balanced judgement that ensures the accommodation of their interests in the design of a management project. In the case of a *sasi*-based management system for the Kei Besar trochus fishery, this would mean that the interests of people in the three lower classes mentioned above should receive particular attention. The discussion in Chapter 4 indicates that the approach to these groups would likely be best carried out through kinship-based strategies. What is suggested here is that policy makers might take advantage of the close kin relationships which exists here to capture their ideas or views and to have them articulated in the planning process.

Table 6.2. Negative responses given by respondents of different social structures

	Income		Education		Caste			Total
	low	high	low	high	ren	ren	mel	
Attitude towards arrangement to restrain rate of harvest in order to sustain level of production.	46.2 (12)	53.8 (14)	69.2 (18)	30.8 (8)	34.6 (9)	42.3 (11)	23.1 (6)	(26)
Attitude towards an involvement of outsider's expertise in the process of determination of harvest control within the context of *sasi* practice (e.g, those of research institutions, NGOs, etc).	52.6 (10)	47.4 (9)	63.2 (12)	36.9 (7)	26.3 (5)	42.1 (8)	31.6 (6)	(19)
Willingnes to participate in planning process to construct a better sasi arrangement.	66.7 (6)	33.3 (3)	55. 6 (5)	44.4 (4)	44.5 (4)	22.2 (2)	33.3 (3)	(9)
Attitude towards a majority decision that is not in accordance with individual's view.	66.7 (12)	33.3 (6)	50.0 (9)	50.0 (9)	55.5 (5)	27.8 (5)	16.7 (3)	(18)
Willingness to participate in training program to create job opportunities.	54.5 (6)	45.5 (5)	63.6 (7)	36.4 (4)	45.5 (5)	27.3 (3)	27.3 (3)	(11)

Note: low income = having minimum housing and furnishings (see Table 6.10)
low education = completed a primary school or a lower grade
the existing castes, from the lowest to the highest are *iri, ren, and mel, respectively*

Carlos and Pomeroy (1996) show from their case studies in the Philippines that the exclusion of important stakeholders such as fish traders was a major factor causing the failure of co-management practices in several project locations. Thus, we also collected comments from outsiders designed to elicit their views on their willingness and capability of being involved in the management design project. These outsiders include institutions that could provide assistance for the project, and local traders that, either directly or indirectly, would be impacted by it.

This information is summarized in Table 6.3. This table indicates that financial issues are a significant constraint. Only the government has the ability to provide a source of funding which could cover the necessary management expenses. In fact, a source of funding to minimize the impact of short-run costs associated with implementation of the project must be provided. For example, in the first stage of the implementation of the new management scheme, such funding might be used to increase the productivity of other potential alternative employment sectors. Fishermen could be provided with funds to expand their markets through the development of processing facilities which are needed to prolong the shelf life of their fish products. Similarly, farmers might be given practical training on processing techniques for their traditional commodities. They might be trained to process the abundant coconut product for cooking oil or brown sugar. Then, in the future, when people have learned about the benefits of better management, this financial assistance might either be used to encourage the pursuit of an even better means of resource utilization or be passed on to other, more efficient uses.

Currently, the most visible source of government funding is that of the *Inpres Desa Tertinggal* (IDT), or the Underdeveloped Village Assistance Program. In 1991, the central government initiated the IDT program by allocating as much as Rp 20 millions a year to each "underdeveloped village", including many villages in the Maluku Province. Unfortunately, while it is expected that this assistance will be used to promote the economic productivity of the villages, local authorities often do not have good plans for the use of the money. As a result, the long-run success of this subsidy program appears to be in doubt. Therefore, coordinating the IDT project with the co-management project is a good proposition. In fact, discussions with village heads and a sub-district IDT project supervisor revealed that this proposition is quite viable.

Tabel 6.3. Type of contribution available at local institutions

TYPE OF INVOLVEMENT	INSTITUTION			REMARKS
	NGO	Government	Local entrepreneur	
Scientific information	√	√		• Appreciation shown by village communities for scientific information provided by a government research institution such as LIPI is an indication of good prospect for a similar interaction in the future. • Activities performed by ARMAN, an NGO involved in the dissemination of agricultural technologies suggests a possibility of similar activities on other commodities including trochus.
Financial assistance		√		• The frequently mismanaged government financial aid such as IDT might fit the framework of a natural resource mgmt. scheme such as the proposed sasi-based co-management.
Legal aid	√			• Some NGOs indicated their availability for legal consultation.
Training arrangement	√	√		• Some NGOs have experience in training arrangements.
Mutual partnership			√	• Local entrepreneurs expressed interest in establishing a business partnership.

6.2. Contextual variables influencing implementation

6.2.1. Supra-community level contextual variables

Enabling legislation

As discussed in Chapter 2, reports such as those of Jentoft (1989) and Felt (1990), emphasize the importance of delegating responsibility and authority to local people to implement and enforce the regulations necessary to promote a workable co-management scheme. A high assurance among the people about the outcomes of whatever action they take will establish the incentive necessary for the people to participate in the management scheme.

If the co-management program proposed in this study is to be implemented, the most essential prerequisite is legal recognition for a *sasi* or *sasi*-like arrangement. Based on observations of arrangements normally employed to promote a *sasi*, it can be argued that this traditional system incorporates almost all of the requirements for successful co-management. For example, Pomeroy (1996) states that the set of requirements for a viable co-management proposal should include the possibility of people participation in the formation of user groups, a clear definition of user access rights, and a practical way of setting up boundaries. These are all well-articulated within this system. Therefore, legal recognition of *sasi* arrangements is all that is necessary to make the proposed system credible. Having said this, the question remains as to whether or not this legal recognition will actually be forthcoming.

Titahelu (1996) discusses the possibility of developing legislation to formally recognize *sasi*. Mainly concerned about the recognition of the existence of customary communities and their traditional regulations, he refers to Point 2 of the official interpretation of Article 18 of the nation's constitution as a reference for the legal means which could empower the existence of a customary arrangement such as *sasi*. Titahelu (1996, p. 13) states:

"Within the territory of the State of Indonesia, there are about 250 *Zelfbesturende landschappen* and *Volksgemeenschappen*, such as *desa* in Java and Bali, *negeri* in Minangkabau, *dusun* and *marga* in Palembang, and so forth. These territorial units have unique structures, therefore they can be considered as special territories.
The State of the Republic of Indonesia acknowledges the existence of these special territories; all state rules applied to these special territories will take into account all of their traditional rights".

Titahelu concludes that the imposition of a customary system at a specific location within Indonesian territory is possible. However, there is no specific law under which the above principles can be implemented. A law that is close to the necessary legislation referred to above is Law no. 5/1960 regarding agrarian affairs. The problem with this law is a statement within it which states that a customary law is acknowledged only as long as it still exists and it does not contradict the existing rules of law. Therefore, it is urgent to formulate additional legal wording that firmly establishes the legality of customary laws.

This issue has drawn much attention from concerned local groups, such as the province's decision-making officials, and a number of non-government organizations. Feeny (1994) suggests that formal recognition is necessary to prevent incursion on long-standing communal property rights, of which *sasi* is one. Following from this, local interest groups have developed an initiative to promote a regional-level regulation, known as *perda,* which establishes a stronger legal basis for *sasi*. Thus far, it is uncertain whether such initiatives will eventually be made effective. The provincial government is indecisive about whether or not to delegate rights to villagers because of skepticism over the capacity of village communities to safely exploit their resources. However a co-management framework where scientific data are incorporated into management might convince the government about the safety of delegating part of the management function to villagers. In general, this discussion suggests that there may be an opportunity to develop legislation that provides for the assignment of greater power to villagers to enforce and implement their own regulations.

Supra-community institutions

Polnac (1994) indicates the importance of non-community institutions in a co-management project. These outsiders, as Racelis (1994) describes them, will function in a co-management scheme as partners for the villagers. These external groups or individuals are those that have specific capabilities that villagers lack, and who can contribute financial, scientific, or other types of assistance to the management scheme. Partnerships and other forms of assistance are important because despite awareness of the existence of problems, villagers are often unsure about necessary actions to take because, as suggested by Pomeroy (1994), they do not have adequate knowledge about the underlying causes of the difficulties they face.

Several institutions have established linkages with villages in sasi- or trochus-associated matters. Key institutions among these are the Office of the Sub-district Government, the District Fisheries Services Office, the Office of Forest Protection and Natural Conservation, the Sub-district Police Department, several NGOs, and various research institutions.

