Segara Anakan Conservation and Development Project
Components B & C. Consultant's Report.

Segara Anakan Fisheries Management Plan

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Executive Summary

INTRODUCTION

It is the overall goal of fishery management in Segara Anakan to a) provide sustainable fish and shrimp catches in Segara Anakan, and b) provide sustainable catches of coastal shrimp and fish dependent on Segara Anakan.

Three serious issues face the Segara Anakan fishery: a) mangrove habitat destruction, b) disappearance of the Segara Anakan lagoon, and c) the continued growth of the villages in the area so that there are more houses, roads, tambaks, and people who compete for decreasing resources.

With decreasing natural resources and an increasing human population the amount of resource (fish and shrimp) available per person in Segara Anakan becomes less every year. However, government's ability to manage the Segara Anakan fishery and enforce fishery regulations is very limited. Therefore, government needs to assist villagers in setting up their own fishery management framework. The best management approach is to establish, or reinforce existing, community based fishery management structures.

Fishery management must emphasize the role of mangrove rehabilitation when arranging community based fishery management. One option for doing this would be to consider linking community fishing rights to mangrove rehabilitation requirements. Regardless of the approaches used, simple and straight-forward regulations developed by villagers must be the basis of any fishery management in Segara Anakan. The management program should use management ideas received from villagers, and must include a link to the coastal shrimp fishery.

COMPONENTS OF THE FISHERY

Several groups of organisms are caught by Segara Anakan fishermen. Interrelationships between the Segara Anakan fishery and the coastal fishery (e.g., the fisheries outside Segara Anakan) are also extremely important.

Shrimp Fisheries

Cilacap area shrimp fisheries consist of three components: large scale coastal shrimp fisheries, small scale coastal shrimp fisheries and small scale Segara Anakan shrimp fisheries. These fisheries capture nine major shrimp species plus a number of less important species.

The importance of Segara Anakan to the management of the coastal shrimp fishery is that some ocean shrimp species use the lagoon as a nursery area, and are also caught in the lagoon. The major component of the Segara Anakan shrimp catch is the small lagoon species *Metapenaeus elegans*, called udang jari, but lagoon fishermen also catch juvenile *Penaeus merguiensis* and *Penaeus indicus*, important ocean species which use the lagoon as a nursery area. These two species, caught in the ocean as adults, comprise about 40% of the value of the Cilacap shrimp catch. Some other species also use the lagoon as a nursery area, and these contribute an additional few percent to the ocean fishery.

The single most important issue specific to shrimp fisheries is the relationship between the Segara Anakan nursery area and the ocean shrimp fisheries. Because *P. merguiensis* and *P. indicus* are caught in Segara Anakan (primarily with apong - tidal bag nets) the lagoon fishery causes a decreased value in the ocean fishery. The value of Segara Anakan origin shrimp caught in the ocean far outweighs the value of these same shrimp if caught in the lagoon when they are still small. The importance of the lagoon as a nursery area for these species underlines the importance of fishery management in cooperation with both coastal fishermen and Segara Anakan fishermen.

Crab Fisheries

Management of Segara Anakan mangrove crabs of the genus *Scylla* is an essential component of the overall fishery management plan. Crabs are highly dependent on mangrove habitat and crab populations have declined in recent years. Management must be directed at protection of the mangrove habitat, protection of small crabs (under 10cm carapace width), and protection of female crabs, especially those ready to migrate to the ocean to spawn. Protection of large female crabs is a problem because these are particularly valuable to fishermen.

Crab management should focus on the establishment of a permit system, regulation of the size of crabs caught and protection of female crabs. Also, intensive cultivation (fattening) of small crabs captured from the wild will likely have a negative effect on the crab fishery.

Fish

Earlier reports about the Segara Anakan fishery have listed over 60 fish species from the catches. At present no particular species dominates the catch. Although a limitation on the number of fishermen will increase the fish catches of remaining fishermen, the management of fin-fish does not present serious management problems. Most coastal species found as juveniles in the lagoon are also found in the coastal area. At this time management of fin-fish in the lagoon is not considered a priority, but any decreases in gillnet mesh sizes should be discouraged.

Other

Several species of shell fish are havevested in Segara Anakan. Of these the brown clam know as totok (*Geloina* cf *erosa*) is the most common, although in the past two species of cockle (*Anadara*) were abundant. Changes in their abundance was probably due to changes in salinity. Totok are still reasonably abundant although villagers have noted some decline. No special management action is recommended at this time.

COMMUNITY BASED FISHERIES MANAGEMENT

A community based fishery management approach is recommended as a means of improving the management of the Segara Anakan fishery. For such an approach to be successful, the fishery must have clearly defined physical and biological boundaries. The biological boundaries of the Segara Anakan fishery must include ocean-caught lagoon shrimp. Thus, coastal shrimp fishermen must be a part of the management process.

A number of steps are recommended for the success of the community based approach including locally developed regulations, local enforcement, and formal, legal, recognition of this arrangement by various levels of government.

SUGGESTED MANAGEMENT ACTIONS

Establish, and obtain government approval, for a community based management framework like that outlined in this report.

Ensure that the management framework includes, officially recognized mechanisms for linking management of Segara Anakan with the relevant components of the ocean shrimp fishery, especially the return of some of the value of the ocean shrimp catch to Segara Anakan for habitat protection and management.

Through the community management framework, work to:

Establish a system of fishing permits.

Set priorities for fishing gear regulations.

Reduce numbers of apong as soon as possible (see options).

Seriously consider complete closure of the apong fishery.

Reduce crab fishing effort, and link fishing effort to mangrove forest area.

Establish enforcement protocol and sanctions for violations.

Establish a mangrove protection and rehabilitation program.

Ensure that civil works aspects of the Segara Anakan Conservation and Development Project designed to protect Segara Anakan are carried out as soon as possible.

FISHERY DEVELOPMENT OPTIONS

Better management of the Segara Anakan fishery will protect existing fisheries there and in the ocean shrimp fishery, but it must be recognized that no significant increases in the catches from Segara Anakan will be possible unless the current level of environmental degradation is reversed and, even if this is accomplished, any increase in catches in Segara Anakan will be very small. The primary value of Segara Anakan to fisheries is its value to the ocean shrimp fishery.

Development actions for fisheries should emphasize and support habitat protection (mangroves) and lagoon rehabilitation. Improved management and rehabilitation of the mangrove forest, as outlined in the Segara Anakan Mangrove Action Plan, is essential for better Segara Anakan fisheries. All actions which clear mangroves or limit mangrove areas must be avoided.

Serious consideration should be given to providing incentives to fishermen to fish outside Segara Anakan, but only if this results in a permanent decrease in the number of fishermen fishing in Segara Anakan.

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1. FISHERY MANAGEMENT GOALS AND GUIDING PRINCIPLES

1.1. OVERALL GOALS

It is the overall goal of fishery management to provide sustainable fish catches within the Segara Anakan Lagoon. Because of the strong ecological links between the lagoon and the coastal fishery, an equally important goal is to provide support for sustainable harvest of shrimp and fish catches in nearby coastal fisheries that are dependent on Segara Anakan as a nursery area. Thus, overall goals of management are:

- To provide sustainable fish and shrimp catches in Segara Anakan.
- To provide sustainable catches of coastal shrimp and fish dependent on Segara Anakan.

1.2. MANAGEMENT PRINCIPLES FOR SEGARA ANAKAN

1.2.1. Catches should be based on the ability of the natural system to support the fishery

1.2.1.1. Concept:

The size of the fish and shrimp catch is dependent on the amount of fish naturally available for harvest. Efforts to manage fishery harvests must be based on this natural ability of the habitat to produce fish and other aquatic resources. At present the amount of fish available for harvest in Segara Anakan is severely limited by past and current failures to protect natural habitat.

1.2.1.2. Issues:

One serious issue facing the Segara Anakan fishery is habitat destruction. At present rates of mangrove destruction, fisheries dependent on the mangroves will be gone in 5 to 10 years. No amount of management or new programs will change this fact: protection of the mangrove ecosystem is essential for protection of the Segara Anakan fishery. Thus fishery management must include mangrove management which protects and restores the ecological function of the mangrove system.

A second serious issue facing the Segara Anakan fishery is the disappearance of the Segara Anakan lagoon. This problem is being addressed by the Segara Anakan Conservation and Development Project. However, the dredging and river diversion activities under the project, as originally envisioned, provide only minimum protection for the lagoon. In the longer term a regularly scheduled dredging program will probably be necessary.

A third serious issue facing the Segara Anakan fishery is the continued development of the villages and infrastructure in the area so that there are more houses, roads, tambaks, and people. With decreasing resources and an increasing population the amount of resource (fish and shrimp) available per person is less. Also the increased human population accelerates habitat destruction.

No amount of management, community meetings, or other project inputs will change this fact. The Segara Anakan Conservation and Development Project is seriously flawed in this respect. While pretending to promote conservation, the project is actually accelerating the destruction of the very resources upon which the villagers depend. Other government policies are doing the same. If the natural resources are going to be protected for use by

future generations, then the government's policies which are destroying Segara Anakan (including village development policies within the SACDP project) must be changed.

Unless changes are made in other Segara Anakan policies, fishery management programs are of little use because their positive impact will be zero when balanced against negative impacts of over-development. It is a confusing fact that the Segara Anakan Conservation and Development Project has no component specifically assigned to develop forest and wildlife conservation in Segara Anakan. Perhaps there should be a project implementation unit (PIU) for conservation staffed by the forestry directorate for forest protection and nature conservation.

1.2.1.3. Needed Actions - Natural Ecosystem

Implement and continue activities which will protect, enhance and enlarge areas of mangrove forest.

Eliminate sedimentation in the lagoon via river diversions and dredging.

Add a conservation component to existing SACDP activities.

1.2.2. A community based co-management approach should be used

1.2.2.1. Concept:

Management of fisheries via community groups is the approach most likely to be successful. Consequently, a community based management approach is suggested. Community based management is consistent with Resolution VII.8 of the international convention on the protection of wetlands (the "Ramsar Convention") to which Indonesia is a signatory (see 1.2.2.3).

Extensive studies of common property resource management (e.g. Ostrom 1990) have indicated that under certain conditions a self-management approach can be successful. Ostrom's work emphasized studies of self-governing common property resources, where the users themselves carried out management. However, in Indonesia there has been a long involvement of government in village development and local resource management. Thus, in Indonesia, rather than self-management the approach should be co-management: a cooperation between village level management coupled with government advice. In Segara Anakan a co-management approach will be based mostly on the rights and responsibilities of local people.

Components of a successful co-management system (based on Ostrom 1990 and Pomeroy and Williams 1994) are presented in section 4.

1.2.2.2. Issues:

Assuming that concerns about the Segara Anakan ecosystem can be addressed (see 1.2.1.2), a community based approach to fisheries management is logical for the following reasons:

- ✓ Local people have a strong interest in and knowledge about the fishery.
- ✓ Government ability to manage the Segara Anakan fishery and enforce fishery regulations there is very limited.
- ✓ There are already some elements of local management in place (see section 2.6), and these elements can be strengthened.
- ✓ Local control provides improved opportunities for adjustment of fishing level, and control of fishing gear types, if necessary.
- ✓ Local control provides opportunities for better monitoring of fishing gear, catches, and compliance with regulations.

- ✓ Local control increases the peoples awareness and sense of pride in their own resources.
- ✓ This approach is also consistent with Indonesia's decentralization efforts.

In spite of the emphasis on local management, there is still a positive and important role for government.

- ✓ Government should assist villagers in setting up their fishery management framework.
- ✓ Government should work to implement laws and regulations which will secure the rights and responsibilities of local people to be directly involved in fisheries management.
- ✓ Government should be responsible for research to improve the understanding of the fishery and its supporting ecological regime.
- ✓ Government has the responsibility to see that the overall habitat of Segara Anakan and surrounding area is sufficiently protected so that fisheries and other natural resources are not harmed.

