THE FISHERY OF DANAU SENTARUM

Richard G. Dudley
Bogor, Indonesia
Email: rdudley@indo.net.id

Management of the Danau Sentarum National Park for ecosystem and species conservation must accommodate fishing activity by thousands of villagers living there. Fishery investigations helped determine how this might be accomplished. Fishing gear surveys revealed that villagers use 800 km of gill net, 20,000 traps and 500,000 hooks in 80,000 ha of lakes, rivers and flooded forest within the park. Data from 4,000 catches were collected by local people during 1992 through 1995. Fishing gear use surveys determined fishing intensity and season. The estimated annual catch of between 7,800 and 13,000 tons (or 97.5 to 162.5 kg ha-1) is caught by cylindrical rattan traps 23%, gillnets 20%, cast nets 18%, other traps 15%, hooks 14%, and funnel nets 9%. These data provide insight into what changes might make fishing activity more compatible with conservation.

Villagers and data indicate some species are less abundant and smaller than in previous years, but needed management via direct government regulation is unlikely to succeed. A promising approach would emphasize management by villagers. Regulations at the village level exist, as does understanding of the need for better management. Developing this potential into an officially recognized fishery management system could improve conservation of this important wetland.

Suggested management starting points include the concept of trading exclusive resource use rights for compliance with conservation regulations, and the establishment of a residence permit system for the park. Suggestions for mesh size regulations and other gear changes, to be used as starting points for discussions with villagers, are also presented.

Introduction

Fishing is the most important human commercial and subsistence activity carried out within the Danau Sentarum National Park (DSNP) in terms of participation and income. Both fishing activity and other activities of fishing people affect fishes, wildlife, and the surrounding aquatic and terrestrial ecosystems. Management of the park for conservation purposes is impossible without an understanding of the fishery and the human population's dependence on it.

This paper provides details about the fishery within DSNP including estimates of catch rates and catch composition from each fishing gear type. Where possible this information is presented on a seasonal basis. Also provided is a general estimate of total fish catch from DSNP with a breakdown by fishing gear type. Suggestions for improving fishery management are also presented.

General Description of the Fishery

Fish species found in DSNP and nearby areas have been reported by Roberts (1989), Kottelat (1993, 1995) and Widjanarti (1996). The number of fish species recorded from the Kapuas basin is about 315 (Kottelat 1995). Kottelat (1993) reported 175 fish species from the "lakes area" and 125 from within DSNP boundaries. Subsequently, Widjanarti (1996) reported 210 species from within DSNP.

The fishery was described by Giesen (1987). Earlier reports include those of Vaas (1952) and Sachlan (1957). Additional information related to the fishery within DSNP has been provided in several short reports (Aglionby 1995, Dudley *et al.* 1993, Dudley and Widjanarti 1993) and an undergraduate thesis (Suryaningsih 1993).

The fishery is a small-scale artisanal fishery making use of a large number of gear types to capture many different species. However, most fishing activity makes use of gill nets, hooks, traps, and cast nets although specialized gears are also used. Most fishermen use small (2.5 to 4 m) canoes. About half the fishing families own a small (less than 5 horsepower) outboard engine.

A seasonal flooding regime significantly affects fishing activity. Although fishing takes place all year round, peaks in activity during dropping water, April to August, and early rising water, usually in September and October. Water levels within the park typically exhibit an annual fluctuation of about 12 m. The rise and fall of the river follows a seasonal pattern, with water starting to rise in either September or October and continuing to rise rapidly during November, and more slowly during December and January. This is followed by a period of lesser fluctuations with the peak level usually occurring between January and April. Water levels drop gradually at first and more rapidly in July and August. This pattern can vary considerably from year to year. In 1995 the water level dropped less than 4 m prior to rising again at the start of the 1995-96 flood year. The large area of the floodplain moderates rapid rises in water, and changes of more than 10 cm per day are rare. For a discussion of hydrology of the area see Klepper (1994) and Klepper *et al.* (1994).

Human residence within the park is limited by the lack of land during high water. Permanent houses built on stilts are found on river levees. Some families live in floating houses or house boats. As water drops, additional people move into the park to fish, and fishing activity intensifies. Special seasons occur for certain species such as the ornamental fish, *ulang uli*[1], which is much sought after between December and May.

Between 1,000 and 3,000 families[2] are dependent on the fishery within DSNP for their livelihood. In addition to subsistence needs, the fishery supplies fish for export from the area in the form of dried and smoked fish products, especially from *belida* and *lais*, live fish to be used as food (*toman*), high priced specialty food fish also shipped live (*ketutut*), and ornamental (aquarium) fish (especially *ulang uli*). Juvenile *toman* and *jelawat* are also actively sought for raising in cages. In the past the DSNP area was also a primary source for the red phase of *siluk* (the Asian arowana), a high priced (up to $3,000 per fish) ornamental fish. However, this species is now extremely rare.[3]

---

[1]Throughout this report I have used fish names commonly used at DSNP. See Appendix A for the corresponding scientific names.

[2]The exact number of families varies with season, and is also dependent on the extent of the area under discussion (see footnote 5).

[3]Culture techniques have made "domestic" *siluk* available to the market. Nevertheless, even though it is illegal to capture *siluk* from the wild, few fishermen would pass up the chance to capture and sell one, even at the reduced price of several hundred US dollars.

The value of the fishery has been reported at about US$1.5 million from captured fish (including ornamentals) plus over US$0.7 million from fishes raised in cages[4] within the park. Approximately 75% of income for park residents, and 48% for those living near the park, is from fishing. (Aglionby 1995).

Methods

Fishing Gear Ownership Surveys

Between 21 October 1992 and 30 March 1993 local data collectors visited 12 villages within the park and collected information on fishing gear ownership from 442 families. Later, in June and July of 1995, a second survey was carried out as part of a program to estimate costs associated with fishing. This second program surveyed 10 families in each of 10 villages within and near the park (Aglionby 1995). A comparison of the data from the two surveys is summarized in Table 1 and Table 2. Data from the 1992-3 survey is used herein.

	Number of Families Sampled	
Village	1993 Survey	1995 Survey
Genting	26	
Kenelang	55	10
L. Pengael		10
Lanjak		10
Leboyan	37	
Ng. Sauk	17	
P. Majang	61	10
Pega		10
Pemerak		10
Pengembung	41	
Samar	33	
Sekentut	50	
Sekulat	53	
Semangit		10
Sengkarut	14	
Sumbuk	37	
Tekenang	18	
Tempurau		10
Temukup		10
Tengkidap		10
Total	442	100

Table 1. Villages and number of families sampled during two fishing gear ownership surveys. Data for 1995 reported in Aglionby (1995).

Catch Survey

Catch data were derived from a very simple catch sampling system first tested in late 1992. Because few personnel were available, and, in keeping with the desire to involve local personnel in the project, local people were hired on a part-time basis to carry out an ongoing survey of fish catches. The intention was to formalize and intensify this survey, but such modifications were not possible. Nevertheless, the survey has provided a stream

[4] The fish raised in cages are initially captured from the wild, as juveniles, as is the fish fed to them.

of data covering about 4,000 fish catches from a variety of fishing gears in a variety of locations over a three-year period. The data included here cover the period from November 1992 through November 1995.

Gear Type	1993 Survey n=442 families	1995 Survey n=100 families
Jermal	0.21	0.28
Rattan Traps	7.68*	5.00
Small lift nets	1.07	0.80
hooks	413	466
gill nets (bals)	7.89	8.30**
cast nets	2.61	2.81
canoes	2.03	2.50
outboard motor	0.57	0.81
houseboat	0.31	0.56

Notes:
*The 1992-3 survey distinguished between several types of traps. The number shown here is the total of "bubu" (1.94) and "pengilar" (5.74).
**The 1995 survey recorded 16.6 gill nets per family. Since each "bal" of netting is usually divided lengthwise into two nets, the 16.6 nets are assumed to represent 8.3 bals per family.

Table 2. Comparison of numbers of fishing gears per family within DSNP based on two fishing gear surveys.

Sampling was designed to be simple and to avoid hampering fishing activity. A data sampler traveled within an assigned area with a small boat, at a time when fishing gear was being retrieved, to locate people fishing. At the site of fishing the catch was examined and data recorded. Data collected included information about the people fishing, location, date, type of gear, and length of time it had been used, an estimate of the total fish catch, the percentage species composition of the catch, and in some cases the number of individuals of each species as well as the average, maximum, and minimum lengths of the most common species. Local names of fishes were used in recording data. To a large extent local names correspond to scientifically defined species.

The data collection system, tested by the author in 1992, was first carried out by local people employed by the project for other purposes (e.g. boat drivers). It was later extended to part-time samplers in the "key villages" of Ng. Pengembung, Pulau Majang, Kenelang, Sekulat, and Ng. Laboyan.

The DSNP fishery represents a difficult sampling situation. It is a multi-gear, multi-species fishery, with a very dispersed and migratory fishing population and a great seasonal variation in catch. Greater statistical accuracy would require a sampling regime stratified by time, area and fishing gears. Considering limitations such as the limited supervision given to the data collectors, the data reported herein give a reasonably good picture of the fishery.

Fishing Gear Seasonality Survey

A group survey technique was used to determine the seasonality of fishing gear use in 26 villages during June and July of 1996. A list of 45 fishing gear types was established based on information from project personnel, and on fishing gear names recorded during the catch survey. Photographs provided visual cues during group interviews. During each interview villagers discussed the use of each gear type and agreed on one of six statements (Table 3) for each month or group of months. Months were grouped into seasons as indicated in Table 4. For each village a code was recorded for each month for each fishing gear. These codes were later converted into percent use categories (Table 3).

Statement About Gear Use	Clarification	Code on Forms	Percent Use Used in Calculations
Not used in this village	Never used	1	not included
Not used during this season	Used, but not during the month or season under discussion	2	0
Used almost every day during this month / season	Used more than 21 days per month	3	85
Often used during this month / season	Used fewer than 21 days but more than 13 days per month	4	55
Seldom used during this month season	Used fewer than 13 days but more than 6 days per month	5	29
Very seldom used during this month / season	Used fewer than 6 days per month	6	9

Table 3. Coding used during gear use surveys.

Season	Months Included
Rising Water, Start of High Water	October, November
High Water	December, January, February, March
Beginning of the Dry Season	April, May, June
Dry Season	July, August, September

Table 4. Grouping of months into seasons as used during fishing gear use survey.

Villages surveyed were categorized into one of six areas of the park: Lower Tawang River, Upper Tawang River, Mid-Park, Belitung River drainage, Pulau Majang area, the Laboyan River area and the Kapuas River. The villages within each park area are given in Table 5. Average fishing gear use percentages were then calculated for each area. Then the overall percentage use for each fishing gear for each month was calculated by taking the weighted average of the percentages from each park area. Weighting was based on the number of families living in each area. Weighting for gill nets, very large dip nets, and *jermal* were adjusted to eliminate data for villages where those gears are not permitted or never used. An example is illustrated in Figure 1. In the following discussion only weighted means are presented. Fishing gear types were also grouped for analysis. These groupings corresponded to categories used in the analysis of catch rates.

Area	Village	Number of Families
Kapuas	Nibung	
(not used in	Piasak	
calculations)	Suhaid	
Lower Tawang	Sumbuk	37
(and Tengkidap)	Tengkidap	40
Upper Tawang	Kenelang	83
	Pemerak	20
	Pengembung	42
	Tekenang	16
Majang	Belibis Panjang	40
	Pulau Majang	155
	Radai	30
Mid	Lubuk Lawah	20
	Lubuk Pengael	27
	Sambar	40
	Temukup	19
Belitung	Bekuan	47
	Lubuk Mawang	15
	Pega	80
	Pungau	78
	Sekulat	127
Laboyan	Leboyan	95
	Meliau	30
	Semalah	63
	Semangit	46

Table 5. Grouping of villages used in calculation of fishing gear use percentages.

Approach to Analysis

Fishery data available are suitable for a general analysis, but care must be used in their interpretation. The catch data were not collected randomly within time, location, and gear strata. Thus general information collected via the catch survey needs to be examined in conjunction with other information about the fishery.

In the following sections data concerning catch rate, seasonality of use, and species composition are summarized by fishing gear type. The fishing gear survey provides information about the numbers of each gear.[5] Information about catch rates (e.g. kg per unit of gear) and species composition are provided by the catch survey, which also provides an idea of the size of major species caught. Following that summary is an estimate of total catch which is based on data about the catch rate, quantity of each type

[5]An additional complication is that the area comprising DSNP has changed. At the time the fishery surveys were started (1992) the park covered 80,000 ha. When fishery data was first being analyzed the park had been expanded to 120,000 ha. Data herein are most representative of the original 80,000 ha where most fishing takes place, and may not adequately describe fishing activity in other parts of the park.

of gear, and intensity of use. Within each month an estimate of catch for a particular gear type is obtained by multiplying the following: weighted mean intensity of use, catch rate, estimated number of gear units, possible maximum number of trips.

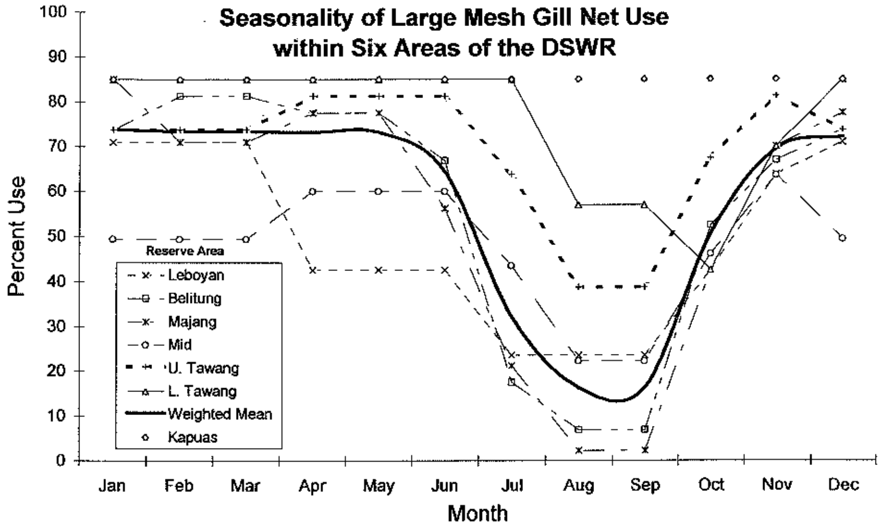


Figure 1. An example of intensity of use data. This information represents the responses of villagers to inquiries regarding how often they used large-mesh gill nets during each month. The weighted mean value, excluding the Kapuas area, was used in calculating catch estimates. In most cases weighting was based on number of villagers living in each region.

Fishing Gear, Catch Rates and Species Composition

Gill nets

Data from gill nets (known locally as *pukat*) were standardized on a per unit basis. A *bal* is an amount of netting which, when set, becomes an approximately 40 m net. However, in most cases fishermen divide each *bal* in half lengthwise to make a net totaling 80 m. The *bal* is used herein as the standard unit of netting.

On the average, DSNP villagers have 7.89 *bals* of gill net per family. There are about 10,375 *bals*, or just over 800 km, of gill net available for use within the park. Some villages, (e.g. Nanga Laboyan) prohibit gill nets, perhaps because they are viewed as overly efficient. Typical "gill net sets"[6] encountered during the catch survey consisted of approximately 10 *bals* of netting but included anywhere from one to over 30 *bals*.

[6]The term "gill net set" refers to a connected group of gill nets placed, and left to fish, at one location. These may include several pieces of netting of different mesh sizes.