- The sub-district government office or *kecamatan* is responsible for the development of villages within its territorial domain. Given this responsibility, the sub-district office in Kei Besar has an interest in maintaining the production of trochus, which has significant economic impact on many villages. To maintain production, the sub-district office exercises control over trochus harvests by villages. This control is in the form of a regulation that requires all of villages to obtain a permit (*surat camat*) prior to a season opening. This is supposed to be a mechanism to ensure that the harvest is done in accordance with the sub-district policy, e.g., that the level of revenue generated from this particular commodity can be maintained.
- The Maluku Tenggara District Office for Fisheries Services (*Dinas Perikanan Tk. II*) is an institution responsible for the development of fisheries in all sub-districts in Southeast Maluku. The relevance of this office to trochus *sasi* comes from the issuance of permits to entrepreneurs for the collection and the transportation of all fisheries products from all places within the district.
- The PHPA is a subsidiary office of the Department of Forestry whose mandate is forest protection and natural conservation. There is one office of PHPA for each district, including one in Southeast Maluku. In connection with trochus *sasi*, this is an influential institution because it employs enforcement officers[48] who are responsible for preventing illegal harvests and illegal trading of protected commodities.
- The Sub-district's Police Department is an institution that is present at all *sasi* related events. Its presence is meant primarily to ensure that no civil disruption will occur at

[48]Two enforcers are responsible for monitoring SE Maluku seaports. As discussed in Chapter 4, this number is insufficient

the harvest time.

- Most NGOs present in Maluku Province seem to focus on activities that are aimed at the empowerment of village people. Some NGOs have a regional/provincial scope of operation, while some others focus on a particular village. The significance of NGOs in the village's resource management is associated primarily with their role in villagers' informal education.
- For Maluku Province, research institutions that are linked with village natural resource management are LIPI (the Indonesian Institute of Science), BPTP (Assessment Institute for Agricultural Technology), and Pattimura University. These institutions are relevant in the sense that they have the capability of providing policy makers and villagers with scientific information.

One problem pertaining to the management roles of these institutions is the lack of coordination amongst them. The overlapping roles of PHPA and the Fisheries Service is a good illustration. As mentioned above, the Fisheries Office issues permits to entrepreneurs for collecting and transporting all fisheries products from all places within the district. This role, however, overlaps with that of PHPA, which is responsible for the prevention of illegal trading through regular checks to important seaports. Although PHPA regulations are supposed to over-ride the authority of the fisheries office, permits to trade fisheries products are still issued by them. Positive contributions of these institutions are possible only if this kind of problem is resolved.

Recent actions by these institutions provide hope for their involvement in a co-management framework. For example, links with villages have been established by research institutions through the collection and dissemination of scientific information on them. Moreover, NGOs maintain contact with communities through counseling and instructional activities aimed mainly at community empowerment. In carrying out their mission, some NGOs even maintain a presence in the community by recruiting villagers to be their representatives and or local organizers. In other cases, NGOs are established by members of communities themselves. However, it is clear that there is a need to synchronize all of this potential capacity in order to achieve the best management outcome.

Supra-community markets

Ostrom (1994) warns that pressures which come from outside communities can seriously threaten the sustainability of a co-management scheme. She refers especially to external factors such as changes in technology, population growth, the availability of factors of production, and heterogeneity of the participants.

In the case of Malukuan trochus fishery, the force of the international market has the potential to affect the level of exploitation of the resource because the world's supply of this unique product is limited. France, Italy, United Kingdom, United States, and Japan are the major consumers of this product; and they maintain a high demand for trochus to supply the needs of their fashion industries. As reported in ICECON (1997), demand for trochus shells is inelastic, and the market influence of substitutes is insignificant. Logically, then, a small disruption in supply from one production center should cause a significant increase in price in another location. However, the price of Indonesian trochus is not affected very much by increases in production by competitors because of the high quality of its shells. In fact, the Indonesian trochus, known as Macassar shells, is considered to be the reference point for world trochus prices.

Even though international demand is theoretically most influential in creating pressure on the resources, the current regional marketing structure seems to need special attention. There are indications that economic dependency of some villages on outsiders' assistance, results in an indirect impact on the demand of the resource. As mentioned above, the obligation of villagers to pay back loans often encourages them to extract resources which must be directly sold to the lenders. Pomeroy *et al* (1996), cite a similar case in the Philippines where market pressures from external sources significantly influenced local resource exploitation.

6.2.2. Community level contextual variables

The perception of resource depletion

During a series of interviews with key informants, it was revealed that there is a perception amongst them that the stocks of trochus and other marine species are being depleted. The stocks' condition is rated by them as ranging from bad to moderate. The respondents, referring to changes in the current trochus harvests as compared to those of the past, stated that in most villages less trochus are being harvested now. For example, in Ohoirenan, recent average harvests have been only about one half of the average harvest of fifteen to twenty years ago. Other informants mentioned the bad conditions of trochus stocks in Banda Effaruan and Weduar. Even though a number of these sources indicated that good harvests had occurred in some years, most of them agreed in describing such events as an anomaly. The general presumption of the informants was that stock depletion is due to the concurrent impacts of environmental change and poor management.

The result of declining stocks is that incentive for better management is growing in the communities. Pinkerton (1989) notes that a crisis in resource depletion perceived by local leaders can elevate the incentive to consider better management. My research clearly substantiates her conclusion. Awareness of resource depletion amongst village leaders in Maluku has created a willingness to accept the need for a better management system to protect resource stocks (see Table 6.1).

Environmental features influencing boundary definitions

It is stated in the literature that fishers' knowledge of boundaries is another essential factor for successful co-management. For example, Ostrom (1994) states that such knowledge can reduce community fear of having another party take part or all of the expected benefits from a managed resource. The validity of this proposition is supported by empirical evidence from studies in several locations; e.g., Khan and Apu (1998) for the Bangladeshi case, and Baticados and Agbayani (1988) and Katon *et al* (1997) for the Philippines case.

Defining the boundaries for a trochus co-management project in most villages in Maluku Province is not very difficult. In Kei Besar, as well as in many other parts of Maluku, villagers are familiar with the customary way of defining territorial boundaries based on natural objects such as big rocks, estuaries, tips of capes, etc. People in Maluku are familiar with the term *petuanan*[49], and this idea could be conveniently adopted by planners of local co-management systems. In my field-work, it was observed that people

[49] *Petuanan* refers to sovereignty of a village over a piece of land or sea

of neighboring villages had no difficulty in pointing to the demarcation locus separating their villages.

When there is a territorial dispute associated with boundaries, there are customary ways of trying to reach a settlement. Legal settlement is required only when the customary resolution does not work. An example of the resolution of a long lasting dispute between two neighboring villages is that of Weduar and Ohoirenen. In 1937, after a customary meeting involving elders and other prominent members of these two villages, it was decided that the Weduar villagers would get the rights to the disputed piece of land in return for them providing water supply for Ohoirenen village (Anonymous, 1993). This was a win-win settlement for both villages. On the other hand, a court settlement was necessary to settle a dispute between Weduar and Tutrean because a customary settlement did not work in that case (Somnaikubun, pers. com.).

Technologies used in Kei Besar coastal areas

Feeny (1994) asserts that the kinds of production technologies available may determine the type of arrangement for natural resource management. A properly selected type of technology might be essential to good resource management. However, as Pinkerton (1994) has warned, improper adoption of technology might cause a local disaster. Similar views were presented in reports by Akimichi (1984), Miller (1989), Matsuda and Kaneda (1984), and Ohtsuka and Kuchikura (1984).

In Kei Besar, I found that the use of sophisticated fishing equipment, such as engine-powered boats, is uncommon. Thus, the exploitation of resources in the coastal areas is limited to inshore waters. Engine-powered boats are used only in a few villages, such as Banda Eli and Banda Effaruan. Instead, the villagers' common fishing techniques are mostly in the form of simple devices, such as hooks, beach-nets, fishing spears, and various types of traps. Generally, these devices are made of local materials and most importantly, are immobile. For trochus, the only type of device used by villagers as a diving aid is hand-made wooden goggles. Effective, modern devices such as air tanks are strictly prohibited.

Prohibition of the use of air tanks in trochus management is in fact in accordance with management goals of trochus management for the following reason: Given that there is no shortage in local labor supply, removal of this restriction might result in two negative outcomes. First, the nil cost of harvest assumed the simulation model would no longer be valid; and secondly, the increase in costs associated with the use of the equipment would reduce net benefits. The use of this equipment by one individual would motivate others to do the same because the marginal benefit of such action would initially be positive. An individual that dives with an air tank would be able to locate an abundance of trochus ahead of the others. However, this initial additional gain would eventually disappear as more and more individuals would be forced to do the same in order to remain competitive. Therefore, at some point, the overall benefit of using such equipment would turn negative. A shorter overall harvest time associated with the introduction of air tanks arguably can be considered as a benefit. However, considering that the opportunity cost of labor is so low in the villagers, a reduction in harvesting time generates little positive impact on net benefits.