In addition a community based approach is appropriate for successful management of the mangrove habitat which supports the fishery. An approach of this type is specified in the Segara Anakan Mangrove Action Plan (Hanley *et al* 1999, Hanley and Hariyanto 2000).

1.2.2.3. Ramsar Resolution VII.8

In May 1999 Ramsar Resolution VII.8: "Guidelines for establishing and strengthening local communities' and indigenous people's participation in the management of wetlands" was adopted at the 7th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (called the Ramsar Convention). Because Indonesia is a signatory to the Ramsar Convention it also agrees to uphold this resolution by following these guidelines.

In particular the resolution "Calls upon Contracting Parties to apply these Guidelines so as to encourage active and informed participation, and the assumption of responsibility, by local communities and indigenous people in the management of Ramsar-listed sites and other wetlands and the implementation of the wise use principles at the local, watershed, and national levels".

Thus Indonesia has agreed to use participatory management in the management of all wetlands including Segara Anakan.

1.2.2.4. Needed Actions - Community Based Co-Management (see section 4)

Establish, or reinforce existing, community based fishery management structures. Use Ostrom (1990) and Pomeroy and Williams (1994) as a basis for developing a framework for co-management.

Provide mechanisms by which existing fishermen are assured of rights to fish within a framework of management regulations.

Emphasize local control and responsibility in designing management policies.

1.2.3. An approach integrated into other activities is needed

1.2.3.1. Concept:

Fisheries of Segara Anakan cannot be managed in isolation from the other issues facing the villagers and the ecosystem. For example, as mentioned in Section 1.2.1 fisheries are dependent on adequate habitat protection. In addition, fishery management strategies must be

attainable within the framework of village life. Recommendations requiring even moderate financial outlays by villagers would be inappropriate. In other words, fishery management, in addition to considering environmental relationships, must be carried out within the realities of the overall Segara Anakan social and economic system.

1.2.3.2. Issues:

The issue most linked to fisheries is habitat protection, particularly

- ✓ the protection and reestablishment of a viable mangrove ecosystem and
- ✓ the reestablishment of the Segara Anakan lagoon.

The Segara Anakan Project - Component A is designed to (eventually) improve the lagoon as a fishery habitat. However, if the Citanduy diversion is not completed promptly either additional dredging of the lagoon will be necessary, or the lagoon will disappear with only river and tidal channels remaining. Various authorities have made predictions of the timing of disappearance of the lagoon. ECI (Final Report, Figure 2.4) indicated the lagoon would disappear in the year 2000. It may last longer that that, but if the lagoon disappears then there can be no fishery in the lagoon and only a very limited fishery will exist in the remaining channels.

Protection and rehabilitation of the mangrove ecosystem relies heavily on the rapid and successful implementation of the Segara Anakan Mangrove Action Plan. Activities described under that plan must be carried out if the fishery is to be improved. Under present conditions the mangroves surrounding the lagoon will essentially be gone within 5 years, perhaps sooner. A small strip of mangroves may remain, but its ecological function will be nil. Of particular importance for the reestablishment of the aquatic ecosystem after dredging is the protection of the mangrove area to the east of Segara Anakan lagoon between Motean and Cilacap.

A fishery management program must be meshed with other community needs. This is a very difficult issue because the fishery is dependent on a functioning mangrove environment, but many human actions tend to destroy that environment. Government policies intended to "improve" village infrastructure also accelerate this destruction. Presently most mangrove areas surrounding the immediate lagoon area have been destroyed and these areas need to be reestablished as mangrove.

The difficulty here is that government activities in the Segara Anakan area need to be re-examined, but the proposed management structure for management of Segara Anakan has not yet been established. Government policies are not coordinated with environmental needs and in many cases either defeat the purposes of the project (e.g., settling of several hundred new families in mangrove areas via a PERHUTANI program) or are implemented only on paper (e.g., a regulation limiting the area of tambaks to 200 ha). Thus fishery management must also work to improve overall environmental management and conservation of the area. The linking of fisheries improvement to habitat improvements could be an important motivation for community actions to protect the mangrove environment.

Of special concern is recognition of the fact that while only limited financial benefits accrue to villagers in the Segara Anakan area, significantly larger benefits reach people harvesting and processing shrimp and fish in the coastal area. Thus " recovery" of program costs solely from Segara Anakan villagers would be inappropriate. Any cost recovery programs must necessarily include the beneficiaries who live outside the immediate project area. Also, some portion of benefits are received on both a national and global scale. In fact, it should be noted that sedimentation, and resultant loss of resources, is due to inappropriate activities implemented by others far from Segara Anakan.

1.2.3.3. Needed Actions - Integrated Approach

Emphasize role of mangrove rehabilitation when arranging community based fishery management.

Consider linking community fishing rights to mangrove rehabilitation.

Work to minimize negative impacts of dredged materials on mangroves in discussions with SACDP component A.

Work to speed up the diversion of the Citanduy River.

Consider and discuss with government agencies the negative effects on fishery habitat of activities to "improve" villages. Develop and suggest alternative activities which improve fishery habitat while also helping villagers.

1.2.4. The approach must be practical

1.2.4.1. Concept:

Given the limitations of the system in terms of both funding and management clarity, approaches to fishery management must be simple and straightforward if they are to be effective. For example, overly complex regulations, management requiring knowledge of specific species, management requiring very exact fishing gear specifications will not be practical.

1.2.4.2. Issues:

The importance of limiting fishery management to practical approaches may seem obvious, but needs to be emphasized. Simple and straight forward regulations developed by villagers must be the basis of any fishery management in Segara Anakan. Any new regulation should build on and adapt existing regulations and informal rules (see section 2.6). Complicated approaches requiring special funding, personnel, fishing gear or equipment will not be possible given the current situation in the field and cannot be justified given the relatively low individual catches in the fishery.

Nevertheless, it may be necessary and appropriate to develop regulations which benefit coastal fisheries while limiting the livelihood of Segara Anakan villagers. Such actions might, for example, be implemented to protect shrimp juveniles (see section 2.2.2.2). In such cases implementation may be difficult unless some income replacement strategies are arranged for Segara Anakan villagers.

1.2.4.3. Needed Actions - Practical Approach

Use management ideas received <u>from</u> villagers.

Initiate management initiatives at the sub-village and village level except when higher level action is needed.

Don't create more bureaucracy; use existing organizations and mechanisms if they are available, and if they actually involve villagers in a meaningful way.

Develop mechanisms for regular review and revision of management to incorporate new ideas and eliminate unsuccessful management.

2. COMPONENTS OF THE FISHERY

2.1. GENERAL

As indicated below several groups of organisms are caught by Segara Anakan fishermen. Economically the most important of these is shrimp probably followed by crabs and other shellfish. At present fin-fish caught in the lagoon appear to be of relatively minor importance. However, fin-fish catches have been reported to comprise about one half of the Segara Anakan catch in weight (Figure 1) although the price for fish is lower than that for shrimp. In addition, the proportion of fish in the Segara Anakan catch may have been different in the past when the lagoon was larger and deeper.

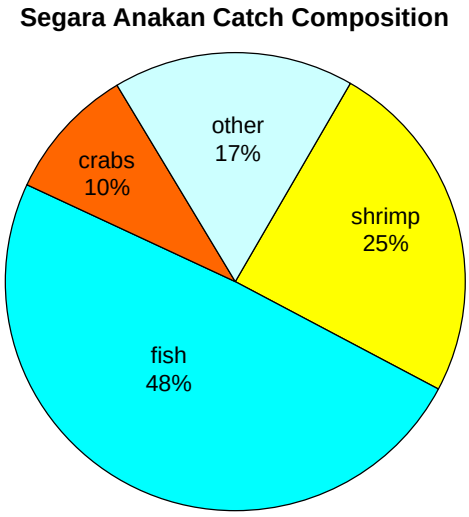

Figure 1. Estimates of the proportion of fish, shrimp, crabs and other organisms reported by fishermen in their catches. Based on data from Amin and Hariati (1991) and also from household survey data Duewel (1994). Using this same information, the total catch from Segara Anakan was estimated at about 1,500 tons in 1994. Also see Figure 2.

Interrelationships between the Segara Anakan fishery and the coastal fishery (e.g., the fisheries outside Segara Anakan) are limited to shrimp and selected species of fish. It should be mentioned here that the dependence of coastal fisheries on Segara Anakan has been overstated in past reports, though it is very likely that this dependency was greater in the past when the lagoon was several times larger. Direct dependency of the coastal fishery on the lagoon concerns species of shrimp that use the lagoon as a nursery area. The extent of this dependency is related to the extent to which these lagoon dependent species use Segara Anakan as a nursery to the exclusion of other nursery areas. That is, if Segara Anakan is the only nursery then lagoon dependent species of shrimp would be 100 percent dependent on Segara Anakan. On the other hand, if these same species can use other estuarine and coastal inshore nursery areas, then dependency on the lagoon is less important.

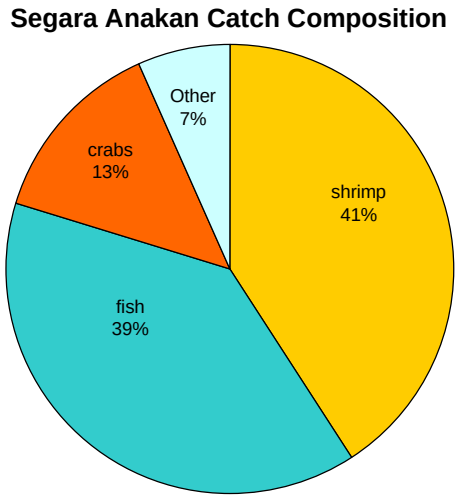

Figure 2. Estimates of the proportion of fish, shrimp, crabs and other organisms determined from field sampling in 1999 - 2000. The proportion of fish has decreased in relation to the proportion of shrimp reflecting the decreased size and depth of the lagoon. Also see Figure 1.

2.2. SHRIMP

2.2.1. Introduction to Cilacap area shrimp fisheries

The shrimp fisheries of the Cilacap and Pangandaran area can be defined as consisting of three primary components:

large scale coastal shrimp fisheries,

small scale coastal shrimp fisheries and

small scale Segara Anakan shrimp fisheries.

The importance of Segara Anakan to the management of the coastal shrimp fishery is that some shrimp species use the lagoon as a nursery area and some of these species are also

caught in the lagoon. Only one species (*Metapenaeus elegans*) appears to be both abundant in the lagoon and restricted to it. Four additional species (*Penaeus merguiensis, Penaeus indicus, Metapenaeus dobsoni* and *Penaeus monodon*) which are relatively abundant in coastal catches also occur in lagoon catches as juveniles.

Several other species are found in the coastal fishery but are not normally found in Segara Anakan. The most important of these are: *Metapenaeus ensis* (which is sometimes seen in the lagoon), *Metapenaeus affinis,* and *Parapenaeopsis coromandelica*. Several small shrimp species comprise a sales group commonly called rebon. In the Cilacap area this group is dominated by *Nematopalaemon tenuipes*.

Penaeus monodon reaches a moderate size in the lagoon with larger adults moving out of the lagoon into coastal areas. Although valuable[1], this species is rarely abundant. On the other hand *P. merguiensis* and *P. indicus* are valuable and abundant species which are caught in the lagoon as juveniles and form an important component of the coastal catches. *M. dobsoni* is a small moderately priced species which can be very abundant in some components of the coastal fisheries (e.g., landed at Sentolokawat and Pangandaran) during August through November and in May. Juveniles of this species are now caught seasonally in small numbers

Table 1. List of common shrimp species encountered in the Cilacap area. Also indicated is whether the species was found in catches from Segara Anakan, the probability of use of Segara Anakan, and the coastal fishery landing sites where the species is common. Probability of use is based on our observations and on several literature sources. The landing site Tegal Kati Layu has a catch composition similar to that at Lengkong.