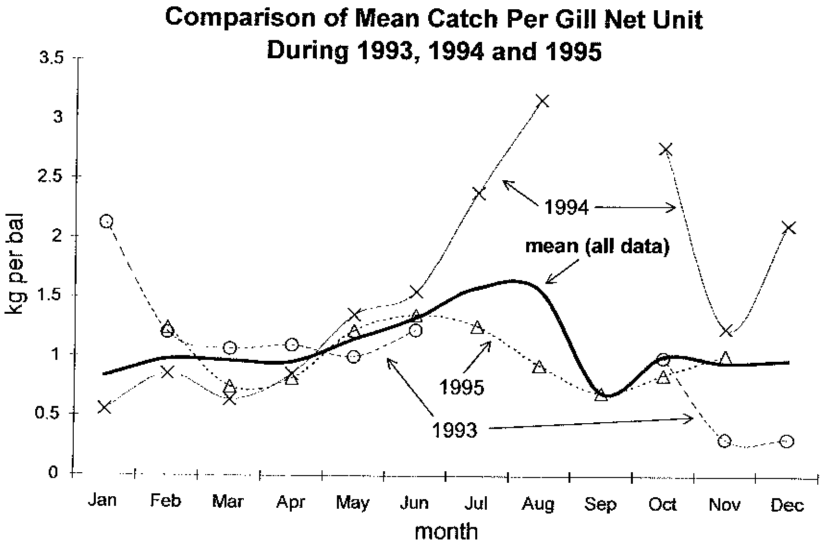


Figure 2. Monthly mean catch rate from gill nets during a three year period. Mean for each month within each year shown separately. Overall within month means spanning three years are shown by the bold line. Mean for September is based only on data from 1995, thus a higher average value of perhaps 1.0 kg per *bal* might be assumed for an across-year average for that month.

Gill net mesh sizes reported as part of the catch data and gear surveys ranged from 0.5 inch to 7.0 inch.[7] For catch analysis mesh sizes were grouped into large (4.5 inches and larger), medium (3 to 4 inches) , small (1.5 to 2.75 inches) and very small (less than 1.5 inch). Almost 80% of gill nets encountered during our work were between 1.5 and 2.75 inches stretch measure, and this pattern varied little among the villages sampled.

Gill nets are a common fishing gear and are used throughout the year. Large mesh gill nets are regularly fished across river channels, a method which becomes less practical as water drops resulting in less use of large mesh gill nets during the dry season (Figure 4).

Typically, villagers caught between 5 and 15 kg of fish per gill net set. The data are strongly skewed, and although some catches over 50 kg were reported, 92.1% were smaller than 25 kg. On a kg per unit basis, catch rates over 6.5 kg per *bal* occurred, but 89.5% of catches yielded less than 2.5 kg per *bal*. The mean catch rate reported from gill nets was 1.17 kg per *bal* of netting.

Gill net catch rates varied with season and mesh size, but limited data makes analysis of patterns difficult. Combining data for all years, gill net catch rates exhibit an increasing trend during April through July, and then drop in September through December. This pattern is apparent in the 1994 (and perhaps the incomplete 1993) data. In 1995, when water levels did not drop, the pattern is absent. (Figure 2).

---

[7]The sizes of gillnets used in DSNP are generally referred to by their stretch mesh size in inches (*inci*). Stretch measure is the distance between corners of a single mesh when the mesh is pulled diagonally corner to corner.

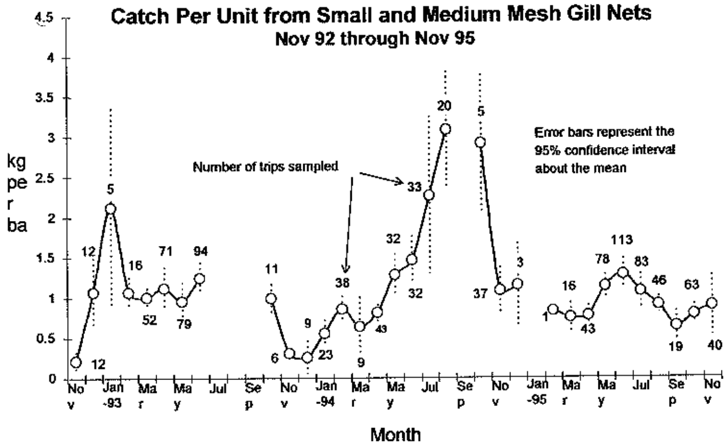


Figure 3. Monthly catch rates from small and medium mesh gillnets. Each point represents the mean catch per fishing gear unit (*bal*) from the number of fishing trips shown. The number of *bals* within each trip varied.

Catch rates from the commonly used small and medium mesh gill nets, are typically between 0.5 and 1.5 kg per *bal*. During periods of dropping water catch rates can be three times as high as indicated by catches recorded during July through October 1994.[8] In 1995 floodplain waters did not recede and no increased catches during those months were apparent (Figure 3).

Catch rates for large mesh gill nets are higher than catch rates from medium and small meshes, but because relatively few large mesh gill nets were sampled a comparison on a quarterly, rather than monthly, basis was necessary (Figure 5).

Large mesh nets caught almost 80% *belida* with occasional *tebirin, tapah,* or *lais jungang* (Figure 6). Catches from medium mesh nets were dominated by *lais* and *patik* which typically comprised 30 to 40 percent of the catch. Several other species were regularly caught including *kelabau, umpan, buin* and *juara,* while other species seemed to be more seasonal (Figure 7).

Over 40 percent of the catches from small mesh nets were typically various types of *lais*, and *patik.* Other species recorded regularly included, *umpan* and *kelabau,* while species such as *belida, kerandang, tebirin,* and *biawan* seemed more seasonal (Figure 8).

Very small mesh nets tended to catch the same species as the small mesh nets although they tended to have more representatives of some small species (e. g., *engkarit, temunit*).

Hooks

Several types of fishing gears employing hooks are used in DSNP. These comprise three categories: long lines, consisting of many short lines with hooks attached to a longer line (called *utas, rabai, ulur, takan*); set hooks consisting of hooks tied to tree branches or attached to sticks stuck into the ground (usually called *kail*); and hand-lines held in a person's hand as they fish (called *kail* or just *pancing*).

[8]Unfortunately, samples were not obtained during the same period in 1993.

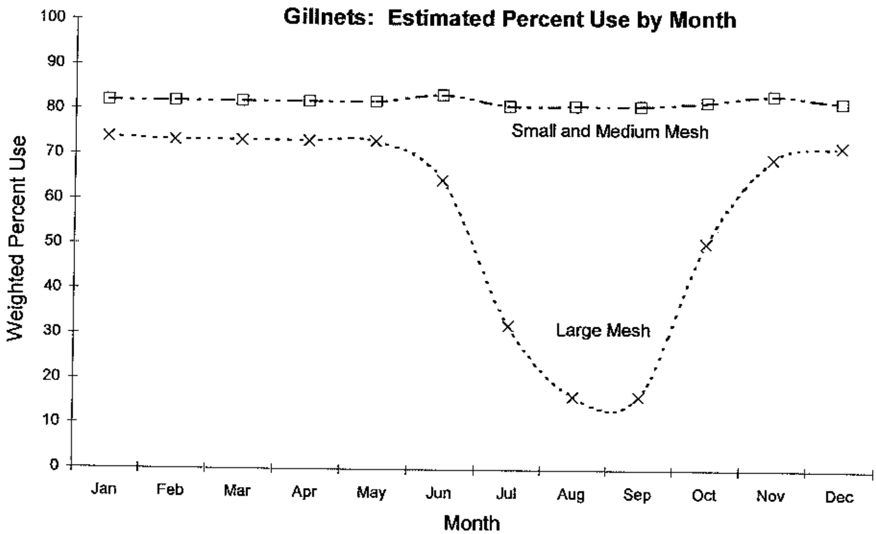


Figure 4. Seasonality of gill net use.

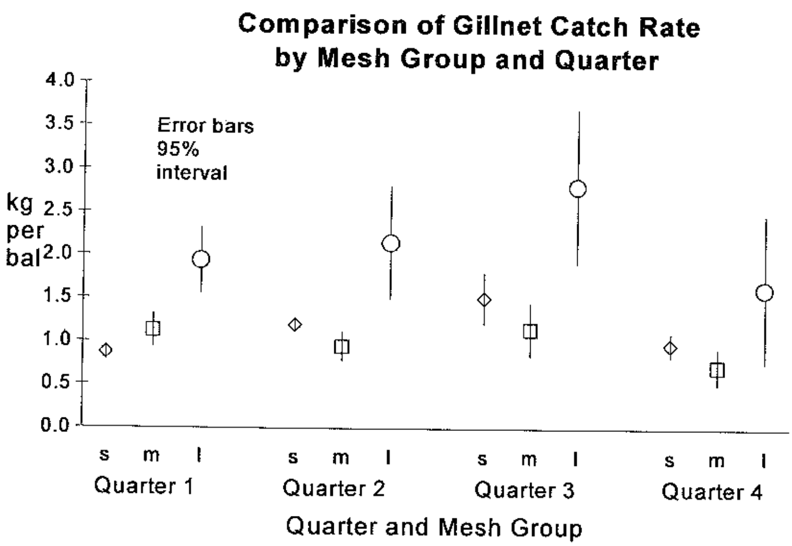


Figure 5. A comparison of catch rates by gill nets of differing mesh size groups. Because of the relatively small number of large mesh nets sampled, the rates have been compared on a quarterly basis. Mesh sizes: s=small, m=medium, l=large.

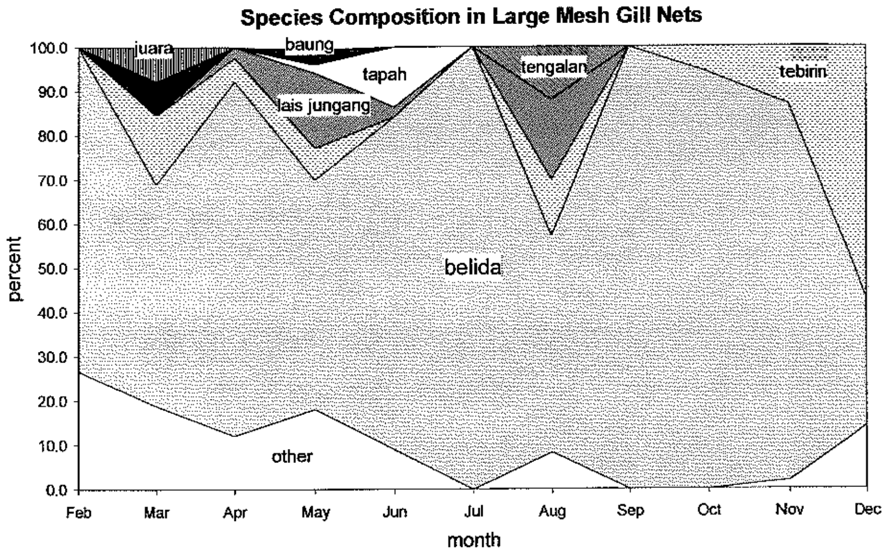


Figure 6. Species composition in large mesh gill nets by month.

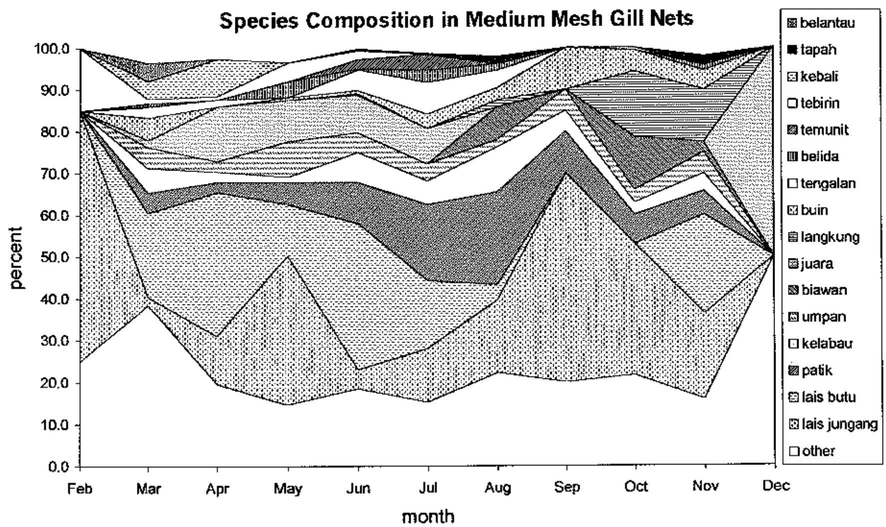


Figure 7. Species composition in medium mesh gill nets by month.

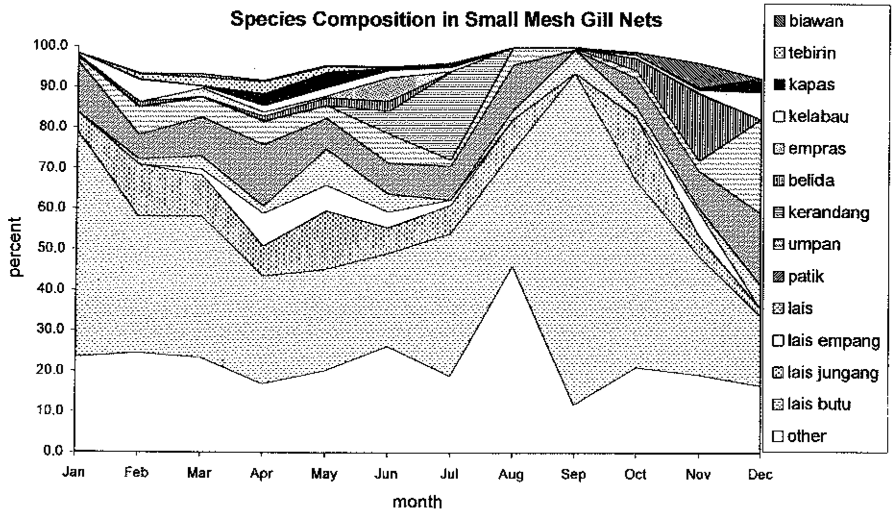


Figure 8. Species composition in small mesh gill nets by month.

For analysis these were grouped into two types: hooks set and left unattended, hereafter referred to as set hooks, and hooks actively used by a person hereafter referred to as hand-lines. Set hooks were also categorized based on hook size: large (hook sizes 5, 6, 7, and 8), medium (size 9, 10, and 11) and small (12, 13, 14, 15 and 16).

Hooks are common within DSNP, and on the average, DSNP villagers have 413 hooks per family or over 540,000 hooks available for use. Based on data from the catch survey 65% of trips making use of set hooks used small hooks, 15% medium hooks and 20% large hooks[9].

Fisherfolk reported that set hooks tend to be used more during high water periods from December through March when hooks can be set and left in quiet backwaters. Hand lines had a more uniform use pattern with a decrease in use occuring only during October and November (Figure 9).

Catches from hook gears are expressed in kg per 100 hooks to standardize the catch per fishing trip.[10] Standardized catch rate varied from less than 0.5 kg per 100 hooks to more than 60 kg. The catch rate from small size hooks was considerably lower than that from large and medium hooks. Most catches from small hooks were less than 2 kg per 100 hooks. Large hooks tended to catch between 10 and 40 kg per 100 hooks while

[9]Based on 841 records, not including records for which hook size was not recorded.

[10]Considerable difficulty was encountered with the data from hook gears because of a lack of standardization of the fishing gear information entered on the data forms. Sometimes the number of hooks was entered, and sometimes the number unit of fishing gear units (usually called "rols") was entered. In a few cases both the number of hooks and the number of rols was recorded, and this information was used to calculate the number of hooks used for those records which had no information for number of hooks. However the number of hooks per rol varied with the gear type and location. Also, even in cases when the number of hooks was recorded on the data form, that number is an estimate provided by the fisher.

medium size hooks caught slightly less (Figure 10). No clear seasonal patterns were apparent. Catches from large hooks dropped during low water in 1994 but did not drop during that period of the year in 1995 when water remained high.

