THE FISHERY
OF THE
DANAU SENTARUM WILDLIFE RESERVE

Abstract

Fishing is the most important human activity within the Danau Sentarum Wildlife Reserve. Management of the Reserve for ecosystem and species conservation must therefor also consider fishing activity by several thousand villagers. 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 reserve. Data from 4,000 catches were collected by local people during 1992 through 1995. Fishing gear use surveys determined fishing intensity and season. The annual catch of between 7,800 and 13,000 tons 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.

Some species appear to be over-fished, and villagers reported some to be less abundant and smaller than in previous years. Needed protection cannot be given on a species basis, and direct government regulation is unlikely to succeed.

A promising approach, emphasizes 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 can also improve conservation of this important tropical wetland.

Some starting points for such a system are suggested. These include the concept of trading exclusive resource use rights within DSWR for compliance with a set of conservation regulations, and of establishing a residence permit system for the reserve. Suggestions related to regulations for mesh size and other gear changes, to be used as starting points for discussions with villagers, are also presented.

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Introduction

Fishing is the single most important human commercial and subsistence activity carried out within the Danau Sentarum Wildlife Reserve (DSWR) in terms of both participation and income. Fishing also has a major impact on the conservation role of the reserve. Both fishing activity itself and other activities of fishing people affect fishes, wildlife, and the surrounding aquatic and terrestrial ecosystems. Management of the reserve for conservation purposes is impossible without a thorough understanding the fishery and the human population's dependence on it.

This chapter provides details about the fishery within DSWR 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 DSWR with a breakdown by fishing gear type. Suggestions for improving fishery management are presented as well.

General Description of the Fishery

Fish species found in DSWR 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 DSWR boundaries. Subsequently, Widjanarti (1996) reported 210 species from within DSWR.

The fishery was described by Giesen (1987). Earlier reports include those of Vaas (1952) and Sachlan (1957). Additional information related to the fishery within DSWR 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 different gear types to capture a large number of different species. However, most fishing activity makes use of gill nets, hooks, traps, and cast nets although specialized gear types such as special types of traps 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 reserve 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 then start to drop gradually and in July and August drop rapidly. 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 reserve is limited naturally by the lack of land during high water. Permanent houses are limited to river levees where houses are built on stilts. Other families live in floating houses or house boats. As water drops, additional people move into the reserve 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 are dependent on the fishery within DSWR 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 DSWR 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.[2]

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[3] within the reserve. Approximately 75% of income for reserve residents, and 48% for those living near the reserve, is from fishing. (Aglionby 1995).

Methodology

Data Sources

Fishing Gear Ownership Surveys

Between 21 October 1992 and 30 March 1993 local data collectors visited 12 villages within the reserve 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 programme to estimate costs associated with fishing. This second program surveyed 10 families in each of 10 villages within and near the reserve (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.

Catch Survey

The 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. Although the intention was to eventually formalize and intensify this survey, such

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

[2]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.

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

modifications were not possible. Nevertheless, the survey has provided a stream 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.

The system was designed to be simple, and catches were sampled without unduly hampering fishing activities. The basic approach was for the data sampler to travel within an assigned area with a small boat, at a time when fishing gear was being checked, 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. Local names are quite specific and usually correspond to scientifically defined species.

This data collection system was tested by the author in 1992, and was carried out first 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.

Data collection was influenced by the limited training and education of the data collectors. Toward the beginning of the survey, for example, the concept of percentage had to be explained to some data collectors. Also, some data had to be discarded because the forms were incomplete or were missing critical information.

The DSWR 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 their limitations, the data reported herein are reasonably good. Under the circumstances, the simplicity of the data collection system was its strong point.

Fishing Gear Seasonality Survey

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

For purposes of analysis, the villages surveyed were categorized by their location into one of six areas of the reserve. The areas used for this purpose were: Lower Tawang River, Upper Tawang River, Mid - Reserve, Belitung River drainage, Pulau Majang area, the Laboyan River area and the Kapuas River. The villages within each reserve 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 reserve area. The 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.