Common Shrimp Species				Probability of Use of SA				Role in Ocean Fishery				
Family	Genus	Species	Role in Segara Anakan Catches	No use	as juvenile	full life	abundance	PPNC	Sentolokawat	Pangandaran	Lengkong	Sidakaya
Penaeidae	*Metapenaeus*	*affinis*	-	0.7	0.3	0	2	2		1	1	1
Penaeidae	*Metapenaeus*	*dobsoni*	1	0.2	0.8	0	3	0	3	3	0	0
Penaeidae	*Metapenaeus*	*elegans*	3	0	1	1	2	-	-	-	-	-
Penaeidae	*Metapenaeus*	*ensis*		0.7	0.3	0	3	3		1	1	1
Penaeidae	*Parapenaeopsis*	*coromandelica*	-	1	0	0	3	0		3	3	
Penaeidae	*Parapenaeopsis*	*cornuta*	-	1	0	0	0					
Penaeidae	*Parapenaeopsis*	*uncta*	-	1	0	0	0					
Penaeidae	*Penaeus*	*merguiensis*	2	0.1	0.9	0	3	3	1	1	1	3
Penaeidae	*Penaeus*	*indicus*	2	0.1	0.9	0	3	3				3
Penaeidae	*Penaeus*	*monodon*	1	0	1	0	1	1	1	1	0	1
Penaeidae	*Penaeus*	*semisulcatus*		0.8	0.2	0	0	1				1
Penaeidae	*Penaeus*	*sp.* (cikaso)						0				0
Solenoceridae	*Solenocera*	*crassicornis*	-	1	0	0	1	0		1	1	1
Palaemonidae	*Macrobrachium*	*rosenbergi*	1	0	?	riverine	1					
Palaemonidae	*Macrobrachium*	cf *equidens*	1	0	?	riverine	1					
Palaemonidae	*Nematopalaemon*	*tenuipes*		1	0		3			0	3	
Hippolytidae	*Exhippolysmata*	*ensirostris*					2				2	
Alpheidae			1			1	1					

Abundance & Role in Fishery:
3 - Regularly encountered in large numbers at landing sites (perhaps seasonally).
2 - Often encountered in fairly large numbers during the normal season.
1 - Specimens are regularly encountered, but it is not usually abundant.
0 - Occasional. Not common, but specimens are sometimes encountered.
blank - might be encountered.
- unlikely to be encountered at this location.
Notes: Catches at Lengkong are similar to those at Tegal Jati Layu.

[1] This is also the species grown in tambaks. Thus adults caught from the ocean are valuable not only for sale for food but also as brood stock for hatcheries.

in the lagoon but, according to older lagoon fishermen, large catches of adult *M. dobsoni* were obtained in Segara Anakan in the past.

In summary, the major component of the Segara Anakan shrimp catch is the small lagoon species *Metapenaeus elegans. Penaeus merguiensis* and *Penaeus indicus* are also common in Segara Anakan catches and become more abundant at certain times (the rainy season). *Penaeus monodon* is often found but is not abundant. Small *Metapenaeus ensis* also occurs in lagoon catches at times.

In addition to the above shrimp species several others are caught in the coastal fishery. Some of these may make use of the Segara Anakan lagoon and mangrove areas as juveniles, but we have no direct evidence of this and such use is probably minimal. Based on comments in the scientific literature this group might include: *Metapenaeus affinis* and *Penaeus semisulcatus*. These and other shrimp species of the area are listed in Table 1.

Previous reports have listed several additional shrimp species from the area (see Table 2). However, most additional species listed by other authors, are probably one of the species listed in the upper half of Table 2. For example, Sumiono (1995) listed *Parapeneopsis stylifera* as being a major component of the catch. This was very likely *P. coromandelica*. It is possible that we have misidentified some species, and it is possible that additional species will be found via additional sampling.

Table 2. Shrimp species confirmed in our sampling compared to those reported by other workers. A "y" indicates that a species was confirmed by use of scientific keys. Note that Chong *et al* list commercial species in all of Indonesia. The species listed by other authors include the Cilacap area only. A greenish or reddish *Penaeus* called cikaso or udang wulung has also been noted. (Note 1: Sumiono 1995 listed *Solenocera subnuda* which, according to FAO identification leaflets, is a synonym for *S. crassicornis.*)

Shrimp Species found in Cilacap Area Fisheries					Reported by:		
					White et al	Naamin 83	Sumiono 95
Family	**Genus**	**Species**	**Category**	**Common Names**			
Hippolytidae	Exhippolysmata	ensirostris	rebon				
Palaemonidae	Leptocarpus	sp	rebon				
Palaemonidae	Macrobrachium	equidens					
Palaemonidae	Macrobrachium	rosenbergii					
Palaemonidae	Nematopalaemon	tenuipes	rebon				
Penaeidae	Metapenaeus	affinis	dogol	dogol hitam	x		
Penaeidae	Metapenaeus	dobsoni	krosok	udang barat, udang jambu	x	x	x
Penaeidae	Metapenaeus	elegans	dogol	udang jari, dogol hijau	x	x	x
Penaeidae	Metapenaeus	ensis	dogol	berut	x	x	x
Penaeidae	Parapenaeopsis	cornuta	krosok				x
Penaeidae	Parapenaeopsis	coromandelica	krosok		x	x	
Penaeidae	Parapenaeopsis	uncta	krosok				
Penaeidae	Penaeus	indicus	jerbung				
Penaeidae	Penaeus	merguiensis	jerbung	juviniles=udang peci	x	x	x
Penaeidae	Penaeus	monodon	jerbung	tiger, udang windu, tepus	x	x	x
Penaeidae	Penaeus	semisulcatus	jerbung	udang pacet			x
Penaeidae	Penaeus	sp?	jerbung	cikaso, wulung			
Solenoceridae	Solenocera	crassicornis	krosok	krosok merah			x1
		Reported by other workers but not found in our samples					
Penaeidae	Parapenaeopsis	stylifera					x
Penaeidae	Parapenaeopsis	tenella					
Penaeidae	Penaeus	chinensis	jerbung	jerbung hijau	x	x	x
Penaeidae	Penaeus	esculentus		udang pacet			x

There are sub-categories within the coastal small scale fishery because of different gear types and fishing grounds. To a large extent fishermen landing catches at each site (usually an auction place) use a particular type of gear which tends to catch certain species. Thus overall species composition of the catches needs to consider the data from all auction places.

An estimate of the overall species composition in the shrimp catches is presented in Figure 3, based on the information presented in Figure 5. These figures are based on data collection programs carried out under the Segara Anakan Conservation and Development Project during 1999 and 2000.

At the main fishing harbor (PPNC) shrimp catches come from larger trammel net boats which make multi-day trips. These catches are dominated by *Metapenaeus ensis*, *Metapenaeus affinis*, *Penaeus merguiensis* and *Penaeus indicus* (Figure 5). However, some of these catches may be obtained far from Cilacap. Nevertheless, shrimp are known to migrate several hundred kilometers.

At the Lengkong landing area to the east of Cilacap, and at Tegal Kati Layu near the main fishing harbor, fishermen use small boats on day trips usually fishing for shrimp with a type of bottom seine.[2] Catches there are dominated by *Parapeneopsis coromandelica* and small species, especially *Nematopalaemon tenuipes*. Catches landed at Sentolokawat in Cilacap are from a variety of gears, but very few shrimp are landed there. However, during some months (usually April, May and August, September) boats using a type of pelagic (off the bottom) seine (called payang) occasionally catch large amounts of *Metapenaeus dobsoni*. Similar catches to these are caught at Pangandaran although a larger variety of shrimp species are caught there. From Sidakaya, within Cilacap, boats fish with trammel nets on day trips and the catches are somewhat similar to those at the main fishing harbor (Figure 5).

Catches within Segara Anakan are dominated by the lagoon shrimp species *Metapenaeus elegans* supplemented by catches of juveniles of *Penaeus merguiensis* and *Penaeus indicus, Penaeus monodon* and a few *Metapenaeus dobsoni*. In addition, occasional *Metapenaeus ensis*, at least two species of *Macrobrachium* occur in the catches although many of the latter are small (Figure 5).

Harvest of shrimp juveniles in the lagoon very likely has an adverse effect on coastal catches of *Penaeus merguiensis* and *Penaeus indicus* at PPNC and at Sidakaya. An approximate analysis of this question indicates that complete closure of the lagoon shrimp fishery would yield a net increase in the overall value shrimp fishery of between 300 and 1,000 million rupiah per month. To maintain or increase the catch and value of these species also requires the protection and rehabilitation of mangrove and lagoon nursery habitat.

Based on reports of fishermen, catches of *Metapenaeus dobsoni* within Segara Anakan were reasonably large in the past. At present this species comprises only about one percent of the lagoon catch. The extent to which this species is dependant on Segara Anakan as a nursery area is unknown, but catches at Sentolokawat and Pangandaran are now only periodically seen. The extent of this influence can not be estimated at this time, but it is an important issue under investigation (see section 2.2.2.2).

Please refer to additional project documents for supplemental data regarding shrimp biology.

[2] Note that fishermen at these locations also use other gear types which do not catch shrimp.

2.2.2. Shrimp Management Issues

2.2.2.1. Lack of adequate data

Several issues hamper management of the shrimp fishery of the Cilacap area. Only limited information is available concerning the dependence of the coastal shrimp fishery on the lagoon as a nursery area. There is no definite indication as to how harmful lagoon fishing is to the ocean fishery. These questions are difficult to answer because data about the shrimp fisheries are not collected on a regular basis. Ideally fisheries agencies at the national and provincial level should have a full time research presence in Cilacap, and at a minimum would ensure that accurate statistics from the fishery is collected regularly.[3]

Such data are necessary for the successful long term management of all Cilacap fisheries including those in Segara Anakan. For example, there is no clear understanding of the link between river discharge, resulting salinity patterns in coastal waters, and shrimp production, though such a link has been noted in other shrimp fisheries. No clear records of fluctuations in the catch of specific shrimp species exists. Consequently, no correlation with environmental factors can be examined. Without this understanding we can not know, for example, if a decrease in shrimp catch is caused by environmental factors or by over-fishing.

Thus, two components of an overall management plan are:

> Establish a better system for collecting and reporting statistics related to the shrimp fishery.
>
> Carry out regular surveys and other scientific studies to support management decisions.

As a part of the Segara Anakan Conservation and Development Project a one year data collection program has been carried out, and is reported here. Hopefully this can be the start of a longer term data collection program.

2.2.2.2. Link between lagoon and coastal shrimp stocks

The single most important issue specific to shrimp fisheries is the relationship between the Segara Anakan nursery area and the ocean shrimp fisheries. As indicated above, at least four species (and perhaps more) live as juveniles in Segara Anakan and migrate to the sea as adults.

The exact extent to which these species are dependent on Segara Anakan is not known. Previous workers concluded that this dependency must be high because Segara Anakan is the only lagoon habitat on the south coast of Java. However, during the rainy season the inshore waters near river mouths are all of lowered salinity and may provide suitable habitat for juvenile shrimp. At present no major nursery areas are known to exist outside of Segara Anakan, though no research project has specifically searched for such areas. It is possible that further sampling of commercial catches along the coast, where small scale, fine mesh fishing gears are used, may reveal catches of juveniles of these species. However, no juvenile *P. merguiensis* or *P. indicus* have been found in coastal catches, even in those areas where small mesh sizes are used. Therefore it is assumed that Segara Anakan is the primary nursery area for *P. merguiensis* and *P indicus*, and that it should be managed to protect its role as a nursery.