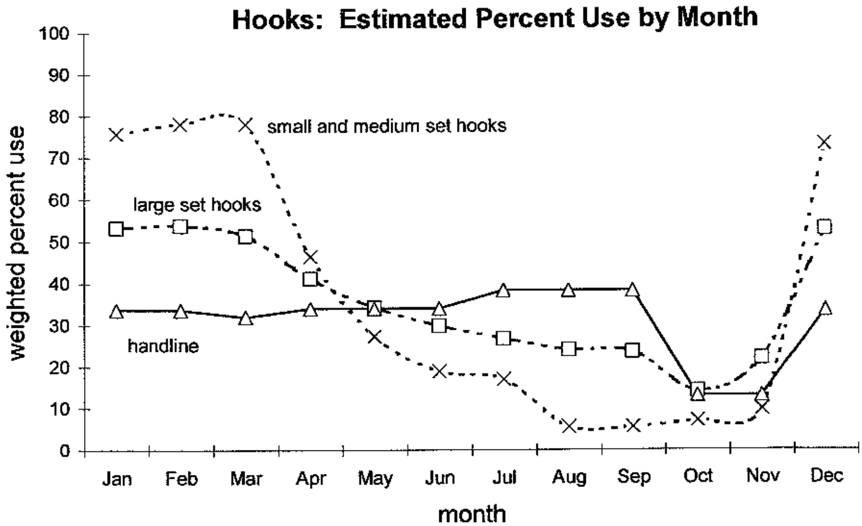


Figure 9. Seasonality of set hook and hand line use.

Catches from hooks were less diverse than catches from other types of gear. The most common species (in terms of weight) reported in catches from large hooks were *toman* (50%) and *tapah* (35%). *Toman* also made up over 70% of the catches recorded from medium size hooks. In contrast catches reported from small size hooks were dominated by *patik* (78%) and *delak* (13%) with *lais butu* common during September through November. Species composition by month is shown in Figure 11.

Hand-lines are particularly common in the village of Leboyan, and are also used regularly by a small group of fishers from Pulau Majang, but few hand-line data were collected during the survey. Hand-lines catches have been expressed as catch per hook-hour. Catches averaged 0.93 kg per hook hour with a possible trend toward higher catches during periods of low water. Hand-line catches consisted of 67% *patik* with no other species making up more than about 7%.

Cast Nets

A number of different types of cast, or throw, nets (*jala*) are identified by villagers based on the size, mesh size, and target species. For convenience these can be grouped by mesh size, though consideration must also be given to the species being sought. DSNP families own, on the average, 2.61 cast nets per family. The number of cast nets in DSNP was estimated at 3,430.

The fishing gear survey identified four types of cast nets: *jala bilis*, *jala toman*, *jala bauk* and *jala perumpan*. However, during the three year catch survey 19 different names were recorded for cast nets. Consequently, the data were grouped based on the mesh size recorded during the catch survey: small (less than 0.5 inches), medium (larger than 0.5

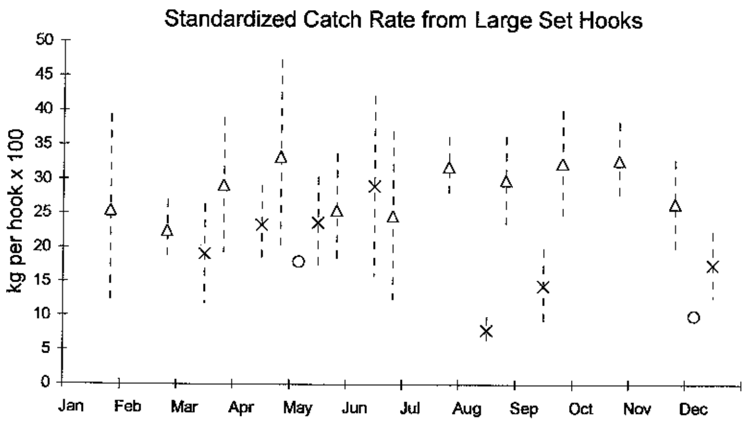
and less than 3.0 inches) and large (3 inches and greater). During the catch survey 44% of cast nets encountered were small mesh, 48% medium mesh and only 8% large mesh.

Large mesh cast nets are used primarily during July through September, while the smaller meshed types are most typically used during high water periods between November and April (Figure 12).

Catches from 887 trips using cast nets were examined. Catches exhibit a mode between 1.0 and 2.5 kg per hour. Mean catch rate from large mesh nets varied with season from a low of 1 to 2 kg per hour to between 7 and 8 kg per hr during July and August.[11] Catch rates from medium mesh cast nets ranged from 1 to over 6 kg per hr with a trend toward higher catches during May through September. Mean catch rates from small mesh cast nets tended to be less than those from medium mesh nets sampled in the same month, ranged from 1 to 5 kg per hr and tended to be higher during June through August (Figure 13).

Species caught in cast nets were dependent on the mesh size used. Large mesh cast nets sampled in August caught mostly *biawan* and a mixture of other species. *Umpan* was very common in large mesh nets sampled in January, February, May and June while *bauk ketup* and *entukan* also formed a large part of the catch sampled in February.

Medium mesh cast nets caught a wide variety of species especially various types of *bauk* and *entukan*, as well as *umpan*, *menyadin*, *bilis* and *patik*. Small mesh cast nets caught a smaller selection of species, and catches from them consisted mostly of *bilis*, *ritak* as well as a variety of other species (Figure 14).



[11]Only 57 trips made by fisherfolk using large mesh cast nets were sampled limiting the analysis of data from this gear type.

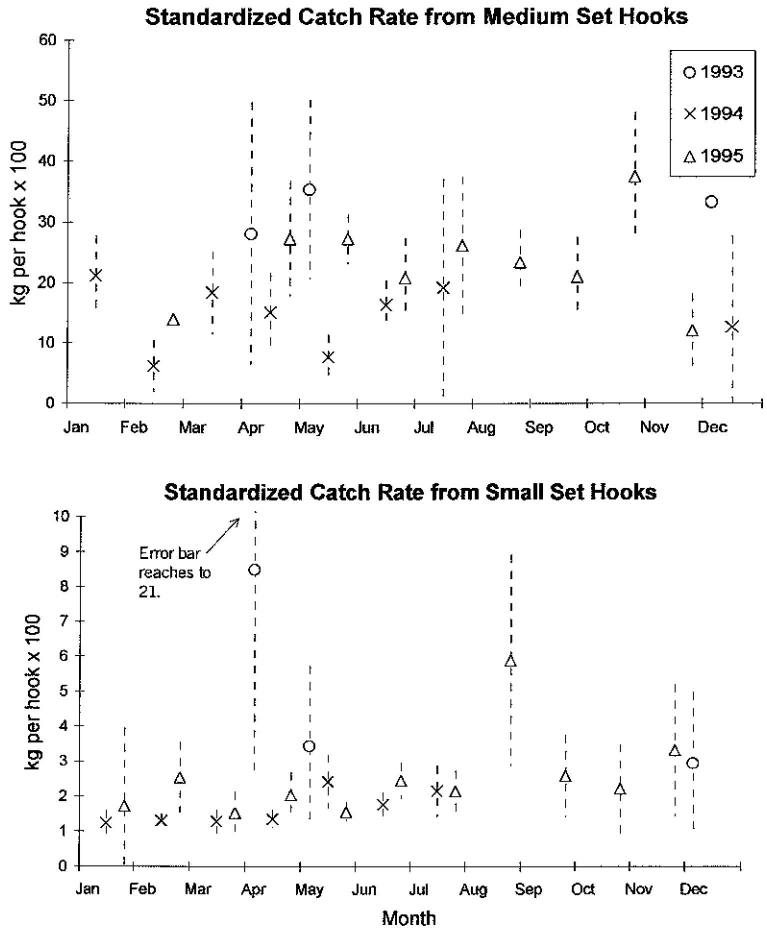


Figure 10 a, b, c. Catch rates from set hooks.

Funnel Nets

Jermal are stationary, open topped, funnel-like nets used to catch migrating fish. They are typically 4 to 6 m across the mouth and 10 to 20 m long, but can be larger. They are left for several to many hours and then are checked by gradually lifting the floor of the net, starting at the mouth, trapping the fish in the back of the net where the meshes are smallest (mosquito mesh). The fishing gear survey reported 92 within our sample resulting in an estimate of 275 *jermal* in use within DSNP. However, our survey emphasized data from an area where *jermal* are more commonly used and may have overestimated *jermal* numbers.[12] *Jermal* are used during all seasons, but the season of use

[12]The Selimbau Fisheries Office reported (in 1992) that there was a limit of 177 *jermal*, and that permits from the Fisheries Office were required, but that in 1991 there were 186 *jermal* in the Selimbau sub-regeancy (*kecamatan*) as well as 377 within the Kapuas Hulu regeancy (*kabupaten*). (Author's field notes 24 September 1992).

varies with location. Their use is most common during high water, and during dropping and rising water (Figure 15). *Jermal* catches vary considerably with time of year, and are most productive during dropping water. The catch survey data indicate that catches varied considerably from less than 1 kg to more than 70 kg per hour. Catches reported in our data were particularly high during October and November 1995, when catches averaged 36 and 70 kg per hour respectively (Figure 16).

By weight, species composition in *jermal* is dominated by *bauk* and *entukan*, but a wide variety of other species are caught, and the dominant species may vary from month to month (Figure 17).

Jermal are important for catching live ornamental fishes, especially *ulang uli* which make up a small portion of the catch by weight but are the most valuable species caught. Mean catch rates reported for *ulang uli* usually ranged from fewer than 2 to over 40 per individuals per hour but could be as high 140 fish per as in May 1998.

Traps

Gear Description and Numbers and Seasonality

Brief descriptions of the several types of traps are used within DSNP are included below. For full descriptions of fishing gear in the area see Anon. (1992) and Giesen (1987). Numbers of traps within DSNP were estimated at: 2,550 cylindrical rattan traps (*bubu*), 7,550 rectangular traps (*pengilar*)[13], 16,500 *seruak* and 3,970 *bubu keli* and 22,680 bamboo tube traps (*tabung*).

Catch data from traps were standardized on a kg per hour basis. Data from *tabung* are expressed in number of *ulang uli* per unit.

Normal Traps (*Bubu*, *Pengilar* and *Temilar*)

Bubu are fairly large, cylindrical traps woven from rattan. They are usually 2 to 3 m long and 0.6 to 1.0 m diameter. *Pengilar* and *temilar* are smaller rectangular traps (approximately 0.7 x 0.7 x 0.5m). These traps, especially *bubu*, are often used in conjunction with fence-like leads or fish barriers.

Both the cylindrical and rectangular "normal" traps are used primarily during dropping water from April through November, although the rectangular type is also used during other months (Figure 15). Data from normal traps were collected from only 77 trips (which included catches from 809 traps) over the three-year period covered by this report.

Bubu catch rate averaged just over 1.0 kg per hour. In some instances the catches were significantly higher but typically ranged from low catches (below 0.2 kg per hour) during high water periods to catches averaging almost 1.5 kg per hour during dropping water. Catches from only 20 trips employing pengilar and temilar were examined although these included catches from 555 such traps.[14] Catches were generally below 0.05 kg per hour. The data were insufficient to determine a seasonal trend.

Catches from both *bubu* and *pengilar* were dominated by *biawan* and *patik*, but a mixture of other species accounted for about 60% of the catch. Occasional large catches of *biawan* are common during dropping water.

---

[13] Including *temilar* and similar rectangular traps.

[14] It was not possible to record the catch from each trap separately because each fisher does not keep the catch from each trap separate.

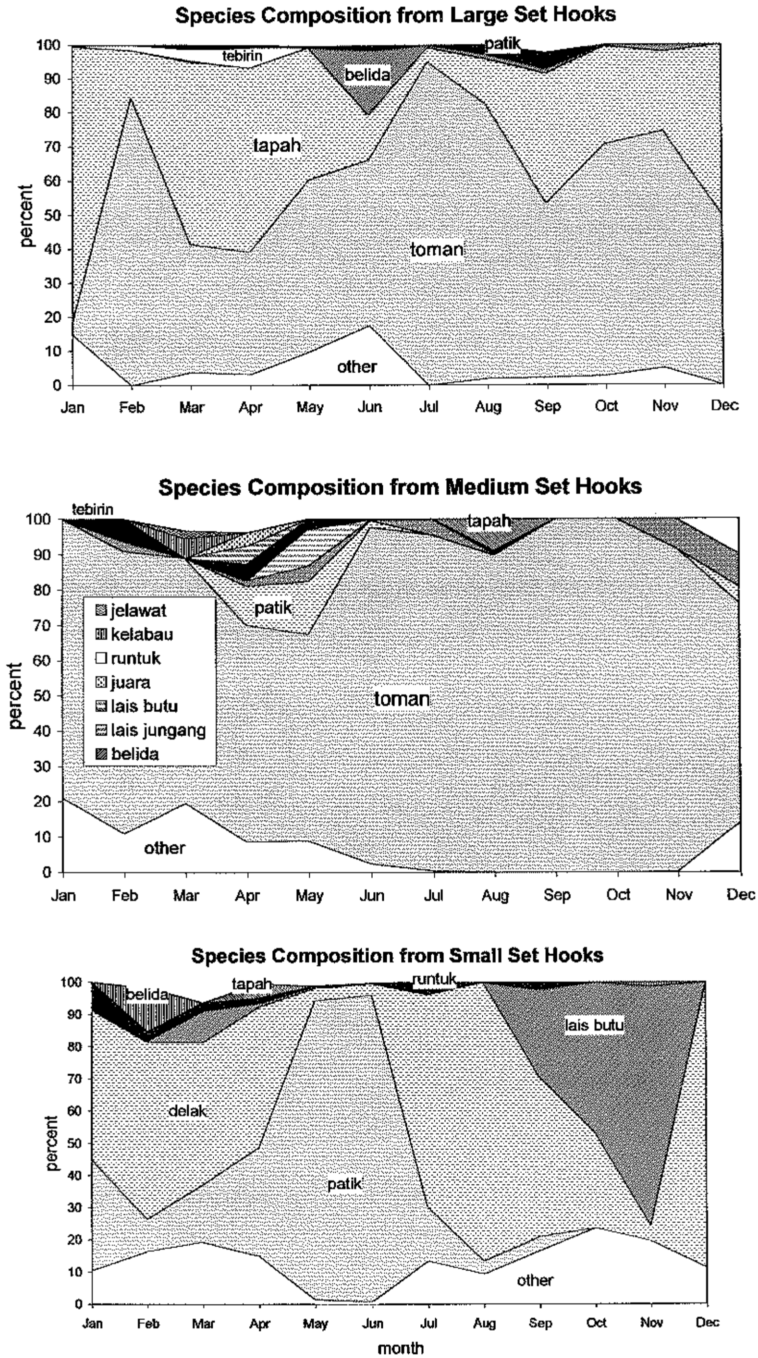


Figure 11 a, b. Species composition from set hooks.

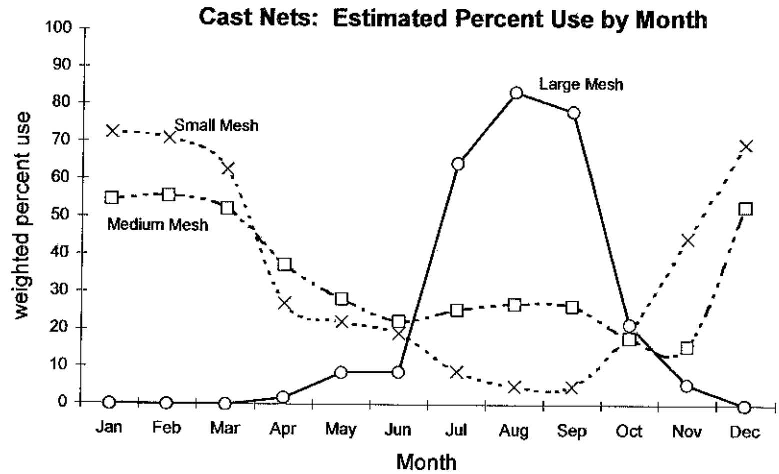


Figure 12. Seasonality of fishing effort with cast nets of differing mesh sizes.