Spear fishing is another common fishing gear in the study area and which has been prohibited in most *sasied* trochus area. The use of spear gives spear divers a comparative advantage over others in the harvest opening. Even though in some cases a 'fair' individual premium such as that accounted for in differential of skills amongst divers might be acceptable, excessive gains attributed to prior knowledge, such as that corresponding to spear fishing activities should not be tolerated. Maintaining a management strategy that promotes a fair distribution of rents among villagers is important. In addition, prohibition on spear fishing also represents a good strategy to counteract temptation for illegal trochus gathering. As discussed in Chapter 4, past experience shows that many poaching incidents were often the result of activities that involved diving, such as spear fishing.

In line with the management system being developed in this study, it is worth noting that even though modern techniques are not common, one traditional fishing method may be at least as destructive as more modern techniques. This traditional method involves the use of a poison called *bori*[50], which is made from a plant that grows in the villages. Although *bori* is used to catch fish and not purposively to kill trochus, its effect on the juveniles of all living organisms can be very significant, and therefore detrimental to trochus management. Usually, the use of *bori* in a village is easily detected by neighboring residents. From a follow up survey that I conducted to collect further information, I found the following: Of 28 respondents, 64 % acknowledged that they had spotted others using the poison at least once. However, these respondents were unwilling to provide any information regarding the frequency in which they encountered such an incident. In most cases, they explained that villagers break the rule only in emergency

[50] When spreads over water, *bori* will kill almost all fish, including juveniles

situations. Other information, however, contradicts these statements because not all violators belong to the lower economic stratum of the community. A number of respondents indicated that they were unwilling to report violations by members of their families. This indicates that the strong kinship links between these villagers has made it unreasonable to expect violations to be reported.

Level of community development

Based on site observations and published statistics on public facilities, Kei Besar communities can be described as still being at a primitive state of development. As an illustration, Table 6.4, shows the availability of village public facilities in the sub-district's communities. Most of them lack electrical service, sewage treatment facilities, and appropriate health care. This lack of facilities is serious because it might significantly constrain some strategic aspects of the proposed project, such as diversification of economic activities. Communications and transportation, two important factors essential for support of the project, are severely lacking. Despite the apparent availability of schools as shown in Table 6.4, the actual condition of education in villages is poor. For example, materials necessary to operate the school system are in short supply. Textbooks that are supposedly used by students are in limited supply. Consequently, villages generally lack skilled human resources.

In general, these conditions result in a local environment which will attract few outsiders. Thus, development of alternative economic activities might be constrained. Furthermore, distributing population pressure over more diverse types of resource uses will become less possible.

Table 6.4. Public facilities in Sub-district of Kei Besar

Facilities	Availability
Hospital	One hospital is available for 44 villages (around 40,000 people)
Health Center	6 Health Centers (*Puskesmas*) and 11small clinics (*Puskesmas Pembantu*) serving 40,000 people
Doctor	3 doctors for the whole sub-district
Dentist	Not available
Secondary School	14 schools for 44 villages
Primary School	48 schools for 44 villages
Public Water Supply Piped to Homes	Available only in the sub district' capital, *Elat*
Sewage Pipes or canal	Not available
Sewage Treatment Facility	Not available
Septic or Settling Tanks	Household-sized septic tanks are available only at homes of about 4 % of the highest income group
Electric Service	Most villages do not have an electric supply
Telephone Service	Available only in the sub-district capital
Food market	In most villages, a food market is not available
Drug store	Available only in the sub-district capital
Hotel or Inn	10 rooms available only in the sub-district capital
Transportation	12 inboards, 31 outboards

Source: Kei Besar Statistics, 1994

Degree of socioeconomic and cultural homogeneity

Ostrom (1994) states that a homogeneous community will likely act together in dealing with collective problems. One main reason for this is that a homogeneous group can more easily establish a common understanding of a problem and agree on alternative strategies. Therefore, consensus on many issues is more likely in homogeneous communities.

In Kei Besar, despite religious differences, there are extensive family linkages that constitute a very important factor in creating a sort of homogeneity. Most of the Kei Besar villages are either Christian or Moslem. Of 44 villages in Kei Besar, 22 have more than 90% of their people in one religion or the other, 9 other villages with 70% to 90%.

There are only 11 villages where two or more religions are represented equally. However, in almost all of these villages religious difference may be neutralized by kin relationships. Other important sources of heterogeneity are related to castes, education, and income gaps. These three factors certainly need special attention. For example *mel* caste groups hold the administrative power in the villages, and consequently, they get a higher share of the benefits derived from the natural resource. Thus, they will likely have a greater incentive than others to manage the resource. And, there might be a difference in the way the *mels* and the other groups view a management problem. Racial factors are mostly insignificant except in the villages surrounding the sub-district capital where different ethnic groups, such as Buginese, Javanese and Chinese, are present.

An observable cultural feature in Kei Besar communities which may impact management programs is the excessive pride commonly characterizing the people behaviour. One practical example of this characteristic is a pride in their home villages, often manifested in various sorts of extreme rivalry with neighboring communities. In practice, their pride could have both constructive and destructive outcomes. A brisk competition between neighboring villages in developing a particular infrastructure, e.g., paved roads or religious facilities, is an observable case illustration of a constructive rivalry. On the other hand, rivalry often turns out to be very destructive. In some cases there may even be physical conflict between villages which claim lives or cause material damage such as destroyed houses or village infrastructures. A recent example occurred in a dispute between Upper and Lower Hollath, which was stimulated by villagers reopening a once settled dispute. A respected elder interviewed indicated that in the end it was village pride that was the cause of the renewed conflict.

An implication of local pride among villagers is that these people are usually picky about types of occupations they are prepared to engage in. People tend to avoid taking job opportunities considered by them to be indecent or less-respectable. For this reason, many people opt not to sell production surpluses of several agricultural products despite having the opportunity to do so. Our survey revealed that 74% of the respondents interviewed stated that they are unwilling to take certain job opportunities, because they lack status.

Tradition of cooperation and collective action

A tradition of cooperation and collective action existing in a village may be a positive contributor to the success of a co-management program. Jentoft (1989), Pinkerton (1989), Doulman (1993), White, *et al* (1994) are among those that have observed the importance of this factor. This is not surprising because the core of a co-management scheme is cooperation among actors and stakeholders. Quite intuitively, a community with a strong tradition of cooperation and collective action will likely find it easy to join into a cooperative arrangement.

As noted in Chapter 4, the most commonly recognizable village organizations in Kei Besar, and many other parts of Maluku, are those associated with churches. The activities of these church organizations are normally related to religious affairs. In some cases, church organizations also deal with more general social affairs, such as providing training aimed at improvement of village human resources, or other types of efforts to empower villagers in general. Practical subjects such as leadership or agricultural skills may be taught within such training activities.

In many villages, effective collective action does not have to be initiated by a formal organization such as the church groups. A collective action might start from within an informal grouping of residents, such as that of a *marga* (clan) or a *soa* (group of several clans) through their tradition of mutual help. The word *maren* is a popular local colloquialism, literally meaning 'work together' or 'mutual help' or 'share work'. Within this tradition, once they have been notified, and subject to availability and capability, all villagers should leave their routine activities and respond to the call. Projects usually carried out through *maren* are various civic works such as improvement, renovation, or rehabilitation of public facilities such as roads, bridges, churches, mosques, school buildings, or even homes of fellow villagers. The signal for a mobilization in *maren* is first given by a high ranking person in the village to family group headmen, *kepala marga*, who pass it on to their respective members. At the time of my field-work, several civic projects involving *maren* were going on, including an ambitious project of constructing a two-level parish house (*pastori*) in Ohoirenan. In Wattlaar, regular *maren* is performed every Monday. Persons who, for some reason are unable to be present are responsible for providing food or drink to compensate for their absence.

Despite such potential for collective action, mobilizing people for a project or program is not always easy. Successful calls are usually those related to a religious function or anything that people think would have an immediate impact on their lives. Since an alternative management system will likely cause short-run economic dislocation, identifying a strategy to compensate for the short-run loss of income is extremely crucial.

Population and population changes

The population of Kei Besar is 39,845, distributed in its 44 villages.

Systematically-written annual records of population change are not normally available. However, sub-district officers provided an estimate of 2 % annual population growth. On the other hand, interviews with heads of villages, gave additional information that villages farther from the capital, which produce more trochus, have less dramatic population increases.

As mentioned earlier, Pinkerton (1989) states that rapid population changes are considered to be a potential threat to sustainability. Thus, these relatively modest population increase projections seem to be favorable to the development and sustainability of a co-management plan.