Juvenile *P. merguiensis* and *P. indicus* are caught in Segara Anakan with apong (tidal bag nets). Consequently the management of apong is of major concern to both the coastal and

[3] As pointed out in an earlier report, fishery statistics currently reported for the area are of very limited use.

lagoon fisheries. Apong now catch between 150 and 250 tons each year with about 15% of this catch being juvenile *P. merguiensis* and *P. indicus*. Amin and Hariati (1991) reported that in 1988 apong caught between 700 and 800 tons annually. They did not report the proportion of different shrimp species, but stated that the total penaeid shrimp catch was 42.4%, somewhat lower than the current value with a larger proportion composed of fish. The apong catch rate (kg/trip) in 1999 - 2000 is less than half that reported for 1987 -1988 (6.5 kg/trip compared to 15.1 kg/trip). Presumably, if the lagoon were larger and deeper, the amount of ocean shrimp using the lagoon as a nursery area would also be larger.

2.2.2.3. Comparative Value of the Lagoon and Ocean Shrimp Fishery

Catches of juvenile shrimp (particularly *Penaeus merguiensis* and *Penaeus indicus*) prior to their migration to the sea may result in a considerable loss of value to the coastal fishery. This is because the price per kg of small shrimp is one tenth to one twentieth the price per kg of large shrimp. But it is also true that fishermen in the lagoon would lose a portion of their income if shrimp fishing in the lagoon were to be terminated or severely limited.

The importance of the lagoon as a nursery area suggests options for management in cooperation with coastal and Segara Anakan fishermen. A healthy Segara Anakan provides significant benefits to fishermen outside the lagoon who harvest approximately US$6 million worth of fishery products (mostly shrimp) dependent on the lagoon as a nursery area. For each hectare of Segara Anakan this amounts to over US$1,500.[4]

It seems logical that some of this benefit should be put back into the lagoon management and protection. Normally, government, realizing the importance of the lagoon, would provide this protection and management through its normal operations. In lieu of this, other arrangements might be tried. Taxes are collected on all fish and shrimp sold through official auction places. In the recent past such taxes amount to 8% of the value of the sale with 5.5% for cooperative operations (including administration). The remaining 2.5% was paid to local government and of that, about US$150,000 annually is derived from lagoon origin shrimp. In other words, shrimp originating in Segara Anakan, caught in coastal waters and sold at auction places had already provided about US$150,000 per year to local government.

However, the tax on fish landings was lowered in June 2000 and now totals only 5% of which 3.15% is for management of the cooperatives (including benefits to fishermen such as savings and insurance programs) while only 1.85% is a provincial tax. Only a small amount, 0.95% is returned to local government. This would amount to about $57,000 per year. Ideally this money could be used for mangrove and lagoon rehabilitation and protection.

It is possible that a special "lagoon rehabilitation tax" on shrimp could be used to channel money directly into lagoon protection and rehabilitation activities. In principle, such a tax would have the support of coastal shrimp fishermen if they understood the benefits. Unfortunately, given the current level of trust in governmental financial arrangements, implementation of such a tax would be difficult, though not impossible.

[4] These values are approximate, and will decrease as the Segara Anakan lagoon and mangrove habitat becomes smaller and shallower.

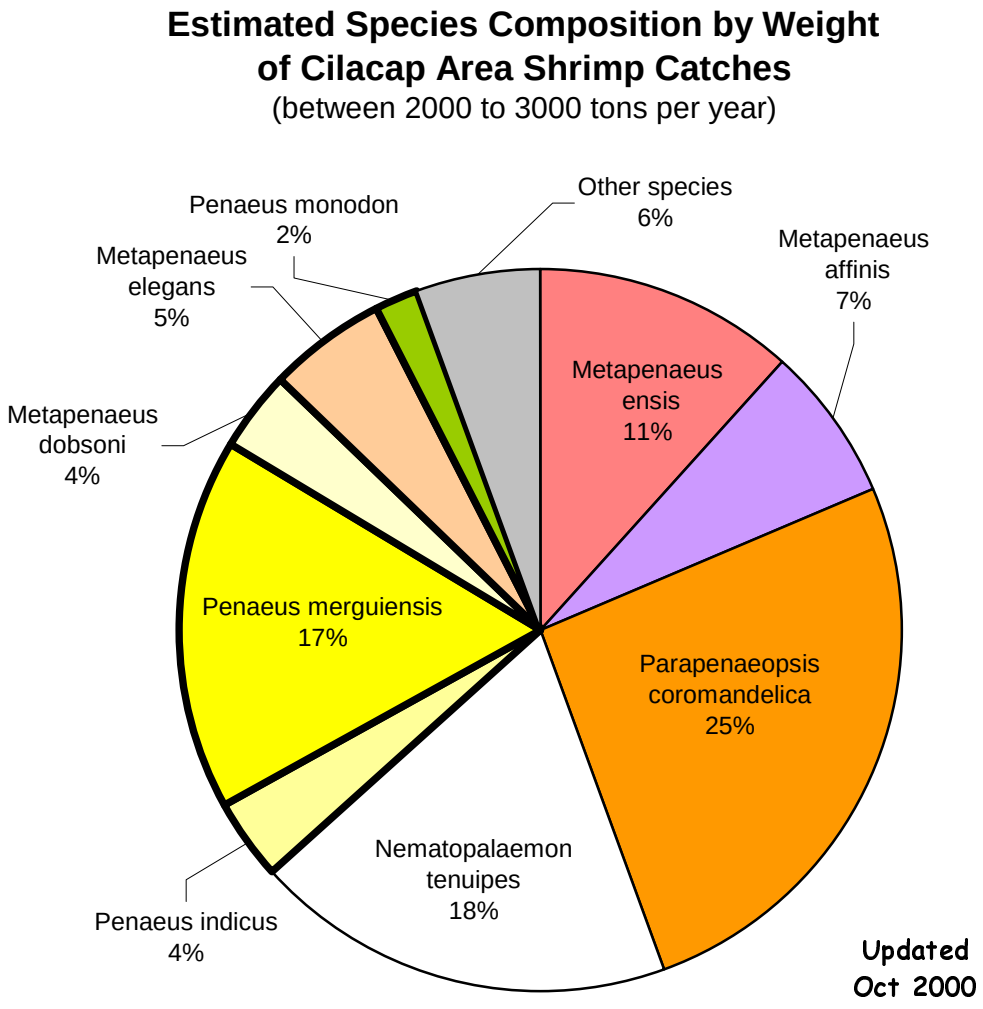

Figure 3. Approximate species composition of shrimp catches in the Cilacap area based on observations at, and catch data reported by, several landing sites. The wedges outlined in black represent species known to occur in Segara Anakan. Of these four species only *Metapenaeus elegans* is resident in the lagoon throughout its life. The other three species outlined in black use the lagoon as a nursery and these species occur as young in the Segara Anakan catches and as sub-adults and adults in the ocean catches. Some of the other species may use the lagoon as a nursery area, but they have not yet been found in lagoon catches. See also Figure 5.

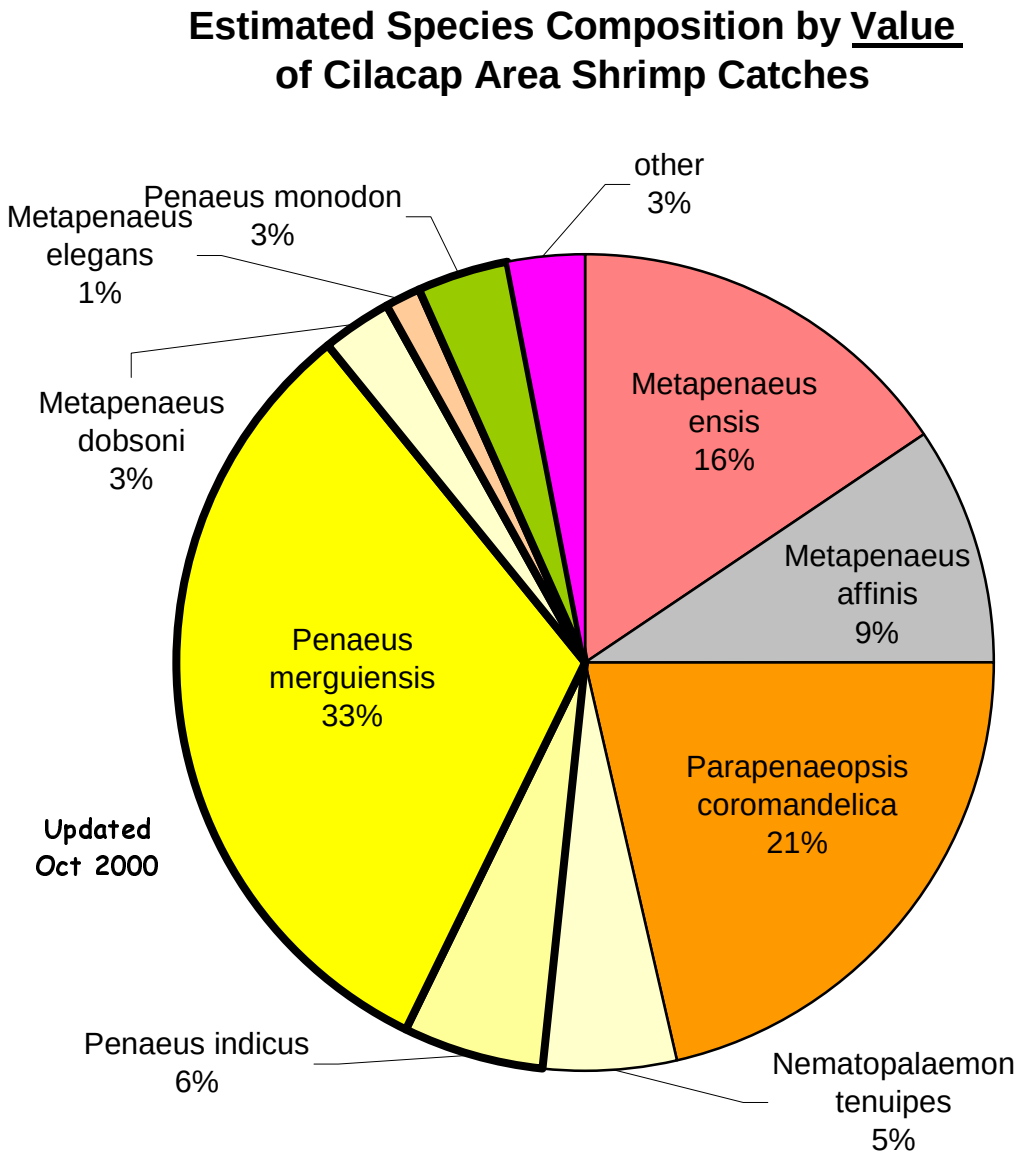

Figure 4. Approximate percentage of the landed shrimp value contributed by each species in Cilacap area shrimp catches. This information is based on the data presented in Figure 3 plus approximate average price for typical sizes of each species. The wedges outlined in black represent species known to occur in Segara Anakan.