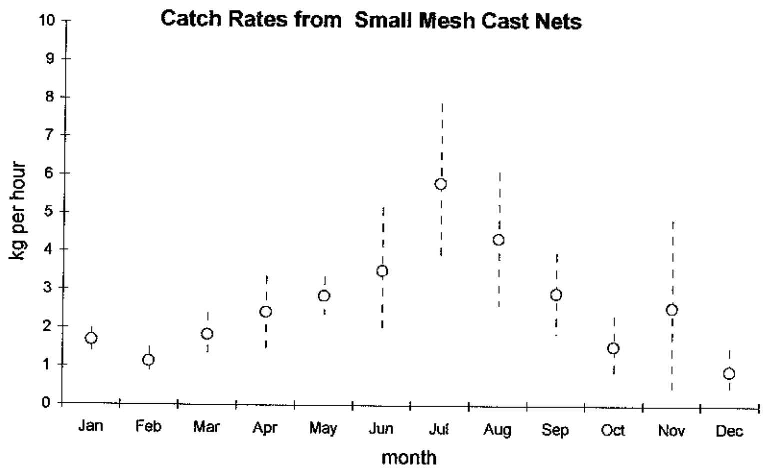
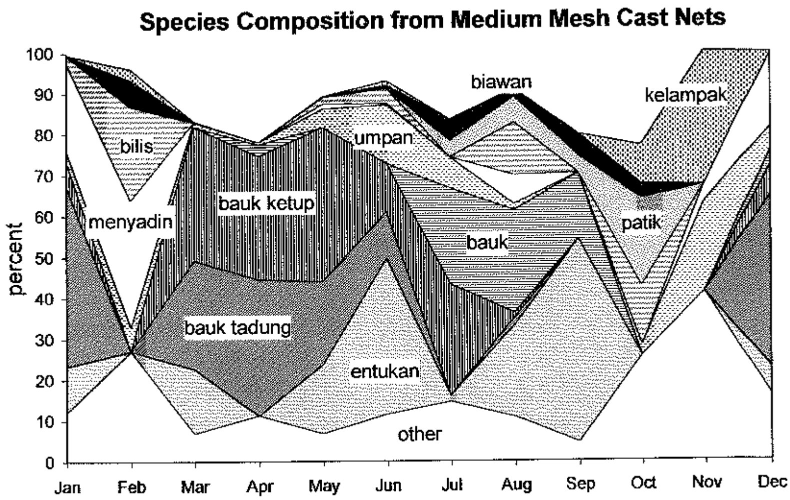


Figure 13. Catch rates from cast nets.



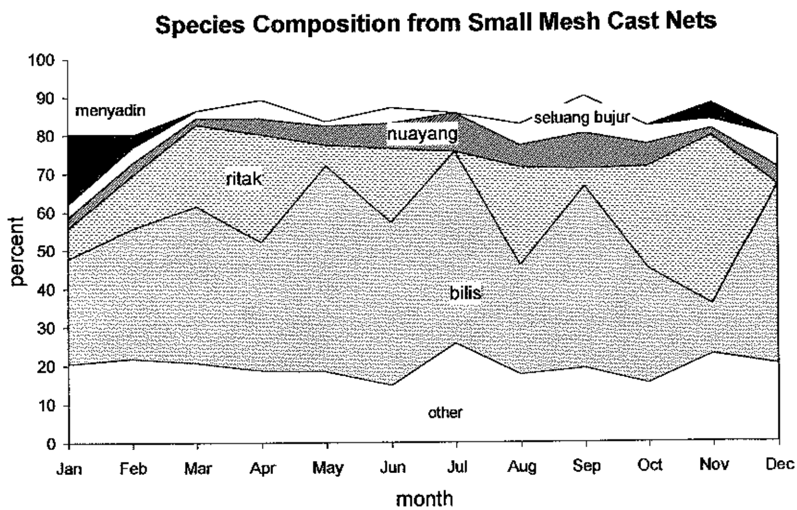


Figure 14. Species composition from cast nets.

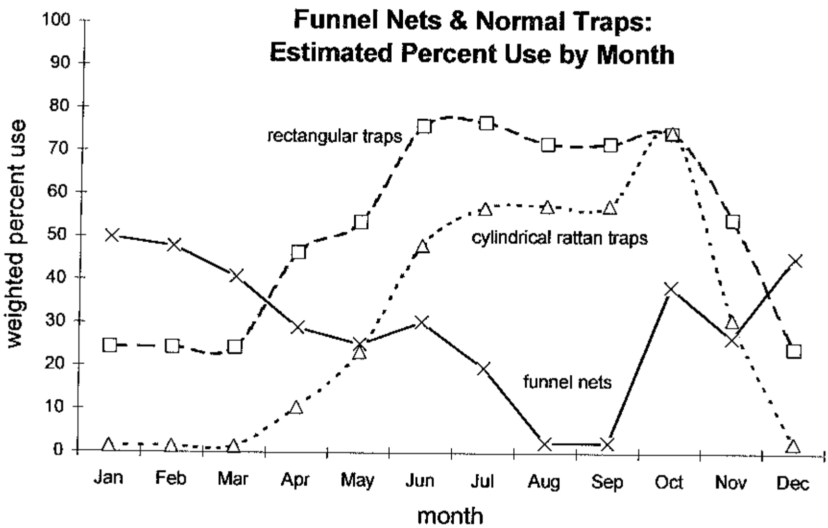


Figure 15. Seasonality of fishing effort with *jermal* and normal traps.

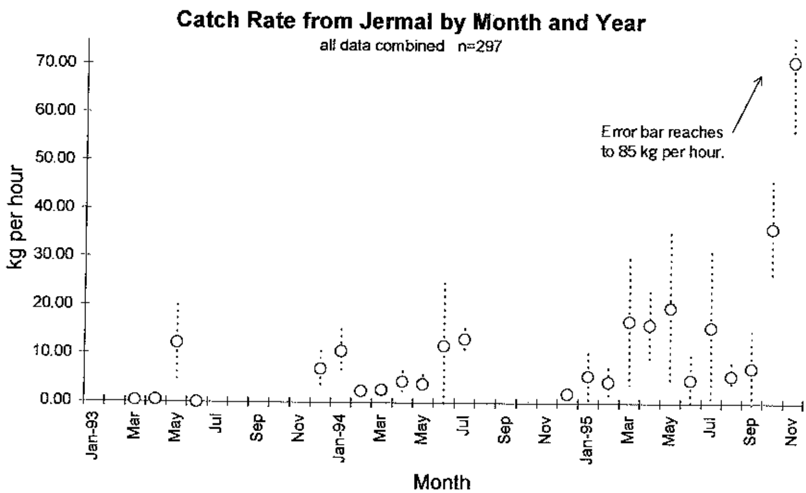


Figure 16. Mean monthly catch rates from *jermal*.

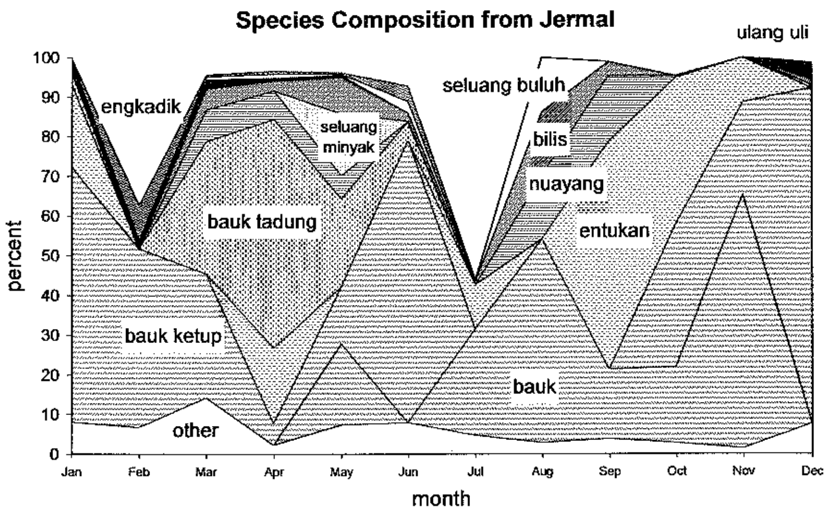


Figure 17. Species composition in *jermal* catches.

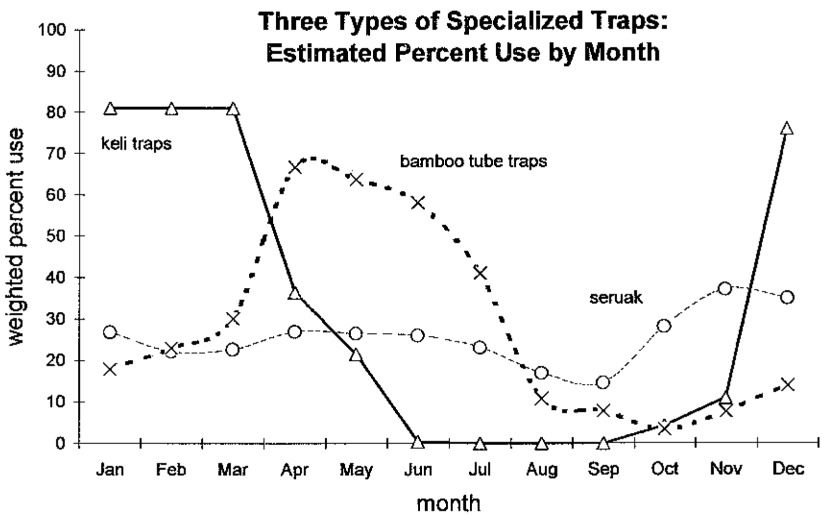


Figure 18. Seasonality of fishing effort with three types of specialized traps.

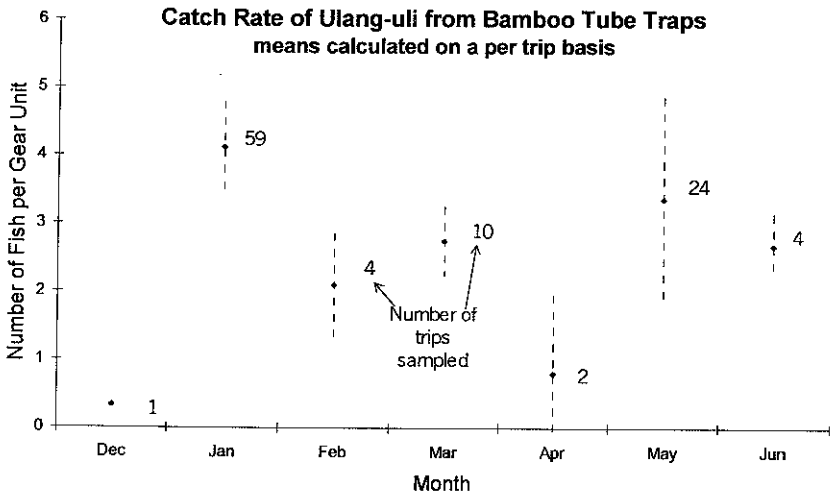


Figure 19. Catch rate of *ulang uli* from bamboo tube traps.

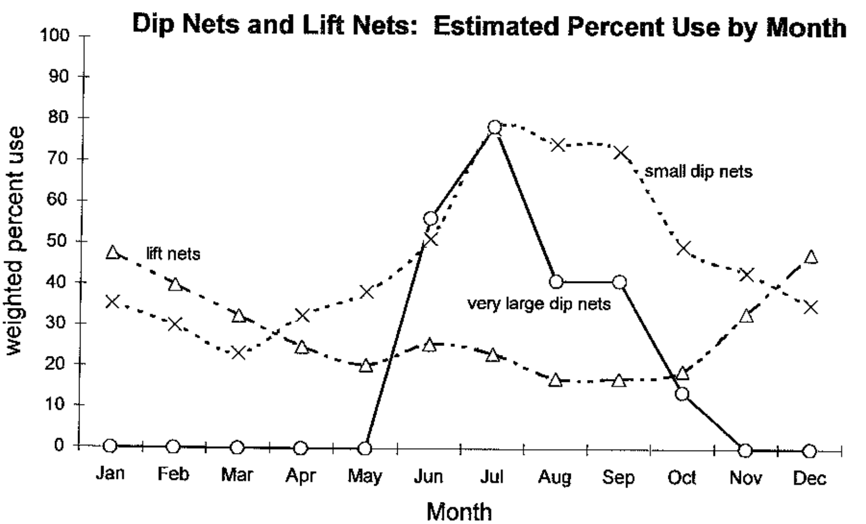


Figure 20. Seasonality of use of dip and lift nets.

Bubu Keli

Bubu keli (also called *seruak keli*) are similar to *seruak* (see below), but larger (up to 50 cm diameter), with a different type of opening. These are deployed specifically to catch *keli*.

Fisherfolk use these traps during October through May and especially during high water (Figure 18). Catch survey data from 59 trips (818 traps) indicate a catch rate typically less than 0.04 kg per hour with somewhat higher catches during March, April and May. *Bubu keli* catch mostly *keli*—over 60% by weight and numbers.

Seruak

Seruak are small (about 35 cm x 35 cm) cylindrical traps made from split bamboo with bamboo tube entrances. *Seruak* appear to be used throughout the year to catch juvenile *jelawat*. Very limited information about this gear indicates a catch rate of 0.06 kg per hour. *Seruak* caught an average of 12.8 juvenile *jelawat* per trap.[15] Young *jelawat* make up more than 25% of the catch by number, but a mixture of other species are also caught.

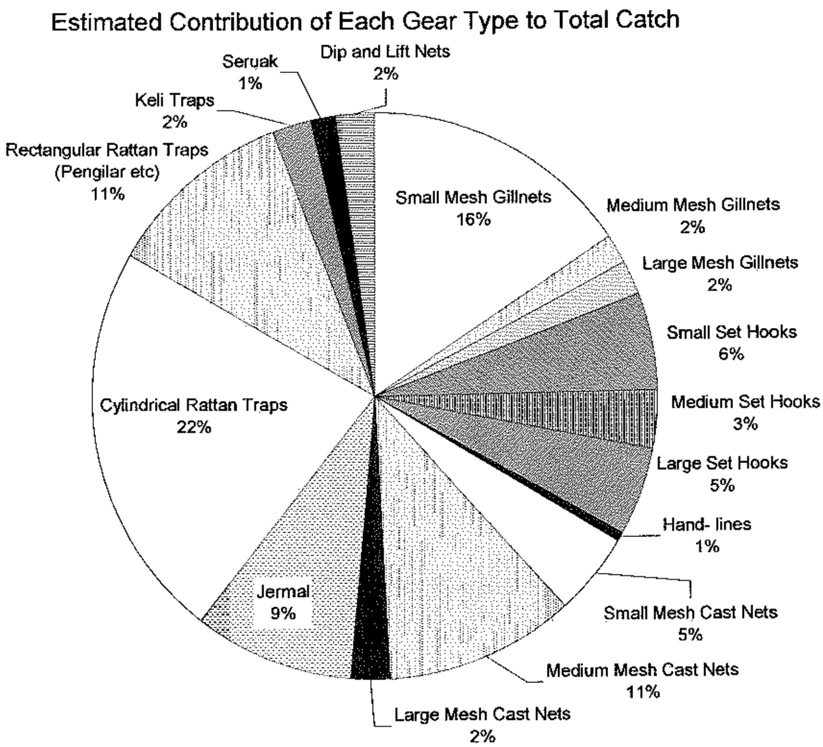


Figure 21. Catch composition by fishing gear type for the revised catch estimate.

Bamboo Tube Traps: *Tabung*

Tabung are bamboo tubes up to 2 m long with a 2 to 3 cm hole cut into the top of each bamboo segment. Sometimes the tubes are tied in bundles. *Tabung* are used primarily to catch live *ulang uli*.

[15]Numbers of *jelawat* caught were recorded for only 23 trips, and this figure is based primarily on 22 trips sampled in December 1994.