Degree of integration into national economy and political system

Doulman (1983) argues that links to the national economy and political system are important for supporting co-management scheme programs. But my research clearly establishes that Kei Besar communities are not adequately connected with national markets, transportation, communication, and political configurations. Table 6.4 provides general information on the condition of transportation and communication systems in Kei Besar. Villagers collect and transport their natural resource products to middlemen living in the capital of the sub-district, Elat. For trochus producing villages, which mostly are located in the island's east coast, such activities are dependent on outboard motor-driven boats that visit villages two to three times a week. It is only when there is an exceptionally good harvest that a village might send products to town more often than on the regular trips. Less than 20 % of these trochus producing villages are connected by land transportation to the sub-district capital. As a result during the east monsoon season when almost all sea transportation is stopped, these villages are completely isolated. The situation is made worse since the telephone communication system is available only at the sub-district capital. And, as in the case of other isolated locations, the villages have a limited link to the national political system. Villagers note that only at times preceding national general elections do politicians and government officials come to visit their villages.

Occupation structure, degree of dependence on and level of commercialization of coastal resource

Even though located on or near the coast, household fishing activities serve only a small part of the villagers daily needs. For the most part, people depend on the land resource products they produce using simple agricultural techniques. This point was emphasized by key informants who ranked agriculture as the most important of all occupations, while trochus came next. According to these informants, fishing is only important in a few villages. This information suggests that with the exception of these few villages, the people of Kei Besar are dependent more on the land than on the ocean.

Collecting trochus is not considered to be an occupation upon which villagers can rely for satisfying their daily needs. However, the incidental cash generated from it constitutes a significant contribution to the provision of non-food needs, such as educational services and maintenance of household and public facilities. As noted in the introductory chapter, these include financial support for the purchase of school book supplies, maintenance of school buildings, village generators, etc. Thus, trochus exploitation is an important source of disposal income and clearly needs a better common management scheme. According to Polnac (1984 and 1994), collective action will be more likely if people are engaged in and dependent upon a similar occupation. In Kei

Besar, despite the lower significance of trochus resource as compared to that of the land resources, the villagers' view of the resource as common property is a positive factor for a collective action.

Table 6.5. Distribution of occupations in trochus producing villages

Occupation	Percentage
Farmer	75
Fisher	10
Civil Servant/Soldier/Retired	5
Laborer	5
Merchant	5

Note: Statistics do not show the distribution of village occupations; the above table is an estimation provided by key informants in trochus producing villages for the type of occupation and percentage of participants for the Kei Besar area.

6.2.3. Individual and household level contextual variables

Differing individual characteristics or attributes are responsible for heterogeneity, and this is a factor that may affect a plan involving the participation of people. Johnson and Libecap (1982) and Karpoff (1987) note that heterogeneity is particularly relevant to the effectiveness of regulations. Feeny (1994) also lists several attributes that might affect the viability of a management scheme. These include education, experience, size and scope of operation, technology, cultural values, degree of lifetime commitment to the industry, and preferences over non-pecuniary aspects of their employment. Following Feeny (1994), the discussion below presents the results of my observations on the status of these attributes as they pertain to the people in Kei Besar. These comments are based on the 186 interviews conducted according to the procedure explained in Chapter 3.

Education and experience

Interview results indicate that the low levels of education in Kei Besar may be detrimental to the establishment of a co-management plan. As shown in Table 6.6, only 16% of the people there completed high school. In some cases, even village heads have only a primary school educational background. Some villagers have been able to complete university degrees, but practically all of these graduates go to other places to find better economic opportunities. One implication of this is that extra effort might be needed to communicate with these people when the time comes to explain something that is beyond their traditional knowledge.

Table 6.6. Educational achievement

Level	Achievement		Remarks
	(%)	#	
Primary school (SD)	50	93	
Junior high school (SLTP)	34	63	
High school (SLTA)	16	30	
College / universities (PT)	NS	0	several villagers completed a university degree but do not live in the village

Note: 5 % of respondents have experience in short-term (less than one month) training.

On the other hand, informal experience in terms of knowledge of their own villages and their natural environment might compensate to some degree for the lack of formal education. Most residents spend their whole lives in the same villages. The number of respondents (aged 21 to 54 years) that were born in a village different than the one in where they live is less than 1 %. Moreover, their mobility is very low; only 3% of them have ever left the village for more than one year.

Regarding work experience, Table 6.7 shows the distribution of people based on the length of time they have in both primary and secondary or past occupations. Sixteen percent of the respondents acknowledged having a second occupation, meaning that a number of people have had more experience than the others. A relevant point here is that even though fishing is not a primary occupation, people have good empirical knowledge of coastal matters. Women and children spend lots of time collecting cockles and mussels on the shore lines, while most men are occasional fishers.

Another relevant experience is participation in organizations. During the interviews, most respondents in Christian villages indicated experiences of active participation in organizing church-based programs. A portion of these respondents can be categorized as having had long-term experience in these programs. Ten percent of them were members of the church congregation executive board for one to five years, while four percent have served more than five years. However, in Moslem villages, organization experience is not as extensive as that in the Christian villages.

Table 6.7. Experience in different jobs

Years of experience	*Current job*	*other/past Job*
<5 years	26.8 % (48)	*5.9%* *(11)*
5-10 years	*45.2 %* *(84)*	*6.9%* *(13)*
>10 years	*29.0 %* *(54)*	*3.2%* *(6)*
Total	*100%* *(186)*	*16%* *(30)*

Job satisfaction

Job satisfaction also is important when considering the development of co-management systems. This term is used by Polnac and Poggie (1988) to mean the degree of lifetime commitment to an industry, and employee's preferences for non-pecuniary aspects of their employment. This factor is important because planning for co-management should anticipate possible difficulties associated with people having a high preference for a particular job. This is particularly relevant when considering developing an alternative economy, because a person who prefers a certain type of job will naturally be less interested in taking an alternative job opportunity offered by a management project. In the case of the Kei Besar trochus management, the significance of this factor is related to the possibility of economic diversification for generating revenue traditionally provided by trochus production.

Table 6.8 shows the percentage of satisfied respondents of different types of occupations. The table shows that most farmers and fishers, and about half of the laborers indicate preference for their current jobs. The reasons for this vary. Farmers enjoy working nearby their home/family while fishers and satisfied laborers enjoy the freedom associated with their occupations. On the other hand, about one half of laborers are not very happy with their occupation because it is considered to be a less respected type of work. Many civil servants are satisfied with their jobs because their occupation requires less physical effort. Most traders, while indicating a lack of satisfaction with their current jobs, are indifferent about other types of occupations. This result is not surprising because traders are inherently more likely to be risk takers, who may easily leave their present occupation to take another with a better profit opportunity.

Because most respondents favored agricultural employment and considering that the common reason for doing so was for them to be close to home, it may be argued that the majority of villagers prefers occupations which guarantee that they do not have to be away from their families. The implication of this is that development of alternative economic activities should be focused on the creation of jobs which do not require separation amongst family members. Pomeroy *et al* (1996) recommends that in such a case, developing supplemental, rather than alternative occupations is an appropriate strategy.

Table 6.8. Percentage of positive response on job satisfaction

TYPE OF JOB	PERCENTAGE OF RESPONDENTS SATISFIED WITH PRIMARY OCCUPATION
Farmers	76% (99/130)
Fishers	82% (18/22)
Traders	16.7% (1/6)
Laborers	46.2% (6/13)
Civil servants/retired	53.3% (8/15)

Ecological knowledge

Wilson *et al* (1994), White *et al* (1994), Ruddle (1994), Chambers (1983), and Johannes (1981) all argue that the incorporation of ecological knowledge in developing a co-management system is important. Moreover, Pinkerton (1989) states that one key aspect of this knowledge is perception about the status of the resource. She goes on to emphasize that perceptions as to the state of stocks is especially important. Table 6.9

reflects the perceptions Kei Besar villagers have about the condition of trochus stocks.

Table 6.9. Ecological knowledge

PERCEPTION ON THE CONDITION OF TROCHUS STOCKS	PERCENT OF RESPONSES
improved	0
significantly	0
moderately	
Unchanged	2.15% (4)
Deteriorated	
significantly	45.70% (85)
moderately	52.15% (97)

As mentioned earlier, the long-term contact of people with their village's environment provides them with empirical knowledge on many aspects of their resources. Most respondents concur that there has been some resource deterioration, although there is disagreement on its extent (see Table 6.9). This implies that awareness has grown among the people that something has gone wrong within their environment. The data in Table 6.1 indicates that most people seem to perceive this negative environmental change as a signal for them to find an improved management regime.

Income multiplicity and asset distribution

Although agriculture is the principle source of income for the majority of villagers, income multiplicity is common. A significant number of people are involved in secondary occupations. A large number of respondents (34 %) also claimed to be receiving remittances from relatives working outside of the villages. However, none of them receives a remittance exceeding the amount earned from their primary occupation. I was also informed that none of the remittances are received in the form of food or are normally allocated for the purchase of food.