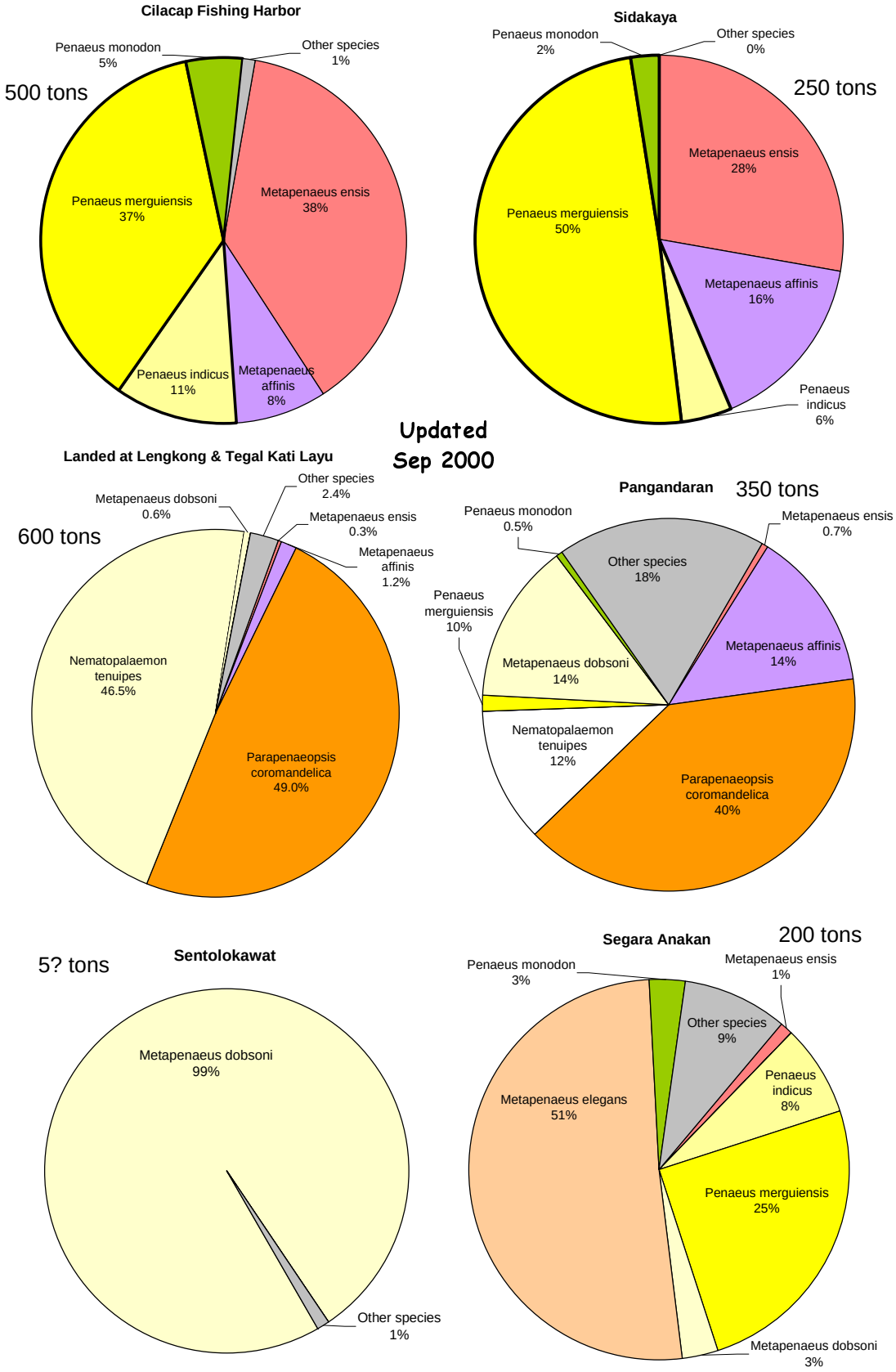

Figure 5. Shrimp species composition data for specific landing sites based on observations at, and reported catch data from, each location. In recent years catch of *M. dobsoni* has diminished. Few shrimp were landed at Sentolokawat in 1999 - 2000.

2.2.2.4. Size of shrimp caught in relation to mesh sizes in shrimp fishing gear

Regulation of Cilacap shrimp fisheries by regulating the mesh size of the various nets would probably be of little use. This is true for both the ocean and Segara Anakan fisheries. Mesh size regulation for these fisheries is of limited value because mesh regulations designed to protect young of large species would also restrict the catch of small species. This problem is particularly pertinent to the management of **apong** (tidal bagnets) in the channels of Segara Anakan. These nets catch both the small species *Metapenaeus elegans* as well as juveniles of the much larger species *Penaeus merguiensis* and *Penaeus indicus*. Because the dominant lagoon shrimp species *Metapenaeus elegans*, is comparable in size to juvenile *Penaeus merguiensis* and *P. indicus*, the use of larger mesh sizes to protect these juveniles is not a viable option unless very serious limitation of the lagoon fishery for shrimp is intended.

Because mesh size restrictions are of limited value, other means of limiting shrimp gear within the lagoon, might be tried. Possible measures include limiting numbers of fishermen, limiting fishing sites, limiting use of apong during peak migratory seasons, and limiting size and placement of the fishing gear (see section 6.4.3).

2.2.2.5. Fishing gear blocking boat channel

Another aspect of shrimp management within Segara Anakan is the conflict resulting from fishing gear blocking the ship channel. Periodically, the ferryboats and other vessels hit and destroy fishing gear. There are regulations which prohibit blocking the channels, but these are not followed. Often apong nets are set across about two thirds of the channel. As the channels become narrower due to sedimentation the shipping channel also becomes narrower. The need to protect the shipping channel may also provide an opportunity to regulate shrimp fishing gear by limiting the width of apong.

2.3. CRABS

2.3.1. Introduction to crab fisheries

Two types of crabs are important in catches from Segara Anakan: the pelagic crab (**rajungan**) and the mangrove or mud crab (which are called **kepiting)**. Although the pelagic crabs (*Portunus pelagicus* and similar species) have been noted in catches in Segara Anakan they don't seem to be abundant there except at certain times.[5] The mud or mangrove crab, on the other hand, is a very important component of the Segara Anakan catch and is exported from Indonesia.

Recently four species of mud crab (*Scylla*) were described (Keenan *et al* 1998), although the name *Scylla serrata* is still commonly assigned to this species. Specimens examined in June 2000 were tentatively identified as two species: *S. tranquebarica* and *S. olivacea*.[6] Limited follow-up sampling indicated that all four species are present in the following proportions: S. *olivacea, 46%*; *S. serrata*, 35%; *S. tranquebarica*, 11%; and *S. paramamosain*, 7%.

Much of the scientific work on *Scylla* reported in the literature is described as being with *S. serrata*. Although that may not be correct, for the purposes of this plan that information will have to suffice. It is believed that the basic biology of the four *Scylla* species is similar, but there may be differences in preferred habitat.

Scylla are primarily estuarine and are primarily dependent on mangrove habitat. Scientific studies indicate that small *Scylla* remain in the inter-tidal area during low tide. Larger

[5] This crab was abundant at the Seleko landing area in September 2000, for example.

[6] Russell Hanley provided assistance with crab and shrimp identification.

individuals migrate into the inter-tidal zone during high water, and the largest individuals tend to remain in deeper estuarine waters. Segara Anakan fishermen report that the abundance of *Scylla* has decreased considerably as the area of mangroves has decreased.

Wasilun (1991) reported catch rates from crab traps of 4.5 kg per trip during 1987 - 1988. Data available for 1999 - 2000 suggests a catch rate of only 1.6 kg per trip. Between 1988 and 1999 the total crab catch has dropped from 850 tons to about 200 tons. During the same period the area of mangroves has been reduced from about 14,000 ha to about 4,000 ha. Based on this data the harvest of crabs has remained between 50 and 60 kg per ha of mangroves per year.

Scylla typically mature at a size of about 9 to 10 cm.[7] Although *Scylla* mate in estuarine waters, the egg carrying females migrate to offshore marine waters. After carrying the eggs for one to two weeks the eggs hatch and the migratory female crabs then return to estuarine waters.

Crab larvae are carried by ocean currents for several weeks, enter the estuary and, at about 30 days, of age develop into the first crab stage which is a few millimeters long. Small crabs (5 to 7 cm carapace width) can gain 1 cm (or about 50g) per month in aquaculture trials, though estimates from such trials vary. Because of their ability to grow rapidly, crabs large enough to spawn are *probably* as young as 12 to 18 months old.

Two types of fishing gear are used for crabs: a type of trap, called wadong, and baited ringnets about 50 cm across, called pintur.

Because of the strong market for *Scylla*, fishing effort appears to be high compared to the available, depleted, resource. Females that are ready to mate (and move to sea and release their eggs) are particularly valuable and are sought by fishermen and buyers.

2.3.2. Crab management issues

Management of mangrove crabs is an essential component of the overall fishery management plan. As mangrove area has declined and human population has gone up, crab fishing effort per unit area of mangrove has increased substantially. Villagers report that the capture rate per fisherman has dropped considerably. Therefore a stabilization and decrease in the fishing effort for crabs is necessary. This can be accomplished by decreasing the number of traps and ring nets being used. In addition, protection is needed for small crabs and for females ready to migrate to the ocean to release eggs.

To attain these management goals: decreased effort, protection of spawning females, protection of young crabs, several mechanisms can be tried. Fishing effort could be limited by establishing use rights for certain areas for individual crab fishermen. Each fisherman could also be limited to a given number of traps with this number being related to the area of suitable crab habitat in his use area. In this way the fisherman would be interested in protecting mangrove habitat. Regulation of pintur could be achieved in a similar manner. That is, pintur use rights in certain areas could be granted to individuals thus limiting the total number of users.

In order to maximize the value of the crab fishery, crabs should be protected until they grow to a larger size. Crabs of a larger size will have a chance to spawn, and are also more valuable. Based on available information, a minimum size for captured crabs should be set at 10 cm carapace width. That is, crabs smaller than 10 cm should be released. It is possible that young crabs could be released by requiring escape doors in crab traps. These small doors

[7] Different species of *Scylla* may mature at different sizes. Quinn and Kojis (1987) reported that *S. paramamosain* became mature at 12 cm compared to 10 cm for *S. serrata*.

would retain large crabs but allow small crabs to escape. This may be an important consideration because fishermen often do not open the traps in the field, but bring them to their village where the crabs are removed. It is unlikely that crabs would be released if this in this case.

Regulations to protect of spawning crabs are more difficult to formulate for two reasons. Firstly the spawning crabs are very valuable and secondly it is possible that *Scylla* spawn throughout the year making the establishment of a closed season impossible. Hopefully the protection of young crabs will provide sufficient management regulation at present. However, if *Scylla* have a restricted spawning season here, then consideration should be given to implementing a closed season to protect spawning crabs.

A related issue is crab culture. Fattening of small crabs would probably have a minor adverse impact on the overall fishery by further encouraging the capture of small crabs. More importantly, and potentially damaging to the crab fishery, is the holding of larger females until they are full of eggs (and have a higher price). This practice would encourage the capture of those females most important to the health of the population.

The most important component of a crab management program is the protection and rehabilitation of the mangrove and lagoon ecosystem.

2.4. OTHER SHELLFISH:

Clam, **totok** (*Geloina erosa*),
Hairy cockle, **kerang bulu** (*Anadara antiquata*),
Blood cockle, **kerang darah** (*Anadara granosa*)

Bivalve shellfish are collected by villagers both for sale and home consumption. Of the three species listed, **totok** appears to be the most abundant at present. Typically totok, still in the shells are sold to buyers who steam or boil them open. The totok meats are then sold to buyers outside the village. Sometimes whole totok are also sold.

We have little information about these species although totok in particular seems to be very abundant in spite of being widely harvested. The other two species may have been more abundant in the past. Conversations with villagers in Motean indicated that totok were more abundant in the past when villagers could fill their buckets in a relatively short time. Now it takes 40 minutes to an hour to fill a bucket. Each bucket contains about 5 to 6 kg or about 75 to 100 totok. Each bucket sells for about 500 rupiah. After the meats are separated from the shells the meats are sold for about 4,000 to 5,000 rupiah per kg.

Villagers consider the other two bivalve species to be very uncommon at present. It is likely that as the lagoon has become shallower reductions in salinity have limited these populations.

The amount of information available about these bivalve species is limited at present and insufficient to develop a management plan. It is likely that changes in habitat conditions, especially reduced salinity, have had a major effect on these bivalves, but this effect is not known. It is likely that the distribution and abundance of these species will change after the Citanduy diversion is built.