Overall, fisherfolk reported the most use of *tabung* during March through early July (Figure 18), but in some years there is another *ulang uli* season in December and January. Villagers in the middle part of DSNP reported more use of *tabung* during December and January compared to other DSNP residents.[16]

Data from 126 trips[17] in which *tabung* were used yielded an average catch of about 3.5 fish per tube (Figure 19). Over 97% of the fish reported from tabung were *ulang uli*. Other species caught included *engkadik, engkarit, menyadin, bantak*, and *seluang batu*, as well as 15 other species. Typical sizes of *ulang uli*, caught by all methods, were 2 to 7 cm and averaged just over 4 cm.

Lift and Dip Nets

Small lift nets and dip nets are commonly used on an occasional or casual basis throughout the year (Figure 20).

Small dip nets (*sauk*) are about 40 to 60 cm in diameter. Lift nets (*pesat*) are square nets usually about 1 to 1.5 m (rarely 2 m) on each side. They are fixed to bamboo cross-pieces and lowered and lifted fixed to the end of a pole. Most families own both a dip net and a lift net. An estimated 1,290 dip nets and 1,410 small lift nets were in use during the survey period.

Very large oval dip nets (*ambai*) are commonly seen along the Tawang and Belitung Rivers. These have 3 to 4 inch mesh and are about 3 to 5 m long and 1.5 to 2 m across. They are used during dropping water (Figure 20). Only 33 of these were reported in the fishing gear survey and an estimate for the park would be about 90. These large dip nets are used to catch *belida*.

The catch survey did not sample small or large dip nets adequately to estimate catch rates. *Bilis* dominated catches of small lift nets which were sampled but many other small species were also caught.

Small lift nets were sampled only 149 times during the catch survey, and were perhaps sampled at times when use of these nets was common. The sampling probably did not reflect the casual, every-day, less productive use of these nets. Catch survey data indicated a catch per hour of 1.5 kg with no obvious seasonal trends.

Total Catch Estimate

Accurate annual estimates of total catch from DSNP cannot be made given the quality and quantity of data currently available. The large number of fishing gear types and the scattered nature of the fishery, would make accurate estimates difficult, and expensive. A approximation of the total catch from DSNP in a typical year, can be made using the data reported herein.

The following estimate is based on estimates calculated for each type of fishing gear within each month. Each of these is the product of the estimated: 1) number of gear units, 2) intensity of use, 3) catch rate, and 4) number of potential fishing trips within each month.

An initial calculation resulted in an value of 15,000 tons, but this seems likely to be an over-estimate. This would amount to a fish yield of 187.5 kg per ha per year, based on

[16]Of the six park sub-areas, three (the mid section, the Belitung section and the upper Tawang section) reported using *tabung* in December and January.

[17]Of these trips 97 included data regarding the weight of the catch and 104 included number of *ulang uli* caught.

an area of approximately 80,000 ha of lakes, rivers and flooded forest within the park. This would fall at the very upper end of the range of fish yields from similar floodplain waters (see, for example, summaries in Giesen 1987 and Lowe-McConnell 1987, Bayley 1988, and Hogarth and Kirkwood 1996). A catch of this magnitude from the relatively sterile black waters of DSNP seems unlikely. Catches from another Indonesian floodplain, along part of the Lempuing River in South Sumatra, was estimated at 130 kg per ha (MRAG 1994).

Also, based on the initial estimate, the average catch per family during November is 17.5 kg per day, a rather high value for a period of time when catches are usually low. In fact catches during that period are almost certainly lower than 5 kg per family per day.[18]

Although Dudley and Harris (1987) reported the difficulties associated with the use of Indonesian fishery statistics for fishery analysis purposes, the Kapuas Hulu regency figures provide another basis for comparison. Reported catches for the Kapuas Hulu have gradually increased since 1973, and during 1984 to 1995 were between 11,000 and 17,500 tons. Thus the 15,000 ton catch estimate calculated for DSNP is more or less equal to the reported catch for the whole Kapuas Hulu. In contrast, Giesen (1987) estimated DSNP catches at about 2,800 tons or about 32% of the average (1973 through 1985) catch of 8,878 tons (reported at that time) for the Kapuas Hulu.

On the other hand current DSNP catches are certainly higher than those reported by Giesen (1987). Dudley and Widjanarti (1993) and Aglionby (1995), independently calculated that about 4,000 tons of fish are captured within DSNP solely to provide food for fish raised in cages. This catch is unlikely to have been reported by the fishery statistics system, but is included in the estimate presented herein. *Toman* were not raised in cages at the time of Giesen's (1987) work.

Factors possibly leading to a catch overestimate are several. Catches weights were usually estimated visually, and supervision of data collectors was minimal. Catches may have been routinely overestimated or there may have been a tendency to sample only larger catches. Fishing gear use could also have been overestimated.

Consequently the overall catch estimate was adjusted downward based on two objectives: to reduce the overall catch estimate to within the range of 130 to 140 kg per ha, and secondly to decrease the estimated per family catch during November through February. A recalculation target for the November catch per family of less than 5 kg per day was combined with an average target no higher than 10 kg per family per day for the months of November through February.

A "revised catch estimate" was calculated using the above constraints with the original per month estimates for each type of fishing gear as a starting point.[19] Each of the month by gear combinations in the original table were multiplied the same fraction to lower the overall catch. Data for November, December, January and February were also multiplied by an additional factor for each month.[20]

---

[18]Based on the author's field observations in 1992 while living in Nanga Pengembung and supported by record keeping by villagers there (personal communication, Carol Colfer).

[19]This was done using the "solver" function of the Microsoft Excel spreadsheet program.

[20]The adjustment factors used for these months were: Nov, 0.29; Dec, 0.37; Jan, 0.37; Feb, 0.48. The adjustment for all other months was 0.81.

The results of this recalculation are presented in Figure 21, and Figure 22. The revised catch estimate, calculated within these restrictions, is 10,400 tons. Any estimate based on these data has a fairly large variance, perhaps plus and minus 25%, which would put the actual catch in a typical year somewhere between 7,800 and 13,000 tons. This is the equivalent of between 97.5 and 162 kg per ha.

About 23% of the catch was derived from cylindrical rattan traps (*bubu*), 19% from gillnets, 15% from cast nets and 14% from hooks. Funnel nets (*jermal*) accounted for about 9 percent. The remaining amount (20%) is caught by other types of traps, liftnets and dip nets.

DSNP catches probably vary considerably from year to year. Fish populations should increase during years of high water, such as 1995 and 1996, when fishing effectiveness is lowered and extent of favorable habitat increased. These fish would then yield additional harvest during following, more typical, dry seasons. Extremely dry years would be expected to yield high catches, and such years may be followed by years with lower catches due to diminished fish populations. Extremely dry years also undoubtedly contribute to atypically high fish mortality which would also contribute to lowered catches for the next one to three years. These factors should combine to produce obvious fluctuations in catches. Such fluctuations have not been detected in fishery data currently available.

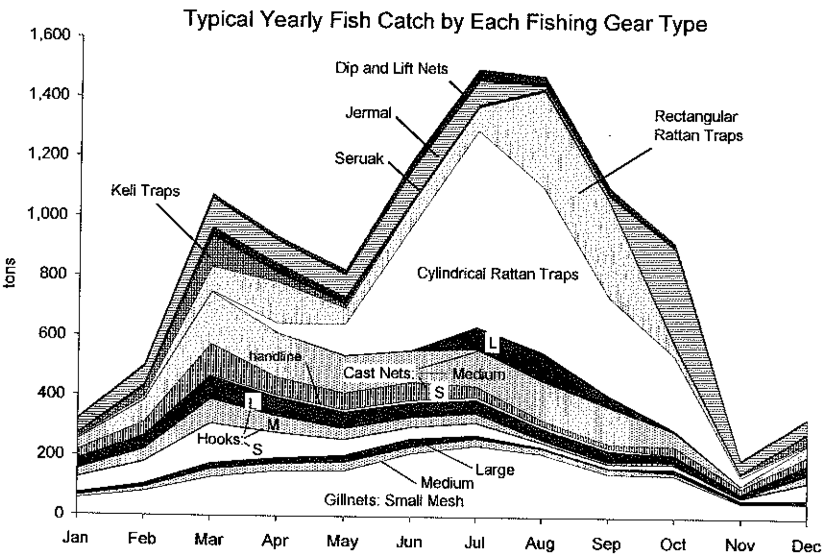


Figure 22. Revised catch estimate from DSNP by month during a typical year showing the contribution of each type of fishing gear. Based on catch survey data after adjustments to lower the overall catch and to lower catches during November through February. The revised total catch estimate is between 7,800 and 13,000 tons.

					Lengths (cm)					Possible Indicators			
						Data from DSWR			max/	ave/	ave L/	ave/	ave L/
Family	Genus	Species	Common Name		literature	ave	ave L	max	lit	lit	lit	max	max
Cyprinidae	Osteochilus	microcephalus	Bantak		14.2	6.6	8	17	1.20	0.46	0.56	0.39	0.47
Cyprinidae	Thynnichthys	polylepis	<u>Bauk ketup</u>		18	6.4	8.8	24	1.33	0.36	0.49	0.27	0.37 x
Cyprinidae	Labiobarbus	ocellatus	<u>Bauk tadung</u>		22	7	8.6	25	1.14	0.32	0.39	0.28	0.34 x
Cyprinidae	Macrochirichthys	macrochirus	<u>Belantau</u>		100	26.0	25.6	42	0.42	0.26	0.26	0.62	0.61 x
Notopteridae	Chitala	lopis	<u>Belida</u>		150	49.1	50.2	112	0.75	0.33	0.33	0.44	0.45 x
Helostomatidae	Helostoma	temminckii	Biawan		30	11.5	14.5	32	1.07	0.38	0.48	0.36	0.45
Cyprinidae	Cyclocheilichthys	armatus	Buin		23	13.1	15.8	20	0.87	0.57	0.69	0.65	0.79
Cyprinidae	Cyclocheilichthys	repason	Buin		28	13.1	15.8	20	0.71	0.47	0.56	0.65	0.79
Channidae	Channa	striata	<u>Delak</u>		90	22.1	26.8	48	0.53	0.25	0.30	0.46	0.56 x
Pangasiidae	Pangasius	polyuranodon	Duara		83	32.2	38.4	58	0.70	0.39	0.46	0.56	0.66
Cyprinidae	Cyclocheilichthys	apogon	Emperas		20	11.5	14.7	20	1.00	0.57	0.74	0.57	0.74
Cobitidae	Botia	hymenophysa	<u>Engkadik</u>		21	5.1	7.3	17	0.81	0.24	0.35	0.30	0.43 x
Cyprinidae	Thynnichthys	thynnoides	Entukan		23	15.1	17.6	30	1.30	0.66	0.76	0.50	0.59
Cyprinidae	Leptobarbus	hoevenii	Jelawat		60	23.2		45	0.75	0.39		0.52	
Cyprinidae	Rohteichthys	microlepis	Kapas		30	15.4	16.1	21	0.70	0.51	0.54	0.73	0.77
Cyprinidae	Amblyrhynchichthys	truncatus	Kedukul		28	-14.4	19.6	25	0.89	0.52	0.70	0.58	0.78
Cyprinidae	Osteochilus	melanopleura	<u>Kelabau</u>		37	14.7	19.0	47	1.27	0.40	0.51	0.31	0.40 x
Cyprinidae	Osteochilus	schlegelii	<u>Kelabau putih=kebali</u>		40	13.6	19.2	36	0.90	0.34	0.48	0.38	0.53 x
Cyprinidae	Parachela	oxygastroides	<u>Kelampak</u>		20	8.6	11.2	25	1.25	0.43	0.56	0.34	0.45 x
Clariidae	Clarias	batrachus	Kelik		40	24.7	29.1	40	1.00	0.62	0.73	0.62	0.73
Clariidae	Clarias	leiacanthus	Kelik		33	24.7	29.1	40	1.21	0.75	0.88	0.62	0.73
Clariidae	Clarias	meladerma	Kelik		34	24.7	29.1	40	1.18	0.73	0.86	0.62	0.73
Cyprinidae	Luciosoma	trinema	Kenyuar		25.5	11.0	11.7	25	0.98	0.43	0.46	0.44	0.47
Channidae	Channa	pleurophthalmus	Kerandang		40	23.1	23.0	36	0.90	0.58	0.57	0.64	0.64
Eleotrididae	Oxyeleotris	marmorata	Ketutuk		46	24.6	30.6	48	1.04	0.53	0.66	0.51	0.64
Cyprinidae	Labiobarbus	festivus	Kujam		24	15.6	7.2	29	1.21	0.65	0.30	0.54	0.25
Siluridae	Kryptopterus	micronema	Lais bangah		32.5	41.0	50.6	68	2.09	1.26	1.56	0.60	0.74
Siluridae	Ompok	hypophthalmus	Lais butu		31	19.7	22.6	40	1.29	0.64	0.73	0.49	0.56
Siluridae	Kryptopterus	apogon	<u>Lais jungang</u>		77	24.3	28.7	61	0.79	0.32	0.37	0.40	0.47 x
Bagridae	Mystus	nigriceps	Landin		33.5	12.8	15.0	21	0.63	0.38	0.45	0.61	0.72
Cyprinidae	Hampala	macrolepidota	Langkung		70	25.1	27.1	40	0.57	0.36	0.39	0.63	0.68
Schilbidae	Pseudeutropius	brachypopterus	Nuayang tebal		11.5	6.4	8.2	16	1.39	0.55	0.71	0.40	0.51
Schilbidae	Pseudeutropius	moolenburghae	Nuayang tipis		10	6.4	8.2	16	1.60	0.64	0.82	0.40	0.51
Cyprinidae	Osteochilus	kahajanensis	Palau		22	10.4	11.3	22	1.00	0.47	0.52	0.47	0.52
Cyprinidae	Osteochilus	kappenii	Palau		17.5	10.4	11.3	22	1.26	0.60	0.65	0.47	0.52
Bagridae	Mystus	nemurus	<u>Patik / baung</u>		57	19.6	22.7	60	1.05	0.34	0.40	0.33	0.38 x
Pristolepididae	Pristolepis	fasciata	Patung		21	10.0	12.4	21	1.00	0.48	0.59	0.48	0.59
Cyprinidae	Leptobarbus	melanopterus	Piyam		24	14.0	14.7	30	1.25	0.58	0.61	0.47	0.49
Channidae	Channa	marulioides	Piyang		27	28.1	27.9	41	1.52	1.04	1.03	0.69	0.68
Bagridae	Mystus	micracanthus	Rik		15	7.0	8.7	18	1.20	0.47	0.58	0.39	0.48
Datnioididae	Datnioides (Coius)	microlepis	<u>Ringau</u>		47	16.1	22.0	31	0.66	0.34	0.47	0.52	0.71 x
Channidae	Channa	bankanensis	Runtuk		23.5	19.2	23.2	40	1.70	0.82	0.99	0.48	0.58
Channidae	Channa	lucius	Runtuk		36	19.2	23.2	40	1.11	0.53	0.65	0.48	0.58
Chandidae	Paradoxodacna	piratica	Senara	?	10	7.4	9.3	22	2.20	0.74	0.93	0.34	0.42 ?
Chandidae	Parambassis	apogonoides	Senara	?	9	7.4	9.3	22	2.44	0.83	1.04	0.34	0.42 ?
Chandidae	Parambassis	macrolepis	Senara	?	10	7.4	9.3	22	2.20	0.74	0.93	0.34	0.42 ?
Chandidae	Parambassis	wolffii	Senara	?	20	7.4	9.3	22	1.10	0.37	0.47	0.34	0.42 ?
Engraulididae	Lycothrissa	crocodilus	Silauari		24	14.5	15.5	19	0.79	0.60	0.64	0.76	0.81
Engraulididae	Setipina	cf. melanochir	Silauari										
Siluridae	Wallago	leeri	Tapah		150	59.7	50.0	130	0.87	0.40	0.33	0.46	0.38
Siluridae	Belodontichthys	dinema	Tebirin		70	46.6	47.7	73	1.04	0.67	0.68	0.64	0.65
Cyprinidae	Labeo	chrysophekadion	<u>Temunit</u>		80	13.8	18.5	34	0.43	0.17	0.23	0.40	0.54 x
Cyprinidae	Barbodes	schwanenfeldii	<u>Tengadak (=suain)</u>		35	7.1	8.1	23	0.66	0.20	0.23	0.31	0.35 x
Cyprinidae	Puntioplites	bulu	<u>Tengalan</u>		37	17.1	22.8	53	1.43	0.46	0.62	0.32	0.43 x
Mastacembelidae	Mastacembelus	erythrotaenia	Tilan belaban	?	76	12.6	18.9	73	0.96	0.17	0.25	0.17	0.26 ?
Mastacembelidae	Macrognathus	maculatus	Tilan kapar	?	28	12.6	18.9	73	2.61	0.45	0.68	0.17	0.26 ?
Mastacembelidae	Macrognathus	aculeatus	Tilan kelokoi	?	27.5	12.6	18.9	73	2.65	0.46	0.69	0.17	0.26 ?
Mastacembelidae	Mastacembelus	unicolor	Tilan kelokoi	?	55	12.6	18.9	73	1.33	0.23	0.34	0.17	0.26 ?
Channidae	Channa	micropeltes	Toman		100	37.8	38.9	97	0.97	0.38	0.39	0.39	0.40
Cobitidae	Botia	macracanthus	<u>Ulang uli</u>		30	4.4	5.9	20	0.67	0.15	0.20	0.22	0.29 x
Cyprinidae	Puntioplites	waandersii	<u>Umpan</u>		50	12.3	15.4	37	0.74	0.25	0.31	0.33	0.42 x

Notes:
for Toman reported lengths of less than 10 cm were excluded from the calculations.
for Jelawat lengths less than 12 cm were excluded from the calculations.