More than two thirds of the population belongs to the low-income group. Obtaining information on total incomes from them was extremely difficult, so an approximation was made using information on the distribution of assets among the people. This is presented in Table 6.10.

Table 6.10. Assets distribution as a proxy for relative income

	Percentage
House structure	
• Low	76.88% (143/186)
• Medium	23.12% (43/186)
• High	0
House furnishing	
• Low	67.74% (126/186)
• Medium	32.26% (60/186)
• High	0
Non-subsistence productive equipment	4% (7/186)

Note :

1) House structure, low=bamboo walled and sago-leaf roofed; high=brick walled and aluminum roofed; medium=combination
2) Furnishings, low=multi-purpose type of furniture; medium=special purpose furniture; high=equipped with electric equipment

Differences in income may carry two different implications. In an empirical study in the Philippines (Pomeroy *et al*, 1996), it was found that in one case higher income increases the possibility of participation, while in another it does not. The explanation they presented for this was that higher participation in the first case was associated with wealthier people having more time for their community; while lower participation in the second case was caused by the decrease in incentive to participate in common projects as people become wealthier. The case which is more relevant to a particular location may depend on the range of the standard of living there. What is being argued here is that in a very low income range, participation is possible only if their income is increased. Where the standard of living is higher, people might find the opportunity cost of participating in a management project increases as they get wealthier.

For the range in the standard of living that Kei Besar has, the first of the two cases mentioned above applies. Thus, it is appropriate to anticipate that efforts to mobilize participation would likely be difficult in the lower income groups. This judgement is based on the results presented in Table 6.1 and 6.2. The negative responses to questions concerning possible participation are in part connected with differences in income, where more people of a lower economic strata responded negatively.

Summary and conclusion

In general, it can be concluded that most indicators presented here are supportive of co-management. All of the indicators, the conditions, and implications of the conditions of each indicator are summarized below.

Table 6.11. Indicators influencing the planning process:

Category	Condition	Implication
Participation of villagers	• Positive response is high but more lower-strata groups provide a more negative response.	• The level of difficulty in people mobilization is higher for the lower-strata groups.
Possibility of involvement of external parties	• Potential external participants are available but their actions/programs are often conflicting	• Need coordination

Table 6.12. Indicators influencing implementation: Supra-community contextual variables

Indicator	Condition	Implication
Enabling legislation	The constitution allows for the establishment of legislation required to empower a customary use right such as that of *sasi*; government seems unconvinced about capability of villagers to exploit safely within the *sasi* arrangement.	The establishment of legislation necessary to support a *sasi*-based co-management is possible.
Supra-community institution	Institutions show the potential for positive contribution, but their approaches have so far been uncoordinated.	Needs coordination to optimize their contribution to the management scheme.
Supra-community market	The international, rather than the domestic/regional market, is the more important determinant for the level of exploitation of trochus; the regional market structure however has the potential to increase pressure on the resource due to the dependency of villagers on local traders.	Dependency should receive special attention to minimize the risk of high pressure on the resource.

Table 6.13. Indicators influencing implementation: Community contextual variables

Indicator	Condition	Implication
a) Crisis in resource depletion as perceived by leaders	• The general perception of key informants about the resource stock is that depletion has been taking place. Stocks' condition is rated as bad to moderate.	• Incentive to find alternative scheme is greater.
b) Environmental feature influencing boundary definition	• In Kei Besar, as well as in many other parts of Maluku, villages have a practical way of defining boundaries of territory, i.e., based on natural marks such as big rocks, estuaries, tips of capes, etc. • Territorial disputes are settled by customary ways; court settlement is done when a customary settlement does not work.	• People will have certainty on the benefit associated with a co-management scheme.
c) Technologies used in relevant coastal areas.	• No sophisticated fishing equipment is used in coastal areas of Kei Besar; however, there is strong indication that a dangerous traditional fishing technique, *bori*, is not irrelevant.	• Assessments based on the model as discussed in Chapter 5 might be affected accordingly.
d) Level of community development.	• Community development is generally low.	• Negative effect associated with immigrating outsiders is low but diversification of resource exploitation is less likely.

e) Degree of socioeconomic and cultural homogeneity	• Based on the level of revenue generation and time allocation, most villagers are traditional farmers that go fishing sometimes for consumption purposes. • Except for a few villages, Kei Besar villages are either Protestant, Catholic, or Moslem villages, but almost all villagers in either case are linked by an extensive kin relationship; ethnic heterogeneity is insignificant. Of 44 villages in Kei Besar, 22 of them are with a more than 90 % religion majority, 9 villages with 70% to 90% majority, and only 11 villages where two or more religions are represented equally.	• Differences in education, income, and castes would be more significant.
f) Tradition of cooperation and collective action	• In most villages, active groups are associated with church organization. Government promoted cooperatives are unsuccessful. • Activities of those church groups are mostly social, mutual helps and in several cases, training on leadership. • Such activities have been going on for more than ten years in most villages.	• Strategies for people mobilization that neglect their existence might fail.
g) Population and population changes	• Population is relatively stable in remote areas, including trochus producing villages.	• Resource is less threatened in this sense.
h) Degree of integration into national economy and political system	• Links of market, transportation, communication, politics are low.	• Development in any sense is constrained

i) Occupation structure, degree of dependence on and level of commercialization of coastal resource.	• In most villages, fishing is a secondary and household type of livelihood; in many villages trochus harvest is a significant source of cash for non-food needs. • Traditional agriculture is the primary livelihood in most villages. • Key informants indicate that agriculture is the most important of all, while trochus comes next; fishery is only important in few villages; other occupations are insignificant. • Therefore, in general, villagers of Kei Besar are dependent more on land than on ocean • Trochus is not an occupation but is important to support non-food needs.	• Trochus co-management is relevant.

Table 6.14. Indicators influencing implementation: Household-level contextual variables

Category	Condition	Implication
a) Education and experience	Formal education achievement is low but traditional knowledge is dependable.	Information exchanges might not be flowing well for issues beyond villagers' traditional knowledge.
b) Job satisfaction	Majority of people prefer jobs within the village.	Supplementary jobs within village are more appropriate.
c) Ecological knowledge	Similar perception of the fact of depleting resource.	Greater motivation to develop a better management.
d) Income multiplicity and asset distribution	A higher proportion of lower-strata groups.	Add more complication in mobilization.

CHAPTER 7. CONCLUSION AND POLICY IMPLICATIONS

This chapter recaps the results of the research objectives, proposes policy implementation strategies, and presents the conclusion to the study.

7.1. Summary of the results of the research objectives

The result of simulation model discussed in Chapter 5 shows that restricted harvests can generate profits and promote sustainability in the trochus fishery in the study area. According to this model, a combination of harvest restrictions consisting of a one-year *sasi* period, two-year age of first capture, and 40-percent actual-to-potential harvest ratio, would result in an optimal harvest. The simulation results also suggest that these recommended levels of harvest restrictions are close to recent *sasi* arrangements. Moreover the sensitivity analysis, intended to look at the reliability of the simulation model, shows that the model is likely to result in similar predictions for locations surrounding the study area.

The local demographic conditions discussed in Chapter 6 show that despite a number of constraints, there is an opportunity for planners to establish *sasi*-based co-management to enforce the proposed harvest restrictions. In fact, the discussion in Chapter 4 shows that the development of a co-management framework might be in accord with several local cultural characteristics. These important characteristics include recognition of the interdependence of life and nature, belief in the supernatural powers which control nature, respect for the wisdom of traditional leaders, and kin relationships. Taking all factors identified through the study into consideration, we suggest the following strategies to implement the proposal in the field.

7.2. Policy implementation strategies

7.2.1. Selecting complementary harvest regulating techniques

The introduction of the set of harvest control mechanisms to realize the hypothesized optimal level of exploitation as shown in Chapter 5 will not be an entirely new experience for most trochus fisheries in Kei Besar. Most trochus harvesting communities are familiar with a variety of harvest restriction techniques, including restrictions on the types of gear, prohibition of spear fishing, limitation on *sasi* (closure) duration, limitation on the size of first capture, and limitation on the duration of season openings.

Therefore, expecting people to become accustomed to regulations will not be a major issue. The more relevant question is how to synchronize the mechanisms that already exist with the optimal scenario. Some existing techniques of harvest control fit quite well into the model, while others require some modification. If necessary, a mechanism that does not fit the model can be altered or omitted.