2.5. FISH

2.5.1. Introduction to Segara Anakan fin-fish fisheries

Earlier reports about the Segara Anakan fishery have listed over 60 fish species from the catches. Some species not reported previously have been noted in our studies.[8] It might be expected that as many as 100 marine, estuarine and freshwater fish species will eventually be reported from Segara Anakan waters. Nevertheless, based on our examination of Segara Anakan catches, fish do not appear to comprise a large proportion of the total Segara Anakan catch. Probably the data presented in Figure 1 (see page 6) represents an upper bound on the amount of fish landed from Segara Anakan waters. According to the information presented there about 50% of the catch is fish. As the lagoon has gotten smaller and the tidal exchange with marine waters has lessened, the quantity of marine fishes entering the lagoon has probably decreased. Fishermen report that this is the case with certain species no longer seen in the lagoon.

2.5.2. Species of interest

Unlike the shrimp catch which is dominated by three species in Segara Anakan, the fish catch reflects the opportunistic nature of the fishery and the diversity of the fish population. Many species are caught in a variety of ways with no particular species dominating the catch. Nevertheless, some groups are more common than others. The mullets (Mugilidae) are the most common group caught. Juveniles of the families Sciaenidae, and Leiognathidae, are also important as are eels (Anguillidae) and Scatophagidae. Other families regularly reported in the catch include: Ariidae, Carangidae, Clupeidae, Engraulidae, Haemulidae, Sparidae, Synodontidae, Teraponidae, Trichiuridae. Overall, about 20 families are regularly reported in the catches.

2.5.3. Relation of the lagoon fishery to the coastal fin-fish fishery

Based on current information it appears that juveniles of marine fish species are not, at present, a significant component of the Segara Anakan fishery. Accordingly, there does not seem to be a need to protect juvenile fish in the lagoon so that coastal fin-fish fisheries could benefit. It is possible however that in the past juvenile marine species were more abundant in the lagoon. When the lagoon was larger with a larger marine component perhaps marine fish made more use of the lagoon. The inshore coastal fishery has a large component comprised of near-shore species such as members of the Sciaenidae, but these make up only a small part of the lagoon fishery in spite of their considerable abundance outside the lagoon. It is possible that this situation will change when the Citanduy River is diverted and the lagoon is deepened. It seems likely that these changes will be accompanied by an increase in marine species within the lagoon, particularly given the expected increase in salinity.

2.6. OTHER POTENTIAL MANAGEMENT CATEGORIES

2.6.1. Fishing gear categories

Much of fishery management is directed at regulation of fishing gear, and management of the Segara Anakan fishery is no exception. We can categorize the Segara Anakan fishery by fishing gear type and these categories are the logical direct target of management strategies for various species groups. Management must be directed at fishing gear rather than at particular species.

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[8] One example is **kating** (a catfish of the family Bagridae) which is apparently abundant, but was not mentioned in earlier reports.

Fishing gear categories to be used as the basis for formulating regulations are indicated in Section 6.4.3.

It is also necessary to consider if coastal fishing gear might influence the Segara Anakan fishery. For example, does coastal shrimp gear significantly affect lagoon shrimp catches? Or do coastal nets catch significant amounts of fish that would otherwise enter the lagoon and be caught there? At present it is believed that coastal fishing gear have little or no impact on Segara Anakan fisheries, and thus management of coastal fishing gear is outside the scope of this plan. However, management of lagoon fishing gear does have a siginificant impact on ocean shrimp catches and thus the link between lagoon fishing and ocean shrimp catches is a vital part of this management plan (as included under Priority 1 above).

2.6.2. Ecosystem categories

As indicated in Section 1.2.1 and 1.2.3 successful management of Segara Anakan fisheries is highly dependent on the successful protection of related ecosystems. While fishery management includes the establishment of regulations to adjust fishing gear numbers and design (for example), the protection of supporting ecosystems must be an integral component of any management program. This ecosystem approach is necessary for successful management of the Segara Anakan fishery.

Of critical importance is protection of the lagoon and surrounding mangroves, and yet these are both under considerable threat from internal and external factors including activities of villagers and government agencies. Consequently, fishing regulations must include, or be coordinated with, rules for protection and nurturing of mangroves. Perhaps this protection can be viewed as a responsibility of fishermen. That is, fishery sanctions might apply for breaching of "mangrove regulations". Habitat protection is an integral part of fishery management, and this protection should be a goal in the Segara Anakan fishery. Positive steps could be taken by fishery management committees to assist in the rehabilitation and maintenance of mangroves. Of particular concern is the relationship between both the shrimp and crab fisheries and mangrove maintenance.

The boundary between lagoon waters and river waters may also be difficult to define ecologically, at least in a practical sense. For management purposes, such as defining the area for fishery management, this upstream boundary is best defined by using clear landmarks such as bridges, river mouths or similar geographic features. That is, the physical boundary of the Segara Anakan fishery area should be clearly marked using natural boundaries.

A related issue is the ecological importance of the physical connections between Segara Anakan and the ocean. These areas are extremely important for shrimp migrations, and special regulations will be needed in these areas. For example, use of apong and similar gears should not be allowed in the eastern and western entrances. For example, see option 3 in Section 6.4.4.

2.6.3. Administrative categories

While it may be tempting to base management of the Segara Anakan fishery within local governmental administrative categories (Dusun, Desa, Kecamatan, Kabupaten) this is not a realistic option. Firstly, no single jurisdiction covers the whole Segara Anakan area. For example, areas in West Java and Central Java must both be included in any management scheme.

Secondly, villagers in some parts of Segara Anakan have little interest in fisheries matters, or their interests differ from villagers in other areas. For example, in inland parts of the Kecamatan of Kawunganten many villagers think of fisheries only in terms of fish ponds and river fisheries.

Thirdly, management via normal government structures will limit the fishermen's direct participation in management and will prevent them from dealing directly with real

management issues. Management via the normal government structure is typically top-down, but with Segara Anakan fisheries management a bottom-up approach is a better option.

Therefore, instead of using existing government administrative structures alone, the institutional approach suggested in section 1.2.2 and outlined in section 4 should be started. A primary goal of the Segara Anakan Planning and Management Agency and the Fisheries Department (Dinas Perikanan) should be to establish this bottom up management system.

3. TRADITIONAL FISHERY MANAGEMENT

3.1. GENERAL SITUATION

Conversations with Segara Anakan villagers and discussion questions posed by NGO workers[9] indicate that local fishery management exists but only in rudimentary form. There are no formalized committees or groups for dealing with fisheries regulation. While some fishing sites are owned "like land" most fishermen do not enjoy such protection and, in theory, the lagoon fishery is freely available to all people. In the view of fishermen anyone is welcome to come and fish in Segara Anakan waters, although, because of low catches, few are attracted.

While villagers claim that there are no restrictions on fishing gear, their comments also indicate that group pressure is used to discourage people from using types of gear that are considered destructive. For example a fisherman setting a fine bamboo screen along the mangroves was told by other fishermen that this was not allowed. In another case a fisherman was attempting to use a trawl like gear from a powered boat, a fishing technique which also resulted in group pressure to stop. In general the fishermen say that fishing gear is restricted to that which is already normally in use. These unwritten regulations related to fishing gear included some other prohibitions. For example driving fish into nets by herding with noise[10] is not allowed.

People who break the unwritten rules are asked to stop, and are expected to apologize for their actions, but if they fail to comply with group pressure they may be banned from fishing in the village in the future. They should, in some way, also compensate people who feel they have been hurt by the improper fishing activities although there is no system of fines as such.

If disagreements arise at the village level they are resolved by consensus among fishermen. If this approach is not successful, the case is brought to the hamlet (dusun) level for resolution and if this is not successful then the case is brought to the village level. Eventually the case may be brought to the police, but this is very rare.

This same approach is used for disagreements between hamlets or between villages. Again a failure to resolve such differences via consensus sometimes results in the case being brought to the police, but this is uncommon.

Basically there are no written regulations at the dusun or village level, but cooperation among fishermen permits the application of a system of unwritten rules. These rules can form the basis of a revised bottom-up fishery management system.

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[9] Personnel of the Lembaga Bangun Desa Sejahtera (Jl. Karang Pola VI No. 3, Pasar Minggu, Jakarta 12540) provided assistance in collecting information from fishermen.

[10] Called krapyak

3.2. OWNERSHIP OF FISHING SITES

Certain types of fishing gear are set at specific sites and the rights to use these sites are, in a sense, owned by individuals. The only fishing gears associated with site ownership is the tidal bag net locally called apong and a large bamboo tidal trap called sero. Apong are set at slack water and catch fish during the dropping tide. They are often also used on the rising tide. The nets are pulled from the water when the current begins to slacken. The nets are removed when not in use but stakes and buoys remain in place. There are similar use rights for sites for the fish traps called sero.

The ownership of apong (and sero) sites is described "being owned like land but without a certificate". Typically ownership changes of these sites is determined by "consensus" (musyawarah), These sites are located in areas of high tidal current and the most productive sites are in the major channels. There is a requirement that these nets not block navigation channels, but such blockage is a problem in some cases, particularly as sedimentation causes narrowing of the channels.

There are more than 200 apong in the Segara Anakan and adjacent channels, but many of these sites are disappearing due sedimentation. If an apong site is lost the fisherman has no recourse except to change to a different fishing technique. Sometimes this means converting to boats and gear that can be used outside the lagoon, but this requires a significant investment.

In Karang Anyar, apong owners formerly had registration cards identifying their apong sites. Recently a disagreement arose over the re-allocation of remaining apong sites to include people who had lost their site due to sedimentation. This disagreement caused a renewed interest in the registration of apong sites by individuals.

In some cases there is an understanding that certain individuals set crab traps in a particular area. While established use rights for these areas do not exist, there appears to be an understanding that other people will not set their traps in the same area.

Registration of trap areas and apong sites for use by particular fishermen or groups of fishermen should be formalized in the future because such registration could be used as a basis for limiting and regulating the crab trap and apong fisheries.

4. A FRAMEWORK FOR COMMUNITY BASED FISHERIES MANAGEMENT

In order to manage fisheries an organizational framework is necessary. The existing system (Section 3) coupled with ideas from other similar fisheries provides the basis for a fishery management system: a system by which fishery management actions and regulations can be established, changed when necessary, and enforced. As proposed in Section 1.2.2, this system is based on the idea of community management in cooperation with government. This framework[11] consists of the following:

4.1. THE FISHERY UNDER MANAGEMENT MUST HAVE CLEARLY DEFINED BOUNDARIES

Physical and use boundaries of the Segara Anakan fishery management area must be clearly identified.

In Segara Anakan the physical boundaries are relative easy to define both for the whole area and for appropriate sub areas within the lagoon. The Segara Anakan fishery management area should be defined as extending from the western entrance to the lagoon to, and including, the

[11] Modified from the works of Ostrom (1990) and Pomeroy and Williams (1994).

Donan River. Sub-areas can be defined as those currently used by the villages[12], although these may have to be refined at intervals. Although in most cases villagers already know where these traditional boundaries lie, government may wish to map these, and villagers may wish to officially record them. The upstream boundaries of the fishery management area should be defined by villagers within each sub-area, but it is recommended that clear physical boundries (bridges, river mouths etc) be used to avoid confusion.

Unfortunately defining the fishery of Segara Anakan by physical boundaries alone has serious limitations. Because Segara Anakan, serves as a nursery area for valuable ocean-caught shrimp, the fishery is not bounded by the physical limits alone. The biological boundaries of the fishery need to be defined to include ocean caught lagoon shrimp. The reason for this inclusion is that much of the benefit of Segara Anakan goes to people living outside Segara Anakan. This includes coastal shrimp fishermen, fishery workers and shrimp processors, and employees of shrimp processors.