Table 6. Fishes commonly caught that reach a maximum size greater than 15 cm. A comparison of typical total length in the catch with the maximum possible length gives a crude indicator of intensity of fishing for each species. Common names for fishes this measure indicated a possible problem are <u>underlined</u>. Maximum size was taken from the literature. If maximum size in our samples (max) exceeded the value from the literature then the largest size from our samples was used in calculating the indicator. If the indicator was less than 0.35 it was taken as a suggestion that the average size caught was relatively small compared to the potential maximum size.

Another indicator using the average of typical large fish in each catch is provided for comparison (ave L/ max or ave L/ lit). Because forms did not always contain information about fish lengths, sometimes ave L is smaller than ave.

Common names were taken from the data forms and, after some consolidation,

matched with scientific names from Widjanarti (1996). Boxes enclose data from species sharing the same common name.

NOTES: ave=average of "average length" reported on the catch forms, ave L=average of "length of large fish" reported on forms, max=largest size reported on any form, lit=maximum length reported in Kottelat *et al.* (1993) or from Giesen (1987).

Fishery Management Considerations

Goals

The overall fishery management goals of Indonesia include the provision of food and employment as well as management to ensure long term productivity of the fishery and the allocation of the fish catch among a relatively large number of people.

Management of the national park implies other goals such as: the protection of biodiversity, the protection of endangered species, general protection of flora and fauna, and the park itself. In fact it is generally agreed that, under Indonesian law, people cannot live within a wildlife park. This legal situation complicates efforts at co-management of the resource because, legally, local people should not be there. Legalities of resource ownership are beyond the scope of this paper, except to say that residents of DSNP have fished in the area for many years. However, numbers of park residents is much greater now than in the recent past.[21]

In theory the issue of resource allocation is reasonably straightforward. Any permitted fish harvest should be allocated to persons who traditionally fished in DSNP. In addition to people living in the park, people from outside the park, from towns along the Kapuas River and from Dayak villages to the north, have traditionally fished within the park, especially during the dry season. Also, fish leave the park during low water, and allocation of permitted fish catches to those outside the park must also be considered.

The general goals of fishery management at DSNP, might be stated thusly:

> To manage the DSNP fishery: on a sustainable basis, for harvest by persons traditionally involved in the fishery, in a way that will protect and enhance the wildlife park functions of DSNP.

Size considerations

Within DSNP some fish species are caught at sub-optimal sizes because of the many types of small-mesh fishing gear being used. Several species identified by villagers as being less abundant than in years past (see page Figure 23) are also species that would typically reach larger sizes than are currently common. As an example *belantau* is listed as having a maximum length of 100 cm (Kottelat *et al.* 1993), but the largest specimen recorded during our three year catch survey was 35 cm, and most individuals examined were less than 30 cm. It is possible that the *belantau* population has been reduced by excessive fishing especially with small mesh gears.

---

[21]Giesen (1987: 184) reported that many villages are fairly recent, but that others were established in the 1800's or earlier. He notes also that the populations of the larger villages grew rapidly during the 1980s, and Aglionby (1995) reported that the permanent population of the park had grown 40% in the last 10 years.

Various workers (e.g. Beaverton and Holt 1959) have reported that the ratio of size at first maturity to maximum size is a constant within species groups. This ratio falls between 0.4 and 0.8. That is, for some species, size at first spawning is 40% the maximum size while for others the ratio is larger. For commonly caught DSNP species we can compare maximum size reported in the literature to typical sizes reported in our DSNP catch data. In lieu of other measures, the ratio of typical size to maximum possible size can be used as a general indicator over-harvest to indicate which species warrant further study. Table 6 contains 48 fish[22] which are both reasonably abundant in DSNP catches and also reach a maximum size of 15 cm or more. Also indicated on this table is the ratio of the typical size[23] in the catch to the expected maximum size. Species where this ratio is less than 0.35 [24] are considered "possibly over-fished." The biology of these fishes should be investigated, particularly with regard to their size at first breeding. These 17 species are:

Belantau: Reported as rare by fishermen since the 1960's, and large individuals are no longer present.

Belida: Listed as a protected species by Indonesia since 1980[25], and is rare in other areas of Indonesia where it was formerly abundant. The population at DSNP is healthy, but the diminishing size of *belida* in the is of concern.

Ulang uli, *engkadik*, and *ringau*: Ornamental species important for the aquarium trade. *Ringau* is vulnerable because it has a relatively large size at breeding compared to its marketable size, and large individuals are rare. Populations of the other two seem tolerant to extreme fishing pressure on the young. Over two million *ulang uli* are exported from the Kapuas Hulu year after year. The adults of both species are increasingly rare, and collapse of these fisheries could occur.

Kelabau, *kelabau putih*, *tengadak*, *tengalan*, and *umpan*: These similar species of the cyprinid family, capable reaching moderate sizes (35 to 50 cm depending on the species), are generally caught at smaller sizes in small-mesh gill nets, and other gear. Generally, large specimens are absent from the catches.

Temunit: Although fairly common, fishermen claim, and data support this claim, that large specimens are absent. The largest individual recorded in our catches was less than half the maximum size.

Delak: One of several similar species. Data concerning it may not be accurate. Members of this genus (*Channa*), including *toman*, are an important component of the hook fishery, and require further study.

Bauk ketup and *bauk tadung*: Common in cast nets and *jermal*. May not be "over-fished" since both abundant at times. Nevertheless, large specimens are not common in the catches.

Kelampak: Caught in cast nets and *jermal* but make up only a moderate to small proportion of the catch.

---

[22]These 48 common names include 56 species names.

[23]Data collectors were asked to recorded the largest, smallest, and "normal" size of fish in each catch.

[24]This is an arbitrary value, but is based on the idea that fish might start breeding at sizes as small as *perhaps* 0.4 times the maximum length. If the average size in the catch is 0.35 L_{max} then some fish will have a chance to breed even if fishing is intense.

[25]Protected by Ministerial Decree: Kep. Ment. Per. No. 716/Kpts/Um/10/1980.

Lais jungang: An important component of the gill net fishery. Larger specimens are fairly rare.

Patik (= *baung*) is probably not currently in danger of being over fished. It is abundant, although large specimens may not be as abundant as in the past.

Species of Special Interest

Other fishes reported as rare or of significantly lowered abundance, but not indicated by the size ratio above, are reported in Table 7. Only two *siluk* were reported during our survey. This species was formerly common. Trade in this ornamental fish is an extreme example of what results if adequate controls are not in place when a natural product increases in value. Twenty years ago fish traders realized that red phase *siluk*, found primarily the DSNP area, could be sold for as much as $3,000. The resulting intensive fishery almost exterminated this species.[26]

siluk (=arowana)	Very high price and resulting intensive fishing has almost exterminated this species from the wild.
bubuk (=*paku*)	Also reported as rare by Giesen (1987).
large *jelawat* (those over 3 kg)	Large specimens are very uncommon. Widely cultivated. Not endangered but no longer an important component of the fishery.
piam	Still present but no longer numerous.
ketutung	Fisherfolk now consider these extremely rare, but were formerly abundant. They are no longer caught, and were not reported in our catches. None reported by Kottelat (1993) or Widjanarti (1996). However, Giesen reported this species as abundant in 1987.
kapas	Reported by fishermen as less abundant than in years past. However, this species was listed on over 200 (5%) of our forms, and the sizes caught do not indicate any obvious problems.

Table 7. Types of fish reported as rare by DSNP fisherfolk. Based on field notes, especially discussions with fishermen in Nanga Kenelang, 5 November 1992.

Ulang uli, intensively harvested in Kalimantan and Sumatra for the aquarium fish trade, may be over-harvested in the Kapuas Hulu region. Large specimens are rarely encountered by fishermen. A local regulation requires that *ulang uli* larger than 15 cm be released. The market for this species is for smaller specimens but larger specimens are vulnerable to gill nets.

Ulang uli are migratory, but the nature of the migration is unknown. Young fish first appear in December and January with a second peak in abundance occurring in April and May. Prasetyo and Ahmadi (1994) reported a similar catch pattern for *ulang uli* in the Batang Hari River in Sumatra. There fish less than "2 inci" were caught downstream, implying that spawning may be in downstream areas. *Ulang uli* caught in DSNP are usually 2 to 6 cm and average somewhat less than 5 cm. Information on the growth, migration and breeding of *ulang uli* is essential for better management.

---

[26]Attempts to increase the value of other harvested products must be coupled with initiatives carefully manage the resource in question. In this regard particular attention should be paid to *siluk, belida, ketutuk, ulang uli*.

Fisherfolk report that large *jelawat* are no longer caught in DSNP area. Although, the size ratio used above did not detect *jelewat* as a species needing attention this result is because the maximum size reported in the literature (41 cm in Kottelat *et al.* 1993, and 60 cm in Giesen 1987) is considerably smaller than the actual potential maximum size. Using a length-weight relationship (Christensen *et al.* 1986) the corresponding weight for a 60 cm fish would be about 5 kg. However, Sachlan (1957) reported *jelawat* as large as 18 kg. It seems possible, then, that *jelawat* are harvested at sub-optimal sizes.

Toman occur in over 80% of catches from large and medium size hooks, and comprise about 50% of the weight caught by those gears. A recent[27] development in DSNP communities is the raising of *toman* in cages (see Dudley and Widjanarti, 1993; Aglionby 1995). This lucrative activity provids almost one third of the total fish-related income in DSNP. Schools of juvenile *toman,* 3 to 5 cm long, are captured with cast nets in quiet backwaters. They are raised in wooden cages for 12 to 15 months until they reach 0.8 to 1.5 kg. While in the cages they are fed fish which are caught by any means possible.

Two potential fishery problems arise from *toman* cage culture. Firstly, large numbers of juvenile *toman* are taken from the wild,[28] and secondly a large amount of fish is caught to feed *toman.*

One opinion is that cage culture of fish is less destructive of the overall resource than fishing and thus is a reasonable money earning option for park residents. However, both cultured *toman* and their food are taken from the wild. Importantly, *toman* culture is carried out in addition to, not instead of, fishing activities. While *toman* cage culture earns needed money for people, uncontrolled growth of this practice could endanger DSNP resources. Consequently, it is necessary to limit, rather than promote, cage culture of *toman.* One approach might be to limit the number of *toman* cages per family.

Toman culture relies exclusively on the capture of juveniles from the wild, and may eventually endanger *toman* populations. At present adult *toman* are common, but as more young are taken from the wild, a negative seems likely. Villagers believe that the fishery for adult *toman* is facing a problem, and many villages have instituted regulations limiting capture of juvenile *toman.* Most have limited the minimum size at which the juveniles can be kept.[29] In some villages the fishery for juvenile *toman* had been (in 1995) closed.

The capture of large numbers of small fishes, including juveniles, for use as *toman* food, also seems problematic as this may add to the early mortality of important species (see also the sections on Natural Mortality and *Jermal* below).

Ketutut are increasingly important in the live fish food trade, and are held in cages until sold. They are caught in small numbers in medium and small-mesh gill nets and in traps. *Ketutut* over 0.5 kg were sold while those under 0.4 kg are held in cages and fed

---

[27]Giesen (1987) in a thorough study of the DSNP area did not discuss *toman* culture. Apparently *toman* culture was not important at that time.

[28]There are approximately 1,500 *toman* cages each stocked with 750 or more fish giving a total of about 1,125,000 fish being raised. Perhaps 67% of these cages are re-stocked with new fish each year requiring perhaps 750,000 *toman* fingerlings per year.

[29]This is also partly due to the fact that *toman* smaller than about 3 cm do not survive well in captivity.

until they are bigger.[30] *Ketutut* apparently spawn in DSNP, and juveniles (2 to 3 cm long) are know to frequent the shoreline at night. There are some reports that the young emerge onto shore. Some villagers believe that *Ketutut* are becoming less abundant, and several villages already have regulations limiting the size of capture of *ketutut*, or forbidding the capture of young. It seems inevitable that cage culture of this species will be attempted.

Fish Movement

Most fish leave DSNP during the dry season and thus are available to fishers outside the park. The flooded area at low water is often a small fraction of the high water area. Not only must fish leave DSNP, but they are forced to move significant distances and in doing so become more vulnerable to various types of fishing gear. Conversely, fish are carried into the park during rapidly rising water when the Tawang River flows into the park at rates exceeding 2,000 m^3 per second (Klepper 1994). Thus fish within DSNP originate from and return to the Kapuas River.

Natural Mortality

Natural mortality of fish, particularly young, is linked to yearly variations in water level. As water drops young (and other small) fish are increasingly vulnerable to predation. Lowered low oxygen concentrations in dropping waters probably increases mortality as well. During years of especially low water these effects are intensified. Predatory air breathing fish, such as members of the family Channidae (*toman* and related species) have more access to food during low water and are not affected by low oxygen concentrations.

In general fish populations that experience high natural mortality are less affected by intense fishing. Fish not caught will die of natural causes in any case. This situation, typical of floodplains, implies that harvest of floodplain fisheries can be fairly intensive without causing undue harm to the fish population.

Nevertheless, the ultimate ecological role of dying fish should be considered, particularly in a wildlife park. Under natural circumstances dying fish would be eaten by predator fishes and other predators including picivorous birds. A puzzling aspect of DSNP is the very low population of fish-eating birds, especially when compared to floodplains elsewhere. Giesen (1987, citing a report from 1903, and comments from DSNP residents) reported evidence of formerly abundant water bird populations. Egg collecting might account for disappearance of colonial water birds such as herons and egrets, while hooks and gill nets could account for the disappearance of other fish-eating birds.

Potentially Destructive Fishing Methods

Certain fishing methods are often viewed as destructive. The most widely cited example from DSNP is poison used by Dayak villagers (Giesen 1987, Aglionby 1995). However, other fishing gears are sometimes viewed as harmful. Within DSNP gill nets are banned in the village of Nanga Laboyan, and funnel nets (*jermal*) are illegal in many villages.

The deleterious nature of a fishing method depends on one's perspective. Dayak villagers catching fish in the traditional way (using poison) have a very different view than do Malay villagers downstream who see their caged fish dying as a result. Villagers

---

[30] Author's field notes 5 September 1992, Nanga Pengembung.

using *jermal* to catch *ulang uli* have a different view from those who perceive *jermal* as overly efficient nets which allow a few individuals to capture large numbers of fish. While recognizing that all fishing methods catch fish, characteristics which define "destructive" fishing methods might be:

1. Catch excessive numbers of fish prior to the minimum spawning size.
2. Cause the death of numerous fish which are not caught or used.
3. Are so efficient that fishing opportunities for other people are significantly decreased.
4. Cause the unnecessary death of organisms other than the target fish.