Air tanks

Prohibiting the use of air tanks in harvesting trochus is common in for all locations in Kei Besar, and the restriction should be maintained in the future to prevent to excessive capital inputs associated with the purchase of this equipment. The benefit in terms of reduction in harvest time brought forward by the use of such gear is insignificant because the opportunity cost of labor is almost zero in the villages (see Chapter 5). Therefore, the capital inputs will eventually override the expected benefits.

Spear fishing

The tradition of banning a popular non-trochus-fishing device, the *fishing spear*, is also worth maintaining. Spear fishing activities involve diving over trochus locations, thus allowing participants to gain advanced knowledge about trochus concentrations in the water. Thus prohibiting spear fishing is a good mechanism to support enforcement of the simulated harvest scenario.

Gillnetting

Gillnetting, is a widely used non-trochus fishing technology which should be continued. Permitting gillnet fishing in water adjacent to the villages is necessary because it is essential for the gathering of food fish, an indispensable source of protein for coastal villagers. Gillnet fisher movements on the water can be easily observed by others, implying there is little chance for these fishers to poach on trochus. There is still a possibility that gillnet fishers may spot trochus beds while fishing, but such occurrences would be limited to relatively shallow water where bed locations would likely be known to most villagers anyway.

Time and area closures

Time and area closures will be adopted automatically to the proposed management system. For *sasi*, these are the mechanisms that provide a general idea of what this traditional system is all about. Community people understand very well that by imposing area and time restrictions, the frequency of harvests can be adjusted to accommodate changes in natural production cycles designed to accomplish objectives such as a higher annual yields and stable stocks. Improvements in time and area closures can be made by incorporating the predictions of our simulation model for determining the right closure period, the length of season openings, and size of first capture.

Size of first capture

The restriction on the size of the first capture, which has become familiar to village people, can be used to implement the age limitation as recommended by the simulation model. In general, this regulation has two purposes; i.e., the assurance of the opportunities for trochus individuals to reach maturity, and for people to harvest the most economical size of trochus. The only improvement that is necessary is the method of measuring the size of harvested trochus individuals. Thus far, the most common measurement method is using the standard of three fingers, which often becomes the source of disagreement between buyers and sellers. A simple wooden gadget resembling an open-end wrench such as is used in Hollath Village, if generally applied would help to settle this problem.

Length of openings

Lama buka sasi is a common mechanism used to adjust the length of season openings. In the context of the management system proposed in this study, this mechanism may be adopted as an operational interpretation for actual-to-potential harvest rate limitations. This regulation implies that the duration of harvest be reduced so that an appropriate number of individuals are left unharvested. That is, by adjusting the duration of harvest opening, a desirable portion of harvest can be realized.

7.2.2. Considering a gradual implementation scheme

The practical application of the simulation model for this study area could be difficult given the conditions which exist in the field. Theoretically, the values indicated by the multiattribute analysis are associated with the optimum harvest arrangement. However whether or not the values are readily implementable is a different issue. At least two categories of problems need to be considered prior to their application: the presence of unaccounted for variable (the use of *bori*) and the limited options available for the development of alternative economic activities.

These conditions confirm the need for considering an interim, sub-optimal, management arrangement for the near term. This would allow people to find a means of reducing their dependence on trochus exploitation. It would also provide an opportunity for additional research to be conducted which might lead to an understanding of the suspected sources of disturbances in the model. Depending on the outcomes of such research, especially findings which explain how capacity or yield potential might become larger or smaller, adjustments will have to be applied to the simulation model.

An example of such an interim arrangement might be to allow villagers to harvest trochus at a rate which ignores the subjective scoring of the multiattribute analysis. That is, harvest controls would temporarily be aimed at assuring resource sustainability, and not established to achieve an optimum. This arrangement could result in social costs to some stakeholders in the short run. However, by letting villagers harvest and trade the trochus, the opportunity would be available for them to prepare for involvement in the proposed optimal management regime in the long run. Given the current situation, such an arrangement certainly is better than letting illegal harvests continue to take place.

7. 2.3. Mitigating problems of market imperfection

We have been able to show that producers being exploited by trochus buyers is another problem that demands attention. Local respondents argue that since trochus prices began to increase in 1960s, this problem has caused both the unfair distribution of benefits and a greater biological threat to the resource. We learned in Chapter 4 that traders often entrap villagers by offering them loans which reduce the freedom of action which might be taken regarding trochus resource use in the following harvest periods. We also found that producers suffer from a lack of knowledge on the art of marketing, and from a poor understanding of existing regulations.

What this adds up to is that the development of our proposed policy must start with an understanding that community people enter the market arena with practically no power, and that they have been vulnerable to unfair treatment by buyers. Therefore, it is clear that all of these problems need to be resolved if an optimal management solution is to become possible. Dealing with only one aspect of them will only result in an unstable solution. For example, an elegant regulation system would be worthless as long as the people remain powerless. Conversely, empowering people might turn out to be a threat to resource sustainability if the regulation system is poorly designed. Consequently, a strategy to deal with such a situation should contain two important elements: empowering the people and improving their legal security.

To empower the people, we propose that producers be encouraged to establish cooperation amongst themselves to reduce fragmentation which currently exists amongst them. This cooperation would improve their bargaining power, and hence provide them with a chance to survive in the market. One way to do this by establishing producers' cooperatives. To avoid failures that have happened to many cooperatives in the past, these producer cooperatives should embrace a bottom-up management system and establish partnering arrangements with entrepreneurs.

In addition to development of cooperatives, we also recommend the enactment of more transparent regulations, and encourage participation of more groups in the proposed co-management regime. The existence of regulations which are easily understood by producers will enable them to be fully aware of the existing rules of the game. Moreover, involving more participants in management is necessary to reduce the probability of collusion between buyers and enforcement agents.

7.2.4. Making the best of cultural advantages

We have argued that cultural factors are very important in carrying through management objectives. The question is how cultural values can be transformed into a practical language which is relevant to the development of the proposed management scenario. Admittedly, this subject is so complex that there is a possibility that we have missed several of the less obvious cultural factors. However, we have identified the most important cultural characteristics in Kei Besar. These are:

Kin relationship

Kin relationship is an important cultural component of people in Kei Besar. In fact, many problems start and end with this characteristics. We found that the kinship phenomenon can be either a positive or negative influence, and we were able to show how this cultural trait has played a role in providing solutions for various issues. Socialization of aspects in a management program may be carried out through channels within their kinship structure. And, since family-group headmen (*kepala marga*) are effective leaders for respective groups (*marga*) within such a kinship structure, the development of our management approach may take advantage of their leadership role.

Religion

Next to kinship, religion is the most important cultural element that controls the way of life, motivation, and actions of the people of Kei Besar. This suggests that the design of any management approach should take into consideration the religious values of the community. In most villages, people have strong faith and show great respect for their religious leaders. With respect to this, it may be relevant to revitalize an old concept (e.g., see Rahail, 1995) which stresses the importance of integrating three effective sources of power in villages; government, custom/tradition, and religion.

Local pride

Another important cultural component that needs to be taken into consideration is local pride. In general, the discussion of this variable suggests two things. First, that a management plan should take advantage of local pride by diverting its power toward constructive goals. This can be carried out by educating people to understand that there are actually links between resource sustainability and their village's reputation. Second, is that local pride must receive special attention in the efforts to develop alternative economic employement. One way to deal with this is to provide job opportunities with different packaging such that people do not have to lose status. This might be carried out by establishing kiosks for people who are willing to sell their production surplus, but cannot do so now because of the pride barrier.

7.2.5. Organizing participation in planning and implementation processes

We have learned from Chapter 6 that we must establish a good first impression amongst participats for our management proposal. An important step to deal with this is to determine which individuals, groups, or government institutions should be active in presenting the scenario to communities to convince people that the objectives of our management proposal would bring benefit to them. Unfortunately, planners do not usually have much freedom in assigning roles to institutions or organizations, because people in the region have demonstrated preference regarding those whose involvement is acceptable to them in resolving their internal matters. On the other hand, the involvement of government is necessary because of its unique properties; most importantly the support of educated and experienced human resources, and capital resources. In light of this, we would suggest that the government play less direct roles at this stage, to back-up active involvement of participants who are more accepted by communities.

To encourage participation, moral suasion and economic incentive may be applied simultaneously. In some villages where the leadership system functions well, there is evidence that motivating voluntary participation is possible. So, for villages showing this characteristic, public campaigns to rally support for a management project is a viable option. Village leaders could help encourage people to take a more positive attitude toward resolution of management problems. In other cases villagers may be more responsive to economic incentives, so the application of economic measures might fit the situation better. These measures, such as penalties or subsidies, can be expected to encourage people to accept changes in policy. In the case of trochus fishery in Kei Besar, allocating a portion of the *IDT* subsidy to promote economic diversification is an example of a positive incentive. The *IDT* contribution also might work to ensure the establishment of trochus-related value-added economic activities, such as a semi-finished product for the button industry.