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.[4] 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 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.

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 each bal is divided in half lengthwise to make two nets totaling 80 m. The bal is used herein as the standard unit of netting.

On the average, DSWR 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 reserve. Some villages, (e.g. Nanga Laboyan) prohibit gill nets. Typical gill nets encountered during the catch survey consisted of approximately 10 bals of netting but included anywhere from one to over 30 bals.

Gill net mesh sizes reported as part of the catch data and gear surveys ranged from 0.5 inch to 7.0 inch.[5] For catch analysis mesh sizes were grouped into large

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[4] An additional complication is that the area comprising DSWR has changed. At the time the fishery surveys were started (1992) the reserve covered 80,000 ha. When fishery data was first being analyzed the reserve covered 120,000 ha. Although most fishing takes place within the original 80,000 ha, data presented herein may not adequately describe fishing activity in the other parts of the reserve.

[5] The sizes of gillnets used in DSWR 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.

(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 did not vary much 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 2).

Typically, villagers caught between 5 and 15 kg of fish per gill net set. The catch data are strongly skewed, and although some catches of over 50 kg were reported, 92.1% of the catches contained less than 25 kg. On a kg per unit basis, catch rates over 6.5 kg per bal did occur, but 89.5% of the 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. Examination of these patterns is difficult because only limited data occur in each combination of categories. Combining data for all years, gill net catch rates exhibit an increasing trend during April through July, and then drop back to a lower rate in September through December. Within each year this pattern exists for 1994 (and perhaps 1993 though the data are incomplete). However, during 1995 (the high water year) the pattern is absent. Note also that the mean value for September is based only on data from 1995, and thus a higher average value of perhaps 1.0 kg per bal might be assumed for an across-year average (Figure 3).

Catch rates from the commonly used small and medium mesh gill nets, are typically between 0.5 and 1.5 kg per unit. During periods of dropping water catch rates can be three times as high as indicated by catches recorded during July through October 1994.[6] In 1995 floodplain waters did not recede and no increased catches during those months were apparent (Figure 4).

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 other 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**).

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

Hooks

Several types of fishing gears employing hooks are used in DSWR. 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).

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. Setlines 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 DSWR, and on the average, DSWR 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[7].

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 in order to standardize the catch per trip.[8] 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 much 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 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.

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.

Few hand-line data were collected during the fish catch survey. Hand-lines are particularly common in the village of Leboyan, and are also used regularly by a

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

[8]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.

small group of fishers from Pulau Majang. Catches from hand-lines have been expressed as catch per hook-hour because hand-lines require the full attention of the fisher. 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. DSWR families own, on the average, 2.61 cast nets per family. The number of cast nets in DSWR 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 during the catch survey. Catches show a mode between 1.0 and 2.5 kg per hour. Mean catch rate from large mesh nets varied with season from 1 to 2 kg per hour to between 7 and 8 kg per hr during July and August.[9] 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).

Funnel Nets

Jermal are stationary, open topped, funnel-like nets. 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

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

are smallest (mosquito mesh). The fishing gear survey reported 92 within our sample resulting in an estimate of 275 jermal in use within DSWR . However, our survey emphasized data from an area where jermal are more commonly used and may have overestimated jermal numbers.[10] Jermal are used during all seasons, but their use varies considerably with location. They are typically used 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, especially during low water. However, their use is not limited to those periods, and jermal are also used effectively during rising water. Jermal are important for catching live ornamental fishes, especially **ulang uli**. 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).

Catches of **ulang uli** make up a relatively small portion of the catch by weight but are the most valuable species caught. Mean catch rates reported for **ulang uli** typically ranged from fewer than 2 to over 40 per individuals per hour. In some instances the catch rate was much higher: in May 1993 several nets caught 2,000 to 3,000 individuals, yielding an average catch rate of over 140 fish per hour for the eight nets sampled that month.