Many fishing methods might fall within these categories if used without regulation. Methods within DSNP most likely to cause these problems are poison, *jermal* and small-mesh gill nets. The use of both *jermal* and poison are already sensitive issues in the area and both have been the subject of various regulations.

Poison

Dayak villagers use poison to catch fish primarily during the dry season. Often use of poison causes death of excessive numbers of fish including those raised in cages by Malay villagers living downstream. Although traditional law specifies sanctions for improper use and types of poisons, some incidents have resulted in the involvement of police and intervention by the Governor (see Aglionby 1995).

Although use of traditional of fish poisons have long been a part of Dayak life, the negative impacts of poison on fish populations and on other fisherfolk are a critical issue. While the Iban (the Dayak group of the area) have rules and procedures for communal fishing with natural poisons (see Sandin 1980), the demographic and social environment of the villagers has changed so much that poisoning should not be practiced as freely as it once was (Wadley pers. com.). Ideally the use of poison should be phased out. The first steps toward making this transition would be enforce traditional law to eliminate the use of non "natural" poisons, to restrict poisoning to small areas, and to require agreement of other villages in the area.

Jermal

Formerly, *jermal* were primarily used to catch ornamental fishes, especially *ulang uli*. With the growing importance of *toman* cage culture, *jermal* have become a primary method of catching anything that can be fed to caged *toman*. Much of the controversy over *toman* culture is related to the use of *jermal* and their perceived impact on fish abundance. *Jermal* account for 10% of the annual DSNP catch. This is taken by relatively few individuals (perhaps 250), compared to more than 1,000 gill net users.

Jermal are, in theory, limited by a fisheries department permit requirement.[31] Many villages also have specific regulations related to seasons and places where *jermal* can be used. A number of villages prohibit *jermal*. The current efforts to limit *jermal* are worthwhile and should be continued. An effort should be made to decrease the role of *jermal* in providing food for *toman*. Possibly regulation could limit the size (mouth opening) of *jermal*, prohibit *jermal* which block more than 20% of a river, require *jermal* to be at least 200 m apart. Mesh size regulations for *jermal* are not realistic given their role in the *ulang uli* fishery.

[31]The requirement is also a source of income for the fisheries department.

Small-Mesh Gill Nets

Kelabau, kelabau putih (= *kebali*), *tengadak* (= *suain*), *tengalan* and *umpan* were identified as "over-fished" based on their sizes in the catch. These species are common in small-mesh gill net catches, and it is likely that excessive use of such nets are responsible for a decline in abundance of larger specimens. Gill nets with meshes of less than 2 inches account for over 58% of the gill nets recorded in the fishing gear survey, and over 45% of the gill nets encountered in the catch survey.[32] It is probable that large numbers of small-mesh gill nets are exerting a negative influence on DSNP fish populations by a) catching young fish prior to their spawning and b) by preventing fish from reaching an optimal size prior to harvest.

Very small-mesh nets (less than 1.75 inches) could be easily phased out because they comprise only 3% of gill nets. Because 55% of gill nets in use had a mesh size of 1.75 inches, further limits on mesh size may be difficult to institute. Nevertheless, it seems likely that a minimum gill net mesh size of 2 inches would be helpful, and regulation requiring meshes of this size or larger might be phased in over a two or three year period to allow retirement of smaller mesh nets.

Better management of large-mesh gill nets, used to catch *belida*, is also possible. *Belida* nets, especially those set across rivers, should have meshes that catch *belida* perhaps 50 cm or larger. The best mesh size for this approach is not yet known, but may be as large as 5 or 6 inches. Fisherfolk may be supportive of such a regulation and could suggest appropriate mesh sizes.

Suggested Fishery Management Approach

The Fishery and its Relation to the Park

At present there is little or no effect of DSNP on the fishery. No new regulations specifically associated with the existence of the park have been implemented. Because the park could act as a fish refuge during much of the flood season, and because some fish species are rare or said to be less abundant than in previous years, controlled and more restrictive fishing policies can benefit villagers, including those in areas outside DSNP. Overly strict regulation of fishing activity would limit the fish harvest and the livelihood of local people. Although considerable attention has been given to maintaining fish harvests by residents within the park, consideration also needs to be given to the role the park can play in protecting fishery resources. Since regulations are rarely enforced except at the local level: 1) enforcement will probably have to take place at the local level with support, when necessary, from local police, and 2) the existence of DSNP can be used to enhance protection and management of the fishery resource.

Human fishing activities have a direct effect on the integrity of the wildlife park. The large amount of fishing gear (especially hooks, traps and gill nets) has an impact on fish and other fauna (e.g. birds, turtles, crocodiles, snakes). The extent of this effect is difficult to gauge because these organisms were likely depleted over many years. Some of this impact, such as the entanglement of birds in fishing nets, is inadvertent, but some is intentional. These include activities directed at particular species (e.g., *siluk*) and continued use of poison for fishing. Excessive harvest of forest products for fishing use may also contribute to adverse effects of fishing on DSNP habitat. The harvest of rattan

---

[32]Additional amounts of small-mesh netting was used in combination with larger meshes, but the ratio of mesh sizes in the mixed nets is not known.

for making fish traps (and for other uses) is one example of human induced changes to DSNP flora (Peters 1993, 1994, 1995a, 1995b).

More general impacts associated with human activity affect wildlife park habitats. The major activities of this type are fire (Luttrell 1994), agriculture (Colfer *et al.* 1993a, b, c, d), harvest of timber and forest products (Indriana, N. 1995, Peters 1993, 1994, 1995a, Colfer *et al* 1993e), and hunting (Colfer *et al.* 1993f, Wadley *et al.* 1997). Of these a major concern is fire with over 20% of the park having been burnt in recent years.[33] For a summary of human impacts on DSNP see Giesen (1995).

Fishery and Park Management Starting Points

Of primary importance for park protection and better fishery management is the need to limit the number of people living within the park. Resources are limited, and an increasing human population has adverse effects on wildlife and habitat. The sensitivity of this issue prevents government agencies and NGOs from discussing it seriously. The first step toward limiting the number of residents could be to provide current residents with exclusive rights to live within the park and use rights for specified park resources. Residence permits might be issued in several forms (Table 8). In exchange for residence and use rights recipients could be obligated to abide by conservation regulations developed by their community in cooperation with appropriate agencies.

For better management of the park, it is essential that existing information be supplemented with a better understanding of the biology and ecology of fish. Information needed includes that about spawning periods, potential and actual maximum size, age, growth rates, size and age at maturity, and migration patterns. In addition, discovery of significant behavioral traits (such as special feeding or spawning requirements, and migratory behavior) would be important for fishery management.

Suggested Permit	Purpos	Time
Permanent stay ____ to be issued long-term residents only (have DSWR more than 8	To provide a fixed long-term DSWR residents the assurance that stay within	No time
Limited stay ____ for persons have lived within DSWR only years (have lived in DSWR 3 years)	To give shorter term an opportunity to DSWR for a limited years	3 to 5 (not
Temporary ____ for other term residents (have lived reserve less than 3 years) who traditionally have reserve for fishing or other management purposes, purposes are in agreement plan	To provide a legal persons to carry out traditional activities reserve. Should limite to those people who traditionally had access to resource	1 to 5 Renewable year but renewable year

Table 8. Suggested types of residence permits for DSNP. The concept of residence permits, and a target park human population, may have to come from outside the DSNP community, but the actual details of its implementation should come from the villagers themselves.

[33]Prior to the very dry 1997 dry season.

Design Principles for Collective Management of a Common Property Resource (adapted from Ostrom 1990)	Current DSNP Situation	Needed Actions
1. Clear boundaries and membership: People who participate in the harvest and management of resources are clearly identified. Boundaries of the resource are also clearly defined.	At present villagers within DSNP do not have recognized exclusive rights to fish, but do have local rules which usually require outsiders to have permission to fish within a village area. For each village a specific "work area" is recognized.	Work toward establishment of exclusive rights of DSNP villagers to fish within the context of a minimum set of conservation rules.
	However, there are ties between many villages and their "parent villages" outside the park along the Kapuas. It is possible that people from these Kapuas towns might also claim park resources. Others traditionally fish within the park.	Clarify other possible claims on park fishery resources and attempt to strengthen claims of villages within the park.
	In addition, there have been some statements from higher officials that the park's fishery is open to everyone.	Work to assure that officials at various levels recognize the claims of DSNP villagers on the fishery resource (within the conservation framework).
	Although villagers tend to recognize a need for overall fishery resource management, their current resource control mechanism extends only to each village's "work area."	See actions under Number 8
	In addition, fish migrate out of the park and are subject to fishing by "outsiders" during the dry season. However, villagers seem to accept this fact.	Examine the relative effects of fishing within and outside the park. If necessary implement rules at a level which includes areas outside the park. (see item 8)
	Note: In some ways the fishing area can be viewed as the collectively managed resource. Nevertheless, rules related to management of the fish resource itself are necessary.	

2. Congruent rules: Operational rules about how the resource is used are related to local conditions. In general those who use more of the resource should expend more time money or effort.	Rules developed in each village are specific to that village's needs. However, because fish migrate, rules for the whole area are needed, but do not exist. Village level rules differ among villages.	Work toward improved understanding of the need for fishery management over the entire researve and surrounding area. Also see Numbers 3 and 8.
	Villagers' (and managers') understanding of fish populations is limited. Consequently current understanding may not be sufficient for making appropriate rules.	Examine and improve villagers' information about biology and ecology of fish populations so that information can be incorporated into local rules. Use their information and new information to assist them in formulating fishery rules.
	Rules are generally equally applied to all people. There may be tendencies for those with more money to have more gear, but fishing sites seem to be allocated fairly (e.g., by lottery, rotation).	Encourage the idea that any new limitations (for example fishing gear limitations) should affect villagers in a equitable way.
3. Collective choice arrangements: People who are actually involved in using the resource have an opportunity to modify the rules governing resource use.	Villagers currently are involved with making village level rules regarding fish catching and fishing site allocation. There also seem to be inter-village mechanisms regarding the rules related to each village's work area.	Encourage the continuation and improvement of this system. Encourage the recognition of it as the fishery management system (within the conservation framework).
	Above the village level there are no such arrangements, although they are essential for good management of the fishery.	Assist in the establishment of arrangements to encourage park wide (and perhaps wider) rules regarding fish catching. See actions under number 8.
4. Monitoring: Users of the resource are responsible for monitoring the use of the resource, either directly or indirectly.	People in these villages generally know what is being done by their neighbors. Monitoring is done by the fishers themselves, at least at the village level.	Work to improve monitoring abilities to include inter-village cooperation.
5. Graduated sanctions: There is a series of gradually increasing punishments for violation of the rules. These depend on the seriousness	Most villages have fines or other measures to punish violators within the village work area. However, there are no mechanisms for park	Establish a park wide system of sanctions for park wide rules. These can probably be monitored at the village level since most fishing

and the context of the offence.	wide rule making or sanctions.	occurs within each village work area.
6. Conflict resolution mechanisms: Some sort of arrangement is necessary to discuss and resolve conflicts and disagreements that will arise.	This approach may be available at the village level.	
	Nevertheless, disagreements exist resulting from different rules in different villages (e.g., use of *jermal*, poison, gillnets), and there does not seem to be an effective mechanism, within the resource management context, to resolve these disagreements. Such disputes sometimes are brought to local police or government officials.	Establish, or improve existing, conflict resolution mechanisms, especially those for solving inter-village conflicts if they should arise.
7. Recognized rights to organize: External authorities do not interfere with the resource users right to devise their own rules.	Normally external authorities do not interfere with village level regulations. However, this may be merely due to a lack of interest on the part of the external authorities.	
	Sometimes, however, external authorities make rules or suggestions for rules which indicate that they do not formally recognize the village level regulations.	Assure that village and park level regulations, and rights to modify them, are officially acknowledged (within the framework of conservation rules).
8. Nested units: For more complex resource systems a system for developing management rules at several levels might be necessary.	There is no specific organization made up of resource users above the village level.	It is essential to help villagers establish fishery management units above the village level.
		These should be established at two (or three) levels: 1) groups of adjacent villages, 2) the whole DSNP, and perhaps 3) the DSNP plus surrounding villages where fishing is important.

	Note: Five sub-districts (*Kecamatan*) form the next higher legal entity above the village level. However, use of these as resource management units may divide rather than unite the DSNP villages. Nevertheless their cooperation is needed.	Work to assure that higher level mechanisms operate to unite park villages in their management of the fishery (for example across *Kecamatan* boundaries).

Suggested Needs for Collective Management within a Conservation Area	Current DSNP Situation	Needed Actions
1. Clearly defined rules and requirements for conservation (approved by conservation authorities) within which fishery (and other resource) rules can be formulated by resource users.	Although many conservation regulations exist, virtually none are enforced except perhaps in the case of large scale violations.	There is a need to formally incorporate conservation rules into the fishery regulations of the park fishery management program.
	Residents are generally aware of the status of the area as a wildlife park. They are also reasonably aware of the overall goals of conservation.	There is a need to continue awareness programs related to conservation goals, and to incorporate conservation enforcement into the fishery management package.
	Nevertheless, villagers have only been given a general idea as to what is expected of them in terms of conservation.	Conservation rules need to be formulated and will, necessarily include some restrictions on fishing methods. Fishery management rules created by resource users need to recognize these.
2. The number of people living in a conservation area should be limited and, over time, should be reduced.	The DSNP population has grown by over 40 percent in the past 10 years.	There is a serious need to stabilize the population of the park. A system of (a fixed number) of residence permits is suggested.
3. Benefits which might accompany conservation activity (e.g., better fishing, eco-tourism) should go to those who had prior resource rights.	This is the de-facto situation at present. However, there is currently no formal arrangement for these rights.	There is a need to establish a system to determine, and prioritize, any prior rights to park resources.

		Even though rights to certain resources may need to be limited by rules of the conservation framework, those with previous rights should have priority in receiving any benefits which might come from the protected area.
4. Arrangements for special rights within the park, need to incorporate a clear statement of who has such rights, what those rights are, and by what process they might be modified.	There is no formal recognition of such rights, although most parties seem to agree to this idea in principle.	Individuals and groups having special rights should be identified and their special rights within the park formalized and recognized.

Table 9. Actions needed at DSNP in relation to management of the fishery as a locally managed common property resource.

A Suggested Framework for Cooperative Management of Fisheries within DSNP

Although few effective means of governmental fishery regulation and enforcement exist at DSNP, this need is fulfilled, to a limited extent, by a system of village-level rules regarding fishing access, sites, and types of gear. These rules tend to be based on the perceived amount of fish available and on the relation between available fishing locations and village population. In some cases specific gear types are not allowed or certain types of fish cannot be captured. Local regulations form core of management ideas around which more comprehensive regulations can be structured. Comments about village-level fishery regulations can be found in Anon (1993) and Sinaga (1994a, b). Nevertheless, an effective management strategy can only evolve if rules are coordinated among all villages.

Basis of Cooperative Management

The existence of village level management leads to an overall strategy for fishery management. By building on existing management, mangers could incorporate both fishery and conservation needs. Ostrom (1990) believes that if certain "design principles" are met the likelihood of successful long-term local management of a common property resource will be enhanced. Table 8 shows Ostrom's eight design principles with the authors perception of the status of each principle at DSNP and probable actions needed to bring the DSNP situation into line with the principles. In the case of DSNP such design principles would be best applied within a conservation framework, and suggestions for such a framework appear at the bottom of Table 8.

Primary among actions needed to increase the likelihood of success of local management of the fishery resource is the need to formally recognize rights of local people to use and manage their resources.

There is a need to define the extent of the fishery resource for which management rights are recognized. Because fish leave the park during the dry season there is a reasonable concern that management only within the park is inadequate. However, fishing outside the park seems less important, and the Kapuas river channel is not suitable for many types of fishing. It may be sufficient to define the resource as the fishery within DSNP boundaries.