7.2.6. Positioning the role of aquaculture in the proposed management framework

Aquaculture technology developed by biologists can play a positive role in trochus management efforts. Local researchers have developed technology that could help improve biological capacity. For example, in the last four years there have been separate research activities focused on attempts to enhance natural trochus stocks in Maluku through artificial restocking (see Chapter 4). The results so far are positive and show that this is possible. The results also show that there is a flexible range of options for the development of trochus management in the region.

However, these accomplishments in aquaculture technology research should not be interpreted as a justification for it to replace a properly managed natural system. As mentioned in Chapter 4, artificial reproduction systems usually produce individuals that have low resistance against external disturbances, such as diseases and natural ecosystem changes. Besides, aquaculture systems often are not cost effective.

Planners must decide whether to rely more on natural or on artificial restocking. For locations where trochus stocks are still in good condition they should be harvested at sustainable levels through natural regeneration. Artificial restocking should only be applied in places or at times where depletion has taken place and natural restocking is not maintaining appropriate stock abundance. Even in these cases, efforts should be made so that the engineered stock introduced will eventually function as a new natural stock, where a sustainability-based management system could once again be applicable.

7.3. Conclusion

The analysis on the *sasi*-based co-management framework proposed for the trochus fishery in the study area shows a good prospect for its implementation. The computer simulation model discussed in Chapter 5 indicates that, theoretically, there is an opportunity for this trochus fishery to move away from the government harvest banning regime to one which allows limited harvest. Discussions in Chapters 4 and Chapter 5, however, do not indicate whether implementing the result of the simulation model will be successful. On the other hand, Section 7.2 of this chapter presents conclusions which can enhance the probability of success in implementing this framework.

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Appendix 1. Assessment of the prospect op participation in co-management project

I. Participation of villagers

Respondents: Samples drawn from villagers

Technique: Ask the following questions to the same respondents used in Appendix 2.

1. What is your opinion regarding management plans to save trochus resource from depletion?
2. What is your opinion regarding outside participation in sasi management?
3. Would you be willing to participate in meeting to discuss trochus management?
4. If the majority decide something different from your opinion, would you still comply with it?
5. Would you be interested in training to enable you to generate more income in order to reduce pressure on trochus resources?

II. Participation of institutions

Sources /respondents: Officers or representatives of relevant institutions.

Technique: Discuss the possibility of participation in co-management for trochus resources.

Appendix 2. Assessment of the prospect of the implementation of co-management

I. Supra-community level variables

1. Enabling legislation

Sources / Respondents: Law experts, ministry of environment, village elders, NGOs

Technique: Discuss/consult with respondent, obtain written document (if any), to answer the following questions:

a. Does the legislation allow formation of user groups?
b. Does the legislation authorize user groups to define boundaries for their exclusive access?
c. Does it provide or allow for the development of mechanism guaranteeing security of tenure?
d. Does the legislation provide general guidelines within which user groups can devise and legally implement locally appropriate management rules?
e. Does the legislation provide for recognition and formalization of traditional or informal management system where they exist?
f. Does the legislation allow for group participation in the development and implementation of surveillance and enforcement functions?

Appendix 2 continued..

2. Supra-community institutions

Source / Respondents : Village elders and staff of relevant institutions

Technique: Consult / discuss with sources, and collect written document (if any) to obtain the following information:

a. The names of organizations or institutions outside community that influence coastal management or village fisheries.
b. The level of operation, e.g., national, regional, etc., of each institution.
c. The objectives of each institution.
d. The local level impact of each institution.
e. Whether the government officials are actively supportative of local organizations and institutional arrangement.

3. Supra-community markets

Sources / respondents: Village elders, traders and local fisheries officers

Technique: Consult / discuss with respondents and collect written document, to obtain information on trochus market destinations, harvest records, and changes in its demand (if any).

Appendix 2 continued..

II. Community level variables

1. Perceived crisis in resource depletion.

Sources / respondents: village elders, village office staff

Technique: Ask respondents whether trochus resource is:

a. in very good shape

b. in good shape

c. neither good nor bad

d. in bad shape

e. in very bad shape

2. Environmental features influencing boundary definitions.

Sources / respondents: village elders, village office staff

Technique: Ask respondents about how verbal descriptions of points of trochus management project area is established. And, ask them to describe difficulties in doing so.

3. Technologies used in relevant coastal area.

Sources / respondents: Village staff, farmers, fishermen, local businessmen

Technique: Ask respondent to describe technologies and techniques used in relevant coastal areas.

Appendix 2 continued..

4. Level of community development.

Sources / respondents: village staff, sub-district office staff, village/sub-district statistics

Technique: Obtain information on the following development indicators:

- hospital
- medical clinic
- resident doctor
- resident dentist
- secondary school
- primary school
- public water supply piped to homes
- sewer pipes of canal
- sewage treatment facility
- septic or settling tank
- electric service
- telephone service
- food market
- drugstore
- hotel or inn
- public transportation

Appendix 2 continued..

5. Degree of socio-economic and cultural homogeneity.

Sources / respondents: Staff of village and sub-district offices, village elders

Technique: Obtain information on grouping of villagers (ethnic, religion, caste).

6. Tradition of cooperation and collective action.

Target: village elders, village staff

Technique: Ask respondents to identify groups of cooperative or collective action which were active sometime during the past ten years and to describe actions undertaken by each group.

7. Population and population changes.

Sources / respondents: Village and sub-district offices

Technique: Obtain most recent census figures and figures from ten years.

Appendix 2 continued..

8. Degree of integration into national economy and political system.

Target: village staff, local traders

Technique: Based on information given by respondents, ask respondents to give scores on the following parameters:

a. Market

- no links = 0
- low links (some specialty products, e.g., dried shark-fin, are collected by a few buyers who occasionally visit the community) = 1
- medium level of links (limited amounts of fish are processed, e.g., iced, smoked, etc, and daily shipped by in small quantities, either by public transportation or small, privately owned trucks to nearby urban areas) = 2
- high level of links (most of the catch is processed in processing facilities and trucked, sea/air freighted to distant areas)=3.

b. Transportation

- no links=0
- low links (small boats linking adjacent islands) =1
- medium level of links (links with all areas in the same district) = 2
- high level of links (national transportation is available) = 3

Appendix 2 continued..

c. Communication

- none=0
- low (communication using a system less advanced than telephone) = 1
- medium links (few telephones are available) = 2
- high (sufficient number of telephones) = 3

d. Political

- none (no visits by provincial politicians) = 0
- low (visits less than once per year) = 1
- medium (visits at least once a year) = 2
- high (visits more than once a year) = 3

9. Occupational structure, degree of dependence on coastal resource

Sources / respondents: village staff.

Technique: obtain information from respondents regarding

a. Participation in coastal dependent and non coastal dependent activities

b. Their view regarding the importance of each activities

c. Degree of people dependence on local resources.

Appendix 2 continued..

III. Individual / household level

1. Name of respondent:

2. Address :

3. Caste :

4. Date :

5. Education

a. Formal education

0 = none

1 = primary school (SD)

2 = junior high school (SLTP)

3 = high school (SLTA)

4 = college or above

b. Non-formal education (short-term training)

0 = none

1 = attended training(s) for .... months

Appendix 2 continued..

6. Job Experience:

a. Primary occupation

1 = farmer

2 = fisher

3 = trader

4 = laborer

5 = civil servant/retired

Number of years engaged in this occupation: ....

b. Other occupation (current or past)

1 = less than one years

2 = one to five years

3 = more than five years

7. Experience in organization

0 = none

1 = yes, what is it ....

If yes, how long................

8. What is your age?..............

9. a. Were you born in this village? ....

b. If not, how long have you been a resident of this village?............

c. Have you ever lived in another village for more than one year?..........

Appendix 2 continued..

10. Job satisfaction

a. If you had your life to live over, and you could make the same income in an occupation other than your current primary occupation, would you change your job?

b. What do you like your current primary occupation?............

11.Ecological knowledge

a. Is the amount of trochus better off, worse off, or about the same as it has been over the past ten years?........................

b. If worse/better off, is it a little worse/better off, just worse/better off, or a lot worse/better off and why?...................

12. Occupational multiplicity

a. income

- Does your household receive money from anyone living outside the household (e.g., in the city, abroad)?............................
- Are these remittances greater than half of your total income?

b. sources of food

- Does your household receive food from anyone living outside the household (e.g., in the city, abroad)?...............
- Is this food subsidy greater than half of your total food consumption?..........

Appendix 2 continued..

13. Assets

a. Ownership of productive equipment (boat, pond, cages, as appropriate); owner or co-owner.