4.2. PEOPLE WHO USE THE FISHERY RESOURCE ARE CLEARLY DEFINED

People who have the right to fish in Segara Anakan should be clearly defined. Fishing permission should be limited to these clearly defined fishermen.

Membership within the Segara Anakan fishery is currently defined as someone who lives in one of the included villages. While this is somewhat vague it provides a *de facto* limit on the number of fishermen. However, this approach also means that anyone can move into a village and can become a fishermen and that any children in the village have the right to become fishermen too.

For fishery management to be successful, there must be some way to limit the number of fishermen, at least in the long term. Establishing a more specific definition on people who can fish is an essential starting point. Specific suggestions should come from villagers and such rules should be fairly uniform throughout the lagoon.

Some points for discussion might include: a) limit the number of fishermen to the current number, b) new fishermen will only be allowed when another has left the fishery, c) new fishermen must be children of existing fishermen. Other possible approaches might be to limit the number of fishermen to the current level, but allow fishermen to sell their permits to another villager from their village. For the present a target of two thirds the present number of fishermen might be a realistic target, although a larger reduction is desireable.

Catches of juvenile shrimp in the lagoon should be severely restricted to enhance the role of the area as a nursery for ocean caught shrimp. For this reason coastal shrimp fishermen must be given a role in the management of Segara Anakan. A part of this role would be to work out cooperative management agreements between coastal fishermen and villagers whereby arrangements could be made to compensate villagers to decrease fishing effort and rehabilitate mangrove habitat. For example, money from a tax on shrimp landings can be used to purchase apong fishing rights from villagers.

4.3. PEOPLE USING THE FISHERY HAVE A LOCAL ARRANGEMENT FOR MAKING THEIR OWN CHOICES ABOUT THE FISHERY

Most people who are actually involved in using the fishery should be involved in making and modifying the rules governing the fishery. For co-management to be successful, the people

[12] Village here is used to mean a "hamlet" such as Motean, Klaces, Karang Anyar. The actual operational areas should be defined by villagers themselves.

using the resource must be the ones setting the rules and regulations. Only technical input should be supplied by appropriate government agencies.

In Segara Anakan groups of fishermen already make fishery decisions in the villages. Therefore it seems a logical step to formalize this arrangement, and expand it to include all village fishermen (through representation if necessary) and to nest village level management within a Segara Anakan wide committee which must include representatives of ocean shrimp fishermens organizations. Such arrangements can be guided by the Segara Anakan Planning and Management Agency.

4.4. APPROPRIATE RULES AND REGULATIONS

Rules about how the resource is used should be related to local conditions and should be created and controlled for the most part by the users as indicated in Section 4.3.

Local people will normally make rules appropriate for local conditions. These rules should also balance profit gained from the resource and the cost of using it. That is, someone who has invested very little should not be able to take a larger share than those who have invested more. One of the difficulties here is that benefits of improved Segara Anakan management will go to ocean shrimp fishermen. For this reason there is a strong need to arrange for some of the value of the ocean fishery to return to the lagoon residents if they decrease their fishing effort for shrimp and improve mangrove management.

Through its advisory role government should strive to ensure that rules are fair for all users.

Although some regulations are suggested in section 6.3 it is envisioned that fishermen will suggest their own regulations, including those already in force locally.

The role of government via the Segara Anakan Planning and Management Agency is to guide decision making, to provide accurate information as needed, and to protect the fishery rights, and other rights of all stakeholders including both lagoon and ocean fishermen. The Segara Anakan Planning and Management Agency and other appropriate agencies (such as Dinas Perikanan) should ensure that regulations developed by fishermen are formally recognized and officially sanctioned.

4.5. FISHERMEN HAVE THE RESPONSIBILITY FOR MONITORING AND ENFORCEMENT

Villagers should have the primary responsible for monitoring the use of the resources, either directly or indirectly. One of the benefits of formally established, officially sanctioned co-management is that local people have a strong personal interest in the proper management of the resource which is supported by law but is under their control. Local individuals then have an interest in protecting their resource and will, in general, accept the obligation and responsibility to monitor and enforce regulations which they have created. When difficulties arise villagers must have the legal support of appropriate enforcement agencies (police, etc.) since their locally based regulations will have been given official sanction.

Thus, to be effective, these village level rules must be officially recognized by Segara Anakan Planning and Management Agency, local, provincial, and national government, and in cases of serious violation these governments should provide enforcement and prosecution backup. Thus another role of these agencies is to ensure that the legal framework establishing local management is established.

4.6. SANCTIONS APPLY FOR VIOLATING REGULATIONS

There should be a series of gradually increasing punishments for violation of management regulations. Punishments should depend on the seriousness and the context of the offence. Initially these sanctions should be developed by fishermen themselves.

One of the difficulties of informal community based management is that fines, suspensions or other sanctions are sometimes difficult to enforce because violators are also neighbors, friends, and relatives. However, if locally formulated regulations are formalized and officially approved by Segara Anakan Planning and Management Agency, then the sanctions will be more easily applied. Fair application of sanctions will encourage a commitment from participating fishermen.

In addition, sanctions should be more severe if the violation is more severe. For example, use of poison to capture fish would require a more severe sanction than use of a net that is slightly longer than permitted. Repeated violators should also receive more serious punishment.

4.7. FORMAL CONFLICT RESOLUTION MECHANISMS ARE AVAILABLE TO FISHERMEN

Some sort of arrangement is necessary to permit discussion and resolution of conflicts and disagreements that will arise. Within the structure of village level and Segara Anakan management committees, a method must be created to solve such disagreements fairly. This might take the form of a special committee of fishermen and community leaders who would resolve the cases in question. This committee must have the respect and support of the fishermen, and must also have the legal authority to take the necessary actions. If this level of conflict resolution does not work then a higher level should be available. This structure should be approved by stakeholders and sanctioned by the Segara Anakan Planning and Management Agency.

4.8. THE FISHERMENS' RIGHT TO ORGANIZE IS LEGALLY RECOGNIZED

Local people should have the right to organize and make arrangements related to their needs as indicated here. External authorities (local government, etc.) should not interfere with the resource users' right to devise their own rules and regulations. Membership in national fishermen's organizations should be optional, for example.

The most important aspect of community based management is the freedom of the fishermen to make decisions about their own fishing regulations. It is essential that government remain neutral as much as possible.

A key component of a local management system is that government officially establishes laws which allow local people to make their own fishery management regulations under these special circumstances. Therefore a part of the management plan would be the establishment and application of laws protecting the right of fishermen to organize in this manner.

4.9. A NESTED ORGANIZATION ALLOWS RULES AT DIFFERENT LEVELS

A system for developing management rules at several levels is necessary for successful management of the Segara Anakan fishery. Hamlet level committees can make regulations at that level (such as who can fish in which area), but a Segara Anakan wide committee is also necessary. Thus, some regulations would be very local (at the hamlet level) and others would apply to all villages within Segara Anakan. See Table 3 for some hypothetical examples.

Because of the importance of the ocean shrimp fishery, the participation of representatives from the coastal fishery is essential. This is an area where government via Segara Anakan Planning and Management Agency and the Fisheries Department will need to provide active guidance.

4.10. THERE IS GOOD COORDINATION BETWEEN GOVERNMENT AND COMMUNITY

Local fishermen's groups should be fully represented on appropriate coordinating government bodies. This membership should be specific. That is, this individual should have the specific role of representing fishermen, and should be a fishermen.

In addition to the local committees and Segara Anakan committees, lagoon fishermen and coastal shrimp fishermen should have specific representation on the Segara Anakan Planning and Management Agency.

Table 3. Shown here are some example regulations that would be formulated at each level of a management scheme. Note: These are examples only. Actual regulations should be formulated using the outlined framework.

Level of Authority	Type of Regulation	Example
Dusun Fishermen's Committee	Includes people from one hamlet (dusun). Determines which people in a village can become fishermen. Allocates ownership of fishing site within a dusun. Develops regulations related to village work area.	 Approves application of fishermen A to fish with crab traps in area B. Approves sites for apong.
Segara Anakan Fishermen's Committee	Includes representatives from all dusuns plus representatives from coastal shrimp fishery. Receives suggestions from village committees. Determines borders between village work areas. Determines Segara Anakan regulations for all villages. Determines Segara Anakan numbers of fishermen and number allowed in each village.	 Resolves dispute between two villages related to apong sites. Sets gillnet mesh size. Sets number of crab traps per fisherman.
Segara Anakan Planning and Management Agency	Approves framework fishery management program for Segara Anakan. Coordinates provision of awareness programs and fishery information to the Segara Anakan committee. Delegates right to make fishery rules and regulation to the Segara Anakan and dusun fishery committees. Reviews rules and regulations when necessary.	Approves appointment of Segara Anakan fishermen's committee. Reviews Segara Anakan regulations. Generally does not interfere in Segara Anakan regulations unless serious problem arise. Provides assistance in resolving serious disputes. Ensures participation of coastal fishery representatives.
Joint Committee DPRD Cilacap & Ciamis	Establishes structure and function of Segara Anakan Planning and Management Agency Provides legal authority for Segara Anakan Planning and Management Agency	Establishes operating and reporting procedures for Segara Anakan Planning and Management Agency.

5. PREVIOUS FISHERY MANAGEMENT SUGGESTIONS

5.1. ASEAN/US RECOMMENDATIONS FROM 1992

The report of ASEAN/US 1992 recommended strategies and actions for the management of the Segara Anakan fishery. In response to the problem which they defined as: "declining production and catching of large amounts of juvenile shrimps" they listed the following strategy: reduce fishing pressure in the lagoon. This was supported by a number of proposed actions including: eliminate all fine meshed nets, transfer some fishermen offshore, draft and approve regulations, communicate new regulations to villagers through field workers, identify village management committees, protect the nursery function of the lagoon.

The approach suggested by ASEAN/US appears reasonable, but it did not emphasize community based management. For example it suggests activities to "draft and approve regulations" and then to "conduct education programs on fishing regulations". This approach ignores the idea that appropriate regulations might best come *from the villagers themselves* with technical input (on resource management principles) from appropriate government agencies. Toward this end the ideas outlined in sections 1.2.2 and 2, should be considered for application in Segara Anakan.

Although some of the ASEAN/US actions were appropriate, they were not implemented. Some suggestions were rather general because the idea was to obtain additional funds to implement recommended strategies at a later date. Elimination of fine mesh nets may be an appropriate goal for some fishing gears, but small meshes are required to catch dominant, small, species such as *Metapenaeus elegans*. The transfer of villagers offshore is also a viable goal, and currently some fishermen from Majinklak and Karang Anyar fish outside of Segara Anakan. Not included in the ASEAN/US actions were specific approaches to reduce numbers of fishing gear, but these were implied in other strategies including the provision of alternate sources of income, and moving fishing effort offshore.

6. SUGGESTED MANAGEMENT ACTIONS

6.1. ESTABLISH MANAGEMENT FRAMEWORK (SEE SECTION 4)

A community based management approach is essential for the management of the Segara Anakan fishery. The approach suggested in section 1.2.2 using the institutional framework set out in section 4 should be established. This approach will build on existing informal fisheries rules already operating in the villages. Strengthening these community based systems, while incorporating the participation of ocean shrimp fishermen, appears to be the best option for improved management.

6.2. FOLLOW UP ON ACTIONS TO SUPPORT GUIDING PRINCIPLES (SEE SECTION 1.2)

Some of the major issues affecting fisheries in Segara Anakan are those falling under the guiding principles outlined in section 1.2 especially under section 1.2.1 related to natural systems with suggested actions presented in section 1.2.1.3.