The ability of the people to make reasonable rules about their fishery needs to be strengthened. Although local people make rules at the village level there is no park-wide mechanism for making fishing rules and such a mechanism should be implemented.

Enforcement of regulations is necessary. Ideally most enforcement will be via peer pressure and cooperation. Nevertheless, sanctions of some sort must apply to those who violate agreed regulations. Presently village level sanctions exist with local police being called in if necessary. Evidence indicates that this approach needs to be strengthened by giving local regulations a firm legal status.

Better information about biology and ecology of fishes would be helpful for management, yet this is not available for many DSNP species. Local knowledge is one source of information. This can be supplemented with scientific studies. Of particular concern is knowledge from both sources related to breeding, migration, and growth of important fish species.

Within a Conservation Framework

For successful management of DSNP the locally managed fishery must be incorporated into the overall conservation framework. Local rules for fishery management should also comply with a set of conservation rules designed to protect DSNP and its biota. One essential is that the conservation rules be clarified, formalized, and disseminated so that people know what they are. Very probably local people need to discuss these rules, their timetable for implementation, and possible exceptions.[34]

A second link between successful management of DSNP and fishery management is the need to stabilize and decrease the human population of the park. This issue can be linked to the idea of prior resource rights if a reasonable formula can be established to determine which people have prior rights to the DSNP fishery. In addition to the permit system suggested above, which can be implemented over many years, more consideration should be given to improving economic opportunities public facilities in villages outside DSNP so people have more incentive to move or remain there.

A third step toward cooperative management of DSNP and the fishery is to provide an assurance to local people that benefits which might result from better management of DSNP will go to people who had prior resource use rights. For example, programs for eco-tourism should be arranged so that local people, rather than outsiders, are employed. Nevertheless, this approach should avoid representing the primary role of DSNP as a source of income, but income which may derive from the park in the course of good conservation management should, as a first priority, go to people who have prior resource use rights.

---

[34]For example, the important fish species *belida* is protected under Indonesian law and accordingly should not be harvested. Nevertheless it is harvested within DSNP, and it would be sensible to allow its harvest to continue. However, this "permission" could be linked to rules suggested to the local people/managers which would provide improved management for *belida*.

References

Aglionby, J.

1995 The economics and management of natural resources in Danau Sentarum Wildlife Park, West Kalimantan, Indonesia: a collection of papers.

Anon.

1992 Alat penangkapan ikan di perairan umum Kalimantan Barat [Fishing gear in waters of West Kalimantan]. Pemerintah Propinsi Daerah Tingkat I Kalimantan Barat, Dinas Perikanan.

1993 Minutes of meeting held with fisherfolk on 3 May 1993. Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Baley, Peter B.

1988 Accounting for effort when comparing tropical fisheries in lakes, river-floodplains, and lagoons. *Limnol. Oceanogr.* 33(4, part 2): 963-972.

Beverton, R. J. H., and Holt, S. J.

1957 On the dynamics of exploited fish populations. *Fishery Invest.*, Lond. Ser. 3, 19.

Christensen, M. S., A. Mulu, and A. Akbar.

1986 Technical report investigations into the fishery of the Middle Mahakam Area. TAD Project.

Colfer, C. J. P. and Noveriawan, Herry

1993a Terrestrial vegetable gardens in Nanga Pengembung and Bukit Tekenang (Study 1) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Colfer, C. J. P., Amoi and Suriansyah, Budi,

1993b Floating gardens. Bukit Tekenang and Nanga Pengembung (Study 2) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Colfer, C. J. P., Wadley, R. L. and Suriansyah, Budi,

1993c A record keeping study of terrestrial gardening in Wong Garai, Nanga Pengembung and Empaik (Study 3) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Colfer, C. J. P., Wadley, R. L. and Zulkarnain, Edi,

1993d Rice cultivation among the Iban of Wong Garai (Study 4) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Colfer, C. J. P., Wadley, R. L., Suriansyah, Budi and Widjanarti, E.,

1993e Use of forest products in three communities: a preliminary view (Study 7) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Colfer, C. J. P., Wadley, R. L., Sinaga, Pangarimpunan and Hood, I.

1993f Hunting among the Iban–first glimpses (Study 8) (June 1993). Attached report within Dudley and Colfer, Quarterly Report, July 1993. AWB.

Dudley, R. G. and Harris, K. C.

1987 The fisheries statistics system of Java, Indonesia: operational realities in a developing country. *Aquaculture and Fisheries Management* 18:365-374.

Dudley, R. G. and Widjanarti, H. E.
1993 Cage culture of ikan toman (Channa micropeltes): a possible problem for natural fisheries. Attached report within Dudley and Colfer, Quarterly Report, June 1993.

Dudley, R. G., Widjanarti, H. E. and Erman, A.
1993 Status of fishery studies carried out at DSNP. Attached report within Dudley and Colfer (1993), Quarterly Report, June 1993. AWB.

Giesen, W.
1987 Danau Sentarum Wildlife Park: Inventory, ecology and management guidelines. PHPA-WWF.
1995 The flooded forests & blackwater lakes of Danau Sentarum Wildlife Park, West Kalimantan, Indonesia. UK-Indonesia Tropical Forestry Management Project: Project 5-Conservation. Draft Report for Work Plan Activity B.1.1, Section A : Rapid Appraisal of Flora and Habitats. AWB (Indonesia)-AWB (Malaysia)-IPT, University of Malaya, Malaysia.

Hogarth, D. D. and Kirkwood, G. P.
1996 Technical interactions in tropical floodplain fisheries of south and south-east Asia. pp. 280-292. In Cowx, I.G., ed. *Stock assessment in inland fisheries*. Fishing News Books Ltd. UK.

Indriana, N.
1995 Pemanfaatan tumbuhan obat oleh masyarakat di kawasan Suaka Margasatwa Danau Sentarum, Kabupaten Kapuas Hulu, Kalimantan Barat [Use of medicinal plants by communities in the Danau Sentarum Wildlife Park area, Kapuas Hulu, West Kalimantan]. Laporan Praktek Lapangan. Fakultas Pertanian, Universitas Tanjungpura, Pontianak.

Klepper, O.
1994 A hydrological model of the upper Kapuas River and the Lake Sentarum wildlife park. PHPA-AWB.

Klepper, O., Suyatno, N. and Asmoro, P. B.
1994 A hydrological model of the Danau Sentarum floodplain lakes. Paper presented at the International Conference on Tropical Limnology, 4-8 July, Salatiga, Central Java, Indonesia. AWB.

Kottelat, M.
1993 Technical report on the fishes of Danau Sentarum Wildlife Park and the Kapuas Lakes area, Kalimantan Barat, Indonesia. AWB.
1995 Four new species of fishes from the middle Kapuas basin, Indonesian Borneo (Osteichthytes: Cyprinidae and Belontiidae). *The Raffles Bulletin of Zoology* 1995 43(1): 51-64.

Kottelat, M., A. J. Whitten, S. N. Kartikasari and S. Wirjoatmodjo.
1993 *Freshwater fishes of western Indonesia and Sulawesi*. Periplus Editions.

Lowe-McConnell, R. H.
1987 *Ecological studies in tropical fish communities* (Cambridge tropical biology series). Cambridge University Press.

Luttrell, C.,
1994 Forest burning in Danau Sentarum Wildlife Park (preliminary report). AWB, Bukit Tekenang Field Station.

MRAG
1994 Floodplain fisheries project. Biological assessment of the fisheries. Internal report to the Bath University Centre for Development Studies. Prepared by the Marine Resources Assessment Group.

Ostrom, E.
1990 *Governing the commons. The evolution of institutions for collective action.* Cambridge University Press.

Peters, C. M.
1993 Forest resources of the Danau Sentarum Wildlife Park: observations on the ecology, use and management potential of timber and non-timber products (Field Report I). AWB–The New York Botanical Garden.
1994 Forest resources of the Danau Sentarum Wildlife Park: strategies for the sustainable exploitation of timber and non-timber products (Field Report II). AWB–The New York Botanical Garden.
1995a Tembesu (Fagraea fragrans Roxb.): Utilisation and management in the Danau Sentarum Wildlife Park (Field Report III). AWB-The New York Botanical Garden. January, 1995.
1995b Rattan: utilisation and management in the Danau Sentarum Wildlife Park (Field Report IV). AWB–The New York Botanical Garden. January, 1995.

Prasetyo, Dadiek and Emod Ahmadi.
1994 Pola penangkapan ikan hias Botia (Botia macracanthus) di daerah aliran Sungai Batanghari Jambi [The pattern of capture of the ornamental fish Botia (Botia macracanthus) in the Batanghari River Basin]. *Lingkungan dan Pengembangan* 14(2):144-150.

Roberts, T. R.
1989 *The freshwater fishes of Western Borneo* (Kalimantan Barat, Indonesia). Memoirs of the California Academy of Sciences Number 14.

Sachlan, M.
1957 Kapuas Hulu daerah perikanan jang terdjauh di pedalaman [Fisheries of the farthest interior of the Kapuas Hulu Region]. Berita Perikanan. Tahun ke VIII, No. 12. Februari 1957.

Sandin, Benedict.
1980 *Iban Adat and Augury*. Penang: Penerbit Universiti Sains Malaysia, School of Comparative Social Sciences.

Sinaga, Pangarimpunan.
1994a Laporan kegiatan dan hasil rapat ketua nelayan wilayah Suaka Margasatwa Danau Sentarum, Juni 1994–Oktober 1994 [Activity report and results of a meeting with head fishermen in the Danau Sentarum Wildlife Park Area]. KSDA–AWB, Bukit Tekenang Field Station.
1994b Rapat ketua nelayan wilayah Sungai Tengkidap di Nanga Sauk. Proyek Konservasi Suaka Margasatwa Danau Sentarum [Meeting with head fishermen from the area of the Tengkidap River and Sauk confluence]. KSDA–AWB, Bukit Tekenang Field Station.

Suryaningsih, N.
1993 Karakteristik berberapa jenis ikan di perairan Suaka Margasatwa Danau Sentarum, Kalimantan Barat [Charactersitics of various species of fish from the waters of the Danau Sentarum Wildlife Park, West Kalimantan]. Skripsi

(D1D88259), Jurusan Biologi, Facultas Matematika dan Ilmu Pengetahuan Alam, Universitas Padjadjaran, Bandung (September 1993).

Vaas, K. F.

1952 Fisheries in the lakes district along the River Kapuas in West Borneo. *Proc. Indo-Pacific Fisheries Council*, Madras, India. S 2/10. p. 198-207.

Wadley, Reed L., Carol J. P. Colfer, and Ian G. Hood.

1997 Hunting and natural resource management among forest farmers in Indonesian Borneo: a comparison of non-human primates and other large mammals.

Widjanarti, H. E.

1996 A checklist of freshwater fishes of Danau Sentarum Wildlife Park and adjacent areas, Kapuas Hulu, West Kalimantan. PHPA-AWB.

APPENDIX A. COMMON AND SCIENTIFIC NAMES OF FISHES MENTIONED IN THE TEXT, TABLES OR FIGURES. (ADAPTED FROM WIDJANARTI 1996). IN ORDER BY COMMON NAME. ALSO SEE TABLE 6.

Common Names					
Used in Text	Alternate Names		Family	Genus	Species
Bantak			Cyprinidae	Osteochilus	microcephalus
Bauk ketup	Bauk pipih		Cyprinidae	Thynnichthys	polylepis
Bauk tadung			Cyprinidae	Labiobarbus	ocellatus
Baung	Baung kuning		Bagridae	Mystus	planiceps
Belantau	Timah-timah		Cyprinidae	Macrochirichthys	macrochirus
Belida	Belida labuan		Notopteridae	Chitala	lopis
			synonyms:	(Notopterus	borneensis)
				(Notopterus	chitala)
Biawan	Bawan	Tambakan	Helostomatidae	Helostoma	temminckii
Bilis			Clupeidae	Clupeichthys	bleekeri
Bubuk			Cyprinidae	Neobarynotus	microlepis
Buin	Engkaras	Kempras	Cyprinidae	Cyclocheilichthys	armatus
Buin	Buing		Cyprinidae	Cyclocheilichthys	repason
Delak	Gabus	Telak	Channidae	Channa	striata
Duara	Juara	Sadarin	Pangasiidae	Pangasius	polyuranodon
Emperas	Engkaras	Mata merah	Cyprinidae	Cyclocheilichthys	apogon
Engkadik	Langli	Pansek	Cobitidae	Botia	hymenophysa
Engkarit	Karit		Cyprinidae	Osteochilus	partilineatus
Engkarit	Karit		Cyprinidae	Puntius	eugrammus
Engkarit			Cyprinidae	Puntius	lineatus
Entukan	Lumo		Cyprinidae	Thynnichthys	thynnoides
Jelawat			Cyprinidae	Leptobarbus	hoevenii
Kapas	Lumbut		Cyprinidae	Rohteichthys	microlepis
Kelabau	Kelabau padi		Cyprinidae	Osteochilus	melanopleura
Kelabau putih=kebali	Kebali batu	Kebali	Cyprinidae	Osteochilus	schlegelii
Kelampak	Entebuloh		Cyprinidae	Parachela	oxygastroides
Kelik	Lele		Clariidae	Clarias	batrachus
Kelik	Kelih		Clariidae	Clarias	leiacanthus
Kelik	Duri		Clariidae	Clarias	meladerma
Kerandang			Channidae	Channa	pleuropthalmus
Ketutuk	Bekutut	Betutut	Eleotrididae	Oxyeleotris	marmorata
Ketutung	Batang buro		Cyprinidae	Balantiocheilos	melanopterus
Lais bangah	Lais jungang		Siluridae	Kryptopterus	micronema
Lais butu	Lais pendek mulut	Limpok	Siluridae	Ompok	hypophthalmus
Lais empang			Siluridae	Kryptopterus/Ompok	not known
Lais jungang	Lai' jungang		Siluridae	Kryptopterus	apogon
Langkung	Adung	Dungan	Cyprinidae	Hampala	macrolepidota
Menyadin			Cyprinidae	Osteochilus	intermedius
Menyadin	Riu'		Cyprinidae	Osteochilus	triporos
Nuayang tebal	Nuajang	Riu' pate'	Schilbidae	Pseudeutropius	brachypopterus
Nuayang tipis	Nuajang	Riu' pate'	Schilbidae	Pseudeutropius	moolenburghae
Patik / baung	Baung	Baung putih	Bagridae	Mystus	nemurus
Rik (or Ri')	Baung		Bagridae	Mystus	micracanthus
Ringau	Ringan		Datnioididae	Datnoides (Coius)	microlepis
Rita' (or Ritak)			Cyprinidae	Rasbora	pauciperforata
Runtuk			Channidae	Channa	bankanensis
Runtuk	Gabus cina		Channidae	Channa	lucius
Seluang *	Enseluai bujur	Seluang bujur	Cyprinidae	Rasbora	agryrotaenia
Seluang batu	Enseluai batu	Tulum	Cyprinidae	Paracrossochilus	vittatus
Seluang buluh			Cyprinidae	Rasbora	borneensis
Seluang engkrunyuk	Pantau bana	Seluang minyak	Cyprinidae	Rasbora	trilineata
Seluang hantu	Seluang batu	Seluang merah	Cyprinidae	Epalzeorhynchos	kalopterus
Siluk	Arowana	Kayangan	Osteoglossidae	Scleropages	formosus
Tapah			Siluridae	Wallago	leeri
Tebirin			Siluridae	Belodontichthys	dinema
Temunit	Ikan arang	Kak'	Cyprinidae	Labeo	chrysophekadion
Tengadak (=suain)			Cyprinidae	Barbodes	schwanenfeldii
Tengalan			Cyprinidae	Puntioplites	bulu
Toman	Anak toman	Gabus tobang	Channidae	Channa	micropeltes
Ulang uli	Entebiring	Ikan macan	Cobitidae	Botia	macracanthus
Umpan			Cyprinidae	Puntioplites	waandersii

* Note: A number of other Cyprinid species share the common name Seluang.