0 = none

1 = available

b. House structure

0 = minimal, bamboo walled

1 = medium, combination and bamboo walled

2 = high, concrete walled

c. Furnishing:

0 = minimal, multifunctioned furniture

1 = medium, single purposed furniture

2 = high, equipped with electric equipment

14. Size and scope of operation

0 = non-motor boat or less-than-one-hectare land or laborer.

1 = motor boat; or at-least-one-hectare land; or leading a business operation.

Appendix 3. Stakeholders' prioritization of trochus management objectives

Statement:

Management of trochus resources in your village may have many objectives, which in general fall into three categories:

- Economic objectives, e.g., maximize net benefits from the harvest of the resource.
- Conservation objectives, e.g., maintain its sustainability in the name of the right of the species to live.
- Social objectives, e.g., maintain the perpetuity of the feast associated with season openings.

Question:

Using a one-to-ten scaling Please give scores to these objectives. The objective which is more important should be given a higher score.

Appendix 3 continued..

Score provided by respondents and weight equivalent on three management objectives

Respondent	Score Provided			Weight Equivalent		
	Econ.	Bio.	Soc.	Econ.	Bio.	Soc
1. VH 1	6	7	9	0.2728	0.3182	0.4090
2. VH 2	6	7	8	0.2857	0.3333	0.3809
3. VH 3	4	6	6	0.2500	0.3750	0.3750
4. VH 4	4	5	5	0.2857	0.3571	0.3572
5. VH 5	4	6	7	0.2353	0.3529	0.4118
6. VH 6	7	8	10	0.2800	0.3200	0.4000
7. VH 7	5	6	7	0.2778	0.3333	0.3889
8. VH 8	4	6	6	0.2500	0.3750	0.3750
9. PF	4	6	7	0.2353	0.3529	0.4118
10. DF 1	5	6	6	0.2941	0.3530	0.3529
11. DF 2	5	8	9	0.2272	0.3637	0.4091
12. ST 1	4	7	7	0.2222	0.3889	0.3889
13. ST 2	5	6	5	0.3125	0.3750	0.3125
14. LT 1	6	8	8	0.2726	0.3637	0.3637
15. LT 2	5	6	7	0.2778	0.3333	0.3889
16. LT 3	6	7	7	0.3000	0.3500	0.3500
17. PT 1	6	8	8	0.2728	0.3636	0.3636
18. PT 2	5	8	9	0.2272	0.3638	0.4090
19. PT 3	4	6	7	0.2353	0.3529	0.4118
20. NG 1	4	6	7	0.2353	0.3529	0.4118
21. NG 2	6	8	9	0.2609	0.3478	0.3913
22. NG 3	5	7	7	0.2632	0.3684	0.3684
23. CE 1	4	5	6	0.2667	0.3333	0.4000
24. CE 2	5	6	7	0.2778	0.3333	0.3889
25. CE 3	7	8	8	0.3043	0.3478	0.3479
26. CE 4	6	7	8	0.2857	0.3333	0.3810
27. CE 5	5	7	7	0.2632	0.3684	0.3684
28. CE 6	5	6	6	0.2941	0.3529	0.3529
29. CE 7	8	6	7	0.3810	0.2857	0.3333
Average				0.2705	0.3499	0.3796
Standard deviation				0.0328	0.0212	0.0263

Remark:

VH = Village head
PF = Provincial Fisheries Officer
DF = District Fisheries Officer
ST = Scientist
LT = Local (village) trader
PT = Provincial trader
NG = Non Government Organization
CE = Customary elder

Appendix 4. The Quick-basic program for the sasi model of trochus exploitation

The following algorithm was written to generate a concise example of the use of the model, which result is shown in Appendix 5. For this purpose, all values of variables and parameters are given. These include values of the assumed 4-year maximum age, the 2-year age-of-first-capture, the 2-year sasi periods, and the initial numbers of trochus individuals resulted from an 80%-harvest of a steady-state stock.

Based on such a simplified version, several algorithm variants were developed using the correct values of parameters and with additional iteration commands, which take account all relevant ranges of the examined variables, to carry out all analysis as discussed in Chapter 5.

```
CLS
    DEF fnround (v, p) = FIX(v * 10 ^ p + SGN(v) * .5) / 10 ^ p'
    fml = 3 * .5  '(annual spawning frequency x the #of female to total # of trochus of the same
ageclass)
    percent = .8
    a = 2
    th = 2
    m2 = .45
    m0min = .9994
    z = 4
    yieldmax = 15

OPEN "a:\newthes.txt" FOR OUTPUT AS #1
'WRITE #1, "year", "yield", "post-harvest stock", "pvnetben"
'PRINT "year", "yield", "post-harvest stock", "pvnetben"
WRITE #1, "year", "t", "age", "age", "n(age)", "harvest(age)", "wt", "dt ", "yield"
PRINT th, "year", "t", "age", "age", "n(age)", "harvest(age)", "wt ", "dt"; , "yield"

'CALCULATING THE STEADY STATE VALUES OF STOCK, JUVENILE PROD. RATE, AND POPULATION OF
AGECLASSES

FOR age = 0 TO z
    IF age > 0 THEN
    dt(age) = 123.16 * (1 - EXP(-.621 * (age)))
    wt(age) = .00124 * dt(age) ^ 2.6798
    END IF
    IF age >= a THEN factor = factor + wt(age) * (1 - m2) ^ (age - a) ELSE factor = factor + 0
NEXT age
```

Appendix 4 continued..

```
FOR age = 0 TO z
    nmax(age) = ((1 / (percent)) * yieldmax * 1000000 * (1 - m2) ^ (age - a) / factor)
    IF age > 0 THEN F(age) = 1394 * EXP(.05834 * dt(age)) ELSE F(age) = 0
    IF 0 < age < z THEN rmax = rmax + nmax(age) * F(age) * fml
    IF age < z THEN stockmax = stockmax + nmax(age) * wt(age) * .000001
    IF rmax > 0 THEN m0max = (1 - (nmax(1)) / rmax)
    nmax(0) = rmax
NEXT age

'CALCULATING INITIAL POPULATION AND STOCK
FOR age = 0 TO z
    IF age >= a THEN n(age) = (1 - percent) * nmax(age) ELSE n(age) = nmax(age)
    stock = stock + n(age) * wt(age) * .000001'convertion g to ton
NEXT age

'SIMULATING DYNAMICS DURING CLOSING
FOR year = th TO 24 STEP th
  FOR t = 1 TO th
      'at the beginning of t
      FOR age = 0 TO z
          r = r + F(age) * n(age) * fml
          m0 = (m0max * m0min) / (m0min + (m0max - m0min) * (m0min / (m0max + m0min)) ^ (3.95 * stock /
stockmax))
          IF age = 0 THEN m = m0 ELSE m = m2
          n(age) = n(age) * (1 - m)
          IF age > 0 THEN endn(age) = n(age - 1)
      NEXT age
      'at the end of t
       FOR age = 0 TO z
          IF age > 0 THEN n(age) = endn(age) ELSE n(age) = r
       NEXT age
       'calculating harvest
       FOR age = 0 TO z
          IF th = t AND age >= a THEN harvest(age) = percent * n(age) ELSE harvest(age) = 0
          IF harvest(age) / percent > nmax(age) THEN harvest(age) = percent * nmax(age)
          yield(age) = harvest(age) * wt(age) * .000001 'convertion g to ton
          cumyield = cumyield + yield(age)
          p = .45 + 5 * (1 - EXP(-.057088 * (21 + year)))
          i = .1
          pvnetben = pvnetben + (p * yield(age)) * ((1 + i) ^ -year)
       NEXT age
```

Appendix 4 continued..

```
'REINITIALIZING POPULATION AND STOCK AND # OF JUVENILES
    n(z) = 0
    stock = 0
    FOR age = 0 TO z
      IF n(age) > nmax(age) THEN n(age) = nmax(age)
      IF harvest(age) > 0 THEN n(age) = (1 - percent) * n(age)
      stock = stock + n(age) * wt(age) * .000001 'ELSE stock = stock 'convertion g to ton
      WRITE #1, year, t, age, age, fnround(n(age), 0), fnround(harvest(age), 0), wt(age), dt(age), fnround(yield(age), 3)
      PRINT year, t, age, age, fnround(n(age), 0), fnround(harvest(age), 0), wt(age), dt(age), fnround(yield(age), 3)
     NEXT age
     r = 0
    'IF t = th THEN WRITE #1, year, fnround(cumyield, 3), fnround(stock, 3), pvnetben
    'IF t = th THEN PRINT year, fnround(cumyield, 3), fnround(stock, 3), pvnetben

  NEXT t
  yield(age) = 0
  cumyield = 0

NEXT year
CLOSE #1
END
```