6.3. ESTABLISH MECHANISM FOR LINKING MANAGEMENT OF OCEAN SHRIMP FISHERY AND SEGARA ANAKAN MANAGEMENT

As indicated in sections 4.1, 4.2, 4.9 and elsewhere, there is a great need to link the management of Segara Anakan to the value obtained from the ocean shrimp fishery. The linking mechanism must include the participation of representatives of the ocean shrimp fishermen. In addition, some benefits from the ocean fishery must be provided back to Segara

Anakan management, or the value of the ocean fishery for shrimp originating in Segara Anakan (jerbung) will be lost.

As indicated in this document, one mechanism for providing that link could be a small tax on shrimp landings to support mangrove and lagoon rehabilitation and management. However, this should be done with the cooperation of both Segara Anakan villagers and ocean shrimp fishermen. Other mechanisms may also be tried.

6.4. FORMULATE REALISTIC REGULATIONS

The regulations suggested here are believed to be appropriate for establishing a fishery management program for Segara Anakan. However, it is essential that these be presented as suggestions for villagers to implement via local a local management system as outlined above. All regulations require the cooperation of local people and in Segara Anakan it is highly unlikely that regulations imposed from above will be successful in obtaining that cooperation. Therefore, concurrent with the development of these regulations should be the establishment of the framework management system outlined in Section 4.

6.4.1. Establish a permit system

One of the first requirements is to begin to limit the number of people fishing in the lagoon. The first step toward this is to establish a system of permits. Each person who wants to fish should have a permit. Ideally permits should be issued for each type of fishing gear.

Permits could be issued as a form of use rights to the Segara Anakan area, or a specific part of it. This approach can expand upon existing village level rules. For example, an apong permit should be a use right (hak guna) for an apong at a particular location.

Importantly, rules governing fishing permits should apply to all of Segara Anakan, because, having a permit system in only one village will not be effective unless similar systems are in place in all villages which harvest from the fishery.

Other issues related to a permit system, which should be discussed in fishermen's meetings, might include the following:

Who should receive initial permits?

Who should be eligible for permits in the future?

Can permits be sold or rented to other individuals?

Under what conditions can the fishermen's organization suspend a permit?

Can a fisherman have more than one permit?

6.4.2. Restriction on number of new fishermen

Subsequent to issuing permits, fishermen's groups can reduce number of fishing gear by restricting permits for new fishermen, buying back permits, or by establishing a lottery to assign a limited number of permits to fishermen desiring them. It is expected that discussion of these concepts will take a long time perhaps several months or even years. However, if the permit system is supported legally, over time people will realize the benefit of having limitations. At the same time alternate means of income need to be investigated.

6.4.3. Prioritize Fishing Gear for Regulation

Based on the information currently available some fishing gear are in greater need of regulation than others. While this information is based on comments an data from fishermen, in the future the fishermen themselves, in cooperation with the Segara Anakan Planning and Management Agency, should be the ones to work out new priorities. For example, fishermen may be aware of other problem areas in the fishery.

Importantly, representatives of coastal shrimp fishermen should also be involved with regulation of the Segara Anakan fishery.

At present the priorities for management of fishing gear are as follows:

> **Priority 1** - Fishing gears that need improved management and are causing problems at present: Apong - Tidal Filter Traps, Wadong - crab Traps , Pintur - crab rings, Sero - bamboo tidal block traps.
>
> **Priority 2** - Fishing gears probably causing only minor management problems at present: Gillnets - (including sirang, ciker and similar gears), Jala - throw or cast nets,
>
> **Priority 3** - Fishing gears not directly causing problems at present: Hook and line - (including recreational fishing), Shellfish collection, other gears not included in the above.

6.4.4. Reduction of Apong fishing

Apong nets catch a substantial proportion of shrimp in the lagoon and are believed to be a problem particularly in relation to the catch of juveniles of shrimp species which later migrate to the ocean (most importantly *P. merguiensis* and *P. indicus*). A reduction of the lagoon depth and area and a reduction in mangrove area have also contributed to a decreased production of lagoon shrimp species (most importantly *M. elegans*). Although many apong sites have disappeared as the lagoon has become smaller, over 200 remain. As channels have narrowed these tend to block boat channels causing conflicts.

Limitation of apong can take several forms:

Option 1: In theory, the best option for apong would be to eliminate them entirely. This is because the overall financial benefit to fisheries would be greatest if apong were eliminated and all migratory shrimp were caught after reaching an optimal size in the ocean. Unfortunately apong are a source of income for villagers, and only 15% to 25% of the apong catch is migratory shrimp. Therefore elimination of apong would be a hardship for villagers using apong and for people who buy and resell the apong catch.

Option 2: A less drastic limitation on apong could be a restriction on fishing during periods of maximum abundance of *P. merguiensis* and *P. indicus* in apong catches. Because these species are considerably more valuable after they migrate to the sea and grow larger, the overall value of the fishery is higher if these are not caught by apong. The problem is that apong fishermen then lose income during these months. The period of maximum abundance appears to be November through February.

Option 3: Another possible limitation on apong, also intended to protect migrating *P. merguiensis* and *P. indicus*, would be to ban apong from critical areas. These areas would include the lower Donan River near Cilacap, the lower Sapuregel downstream from the confluence with the Kembang Kuning River, and the western entrance to Segara Anakan downstream from Klaces. Unfortunately, as Segara Anakan becomes smaller due to sedimentation, the effectiveness of apong becomes greater, and more and more restrictions will be needed.

Option 4: A less effective, but worthwhile, limitation on apong would be to limit their width and the proportion of channel width that can be blocked. Such regulations already exist for the shipping channel. At present some apong block two thirds of the river width. A regulation reducing this to 50% and also setting the maximum mouth opening of apong would be a good start. In addition regulations requiring that the boat channel not be blocked should be enforced.

Option 5: One minor form of limitation could be to limit use of apong to a shorter period. At present fishing takes place during the period of maximum tidal flow (locally called ngangkat)

while apong are not used during the period of lower tidal flow (called ngember). Apong are used about 15 days per month. If the period during which apong were not used was lengthened by 2 days the total fishing effort by apong would be decreased by 13%.

> Recommendation: The recommended action for apong management is a combination of the second and third option, with strong consideration given to the first option.

6.4.5. Reduce mangrove crab fishing effort and link fishing effort to mangrove forest area

Crab catches are very much lower than in the past and the catch per trap has also declined significantly. Crabs command a good price and there is a large demand. Without proper limitation the crab catch will decline further.

Firstly, in agreement with section 6.4.1, all crab fishermen should have a permit.

Permits assigned for mangrove crab fishing for both pintur (ring nets) and wadong (crab traps) should specify permission for a limited number of traps or pintur. Fishermen should decide the appropriate number of traps, but some fishermen currently use between 30 and 40, and it may be easiest to start with the number now being used to help establish the permit system. A related question is the use of baited gillnets for catching crabs. Presumably fishermen who regularly catch crabs by this method should also be part of the crab management program.

Crab permits should also be limited to specific areas. This does not necessarily have to be one fisherman per area, but each fisherman's permit should restrict him to a given area, where others permit holders may also have permission. The purpose of this approach is to give the fishermen an attachment to a certain area of mangroves and thus an interest in improving the habitat in that area. The issue of mangrove land ownership must also be addressed, and fishermen's groups may need to consider whether mangrove owners should be paid for use of their areas. It may also be interesting to consider the idea of renting out mangrove for crab fishing rights. The difficult question is how to ensure that mangrove areas remain in good condition. A small harvest tax on amount of crabs removed from an area might be considered.

Small crabs should be protected until they are larger (even though this concept is in direct opposition to crab fattening aquaculture programs). A preliminary target minimum size should be 10 cm. Crabs smaller than this should be protected.

Ideally, female crabs should be protected. This will be difficult given the higher value of female crabs.

> Recommendation: All crab fishermen should be issued official permits and the number of crab fishermen stabilized. No new permits should be issued. Only crabs larger than 10 cm should be kept. The best way of doing this would be devised with village fishery committees. Female crabs should be released, but such a regulation may need to be postponed for some time.

6.4.6. Regulation of gillnet mesh size

Information currently available is insufficient for making specific comments about gillnet mesh size regulations. Nevertheless no increase in the number of gillnets, and no decrease in the mesh size should be allowed.

6.5. ENFORCEMENT OF REGULATIONS

One of the major issues facing the management of Segara Anakan fisheries is how to implement successful enforcement of fishing regulations. At present regulations are enforced by group pressure, and this is, in some ways, successful. As the number of people in fishing

villages increases more and more people will want to go fishing and catches will decline even further. If the number of fishermen is to be limited, then something more effective than group pressure will need to be instituted.

The approach presented in this document makes the assumption that the provision of official, government sanctioned permits for fishing will enhance the idea of resource ownership by fishermen's groups. The core idea is that fishermen will enforce their own regulations as, for the most part, they do now. Nevertheless, additional backup is necessary so that their own "group pressure" has some additional authority. For this system to work, government must officially sanction the authority of fishermen's groups to make regulations. In addition, government must authorize the appropriate law enforcement officials to back up these regulations when necessary.

6.6. FISHERY DEVELOPMENT OPTIONS

6.6.1. Limitations to Development

Better management of the Segara Anakan fishery will protect existing fisheries there and in the ocean shrimp fishery, but it must be recognized that no significant increases in the catches from Segara Anakan will be possible unless the current level of environmental degradation is reversed. Catches from the lagoon are now extremely limited for environmental reasons, and the likelihood of increased catches is extremely small. For this reason no actions to increase fishing in Segara Anakan are recommended and fishing activity there should be discouraged. This is consistent with the ideas of limiting the number of fishermen indicated in Section 6.4.2.

However actions which would help fishermen move to other fishing areas (the nearby ocean) may be appropriate, and actions which help fishermen adjust to more appropriate fishing gear, or to help them comply with more restrictive regulations might be considered. Such activities could also include compensating fishermen for leaving the fishery, but only if their departure from the fishery is permanent. The strengthening of individual, exclusive, fishing rights for Segara Anakan fishermen is also worthwhile.

6.6.2. Potential development actions

Development actions for fisheries should emphasize and support habitat protection (mangroves) and lagoon rehabilitation. Most village development activities, which in turn attract more people, have a negative effect on fisheries. Likewise the building of new structures (such as roads and buildings) also contradicts efforts to protect fishery habitat, and in the long run, will destroy Segara Anakan.

Development of improved management of the mangrove forest, as outlined in the Segara Anakan Mangrove Action Plan is essential for better Segara Anakan fisheries. The capture fisheries of the lagoon and nearby coastal areas are highly dependent on the natural ecosystem of Segara Anakan. Activities which destroy or degrade that natural ecosystem must be avoided. The mangrove action plan and project aquaculture activities have investigated the idea of "empang parit" on an experimental basis. These one hectare multiple-use homesteads in mangrove areas can be used for aquaculture and for growing mangrove trees and perhaps goats. While this approach is a creative attempt to combine conservation of mangroves with development of village areas, such areas are not substitute for natural mangrove ecosystems, and will not contribute significantly to improved natural fisheries.

Consideration can be given to providing incentives to fishermen to fish outside Segara Anakan. Care should be taken in implementation of this action. There is a danger that the villages of Majinklak, Klaces and perhaps Karang Anyar could become small fishing ports which, if not managed properly, could grossly pollute the Segara Anakan waters. The waters of the Cilacap fishing harbor (Pelabuan Perikanan Nusantara Cilacap) provide an example of

what could happen to lagoon waters if development as fishing harbors occurs deliberately or by accident. Such development of fishing harbors is not recommended.

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8. APPENDIX: OTHER FISHERY MANAGEMENT DOCUMENTS

8.1. The Value of Segara Anakan to Fisheries

8.2. The Value of Closing or Limiting the Segara Anakan Apong Fishery

8.3. Discussion Points for Developing Apong (tidal traps / filter nets) Regulations

8.4. Summary of Data Related to Coastal Shrimp Landings in the Cilacap Area

8.5. Summary of Data Related to Catches in Segara Anakan