Traps

Gear Description and Numbers and Seasonality

Brief descriptions of the several types of traps are used within DSWR are included below. For full descriptions of fishing gear in the area see Anon. (1992). Numbers of traps within DSWR were estimated at 2,550 cylindrical rattan traps (bubu), 7,550 rectangular traps (pengilar)[11], 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 hr basis. Bubu were typically left for two to three days prior to being checked, but other gear types were usually checked at approximately 24-hour intervals and sometimes more frequently. Data from tabung reported here 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

[10] 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).

[11] Including temilar and similar rectangular traps.

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.[12] Catches were generally below 0.05 kg per hour. The data were insufficient to determine a seasonal trend. (Figs. A29 and A30).

Catches from both bubu and pengilar were dominated by **biawan** and **patik**, but a mixture of other species accounted for about 60% of the catches (Figure A31). Occasional large catches of **biawan** are common during dropping water.

Bubu Keli

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

These traps are used in all months except June through September, especially during December through March (Figure 18). The catch survey includes data from only 59 trips (catches from 818 traps) where this gear was used. The catch rate from bubu keli was typically less than 0.04 kg per hour with occasional higher catches. There is a trend of higher catches during March, April and May. Catches from bubu keli consist mostly of **keli**; over 60% by weight and numbers.

Seruak

Seruak are small (about 35 cm x 35 cm x 35 cm) traps made from split bamboo with bamboo tube entrances. Seruak appear to be used throughout the year to catch juvenile **jelawat**. The catch survey recorded only 34 trips for fishers using seruak, and weight of catch was recorded for only 10 of these. Catch averaged 0.06 kg per hour. Seruak sampled caught an average of 12.8 juvenile **jelawat** per trap.[13] Young **jelawat** make up more than 25% of the catch by number, but a mixture of other species are also caught.

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. In some cases bamboo tubes are tied in bundles. Tabung are used primarily to obtain live **ulang uli**.

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[12] It was not possible to record the catch from each trap separately because the person fishing does not keep the catch from each trap separate.

[13] 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 DSWR reported more use of tabung during December and January compared to other DSWR residents.[14]

The catch survey recorded only 126 trips[15] in which tabung were used. The average catch was over 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 with an average of just over 4 cm.

Lift and Dip Nets

Small lift nets and dip nets are commonly used active fishing gears requiring full attention of the person fishing. They are often 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 are used fixed to the end of a long pole. Most families own both a dip net and a lift net (the average per family is 0.98 dip nets and 1.07 lift nets). 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 in certain areas of the reserve (e.g. Tawang River and Belitung River). These have large meshes (3 to 4 inches) and are about 3 to 5 m long and 1.5 to 2 m across. These nets are used exclusively during dropping water especially during June through August (Figure 20). Only 33 of these were reported during the fishing gear survey and the estimate for the reserve would be about 90. They were only reported in villages along the above mentioned rivers, so the actual numbers in use may be lower. These large dip nets are used to catch **belida**.

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.

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.

Estimates of Total Catch

Accurate estimates of total catch from DSWR cannot be made on an annual basis given the quality and quantity of data available. Because of the large number of fishing gear types and the scattered nature of the fishery, an accurate annual catch estimate would be difficult, and expensive. An rough estimate of the total

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

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

fish catch from DSWR in a typical year, can be made using the data reported herein.

This overall catch estimate is the sum of 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.

The total catch estimate was almost 15,000 tons per year; undoubtedly an overestimate (see following discussion). About 20% of the catch was derived from cylindrical rattan traps (bubu), 20% from gillnets, 18% from cast nets and 16% from hooks. Funnel nets (jermal) accounted for about 10 percent. The remaining amount (16%) is caught by other types of traps, liftnets and dip nets.

However, it seemed likely that 15,000 tons was an over-estimate of total catch from DSWR. A catch of 15,000 tons would amount to a fishery yield of 187.5 kg per ha per year, based on an area of approximately 80,000 ha of lakes, rivers and flooded forest within the reserve. This would be at the very upper end of the range of fish yields from similar waters (see, for example, summaries in Giesen 1987 and Lowe-McConnell 1987, Bayley 1988, and Hogarth and Kirkwood 1996). The fish catch from another relatively remote Indonesian floodplain, along part of the Lempuing River in South Sumatra, is about 130 kg per ha (MRAG 1994).

In addition, the average calculated catch per family during November (based on the above data) 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.[16]

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 a basis for comparison. Reported catches for the Kapuas Hulu have gradually increased since 1973, and during 1984 to 1995 have ranged between 11,000 and 17,500 tons. Thus the 15,000 ton catch estimate calculated for DSWR is more or less equal to the reported catch for the whole Kapuas Hulu. In contrast, Giesen (1987) estimated DSWR catches at about 2,800 tons or about 32% of the average (1973 through 1985) catch of 8,878 tons (at that time) for the Kapuas Hulu.

Nevertheless, Dudley and Widjanarti (1993) and Aglionby (1995), independently, using different methods, calculated that about 4,000 tons of fish are captured within DSWR 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. Also, **toman** were not raised in cages at the time of Giesen’s (1987) work.

Factors which could have led to a catch overestimate are several. Individual catches were usually estimated visually, and supervision of the 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. For example, fisherfolk participating in discussions to

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[16]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).

determine fishing gear use might have overstated their planned fishing strategy for each season.

Because of the above considerations the overall catch estimate was adjusted downward. This downward adjustment was based on two objectives. Firstly 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. These values seemed consistent with field observations.

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.[17] Each of the month by gear combinations in the original table were multiplied the same fraction to lower the overall catch. Table cells for November, December, January and February were also multiplied by an additional factor for each month.[18]

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.

It is likely that DSWR catches vary considerably from year to year. Fish populations may increase during years of high water such as 1995 and 1996, and these fish then produce additional harvest during the following, more typical, dry seasons. Extremely dry years undoubtedly contribute to atypically high fish mortality which may result in lowered catches for the next one to three years. These factors should combine to produce obvious fluctuations in catches. However, such fluctuations are not detected in information currently available.

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 wildlife reserve implies other goals such as: the protection of biodiversity, the protection of endangered species, general protection of flora and fauna, and the reserve itself. In fact it is generally agreed that, under Indonesian law, people cannot live within a wildlife reserve. 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 DSWR have fished in the area for

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[17]This was done using the “solver” function of the Microsoft Excel spreadsheet program.

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

many years. However, numbers of reserve residents is much greater now than in the recent past.[19]

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

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

To manage the DSWR fishery:

> on a sustainable basis,
>
> for harvest by persons traditionally involved in the fishery,
>
> in a way that will protect and enhance the wildlife reserve functions of DSWR.

Size considerations

Within DSWR 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 15) 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.

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 DSWR species we can compare maximum size reported in the literature to typical sizes reported in our DSWR 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[20] which are both reasonably abundant in DSWR catches and also reach a maximum size of 15 cm or more. Also indicated on this table is the ratio of the typical size[21] in the catch to the expected maximum size. The 17 species where

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[19]Geisen (1987, p 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 reserve had grown 40% in the last 10 years.

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

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

this ratio is less than 0.35[22] 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, and is rare in other areas of Indonesia where it was formerly abundant. In Riau and Jambi, for example, traditional fish products made especially from **belida** are now made from other species. Seemingly the fishery for **belida** at DSWR is still good, but the relatively small size of fish in the catch is reason for concern.

Ulang uli, **engkadik** and **ringau:** Ornamental species highly sought after for the international 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 are seemingly quite tolerant to extreme fishing pressure on the young. Over two million **ulang uli** are exported from the Kapuas Hulu year after year. Nevertheless the adults of both species are becoming increasingly rare, and the likelihood of a collapse of this fishery should not be dismissed.

Kelabau, **kelabau putih**, **tengadak**, **tengalan** and **umpan:** Similar species within the cyprinid family. All are capable of growing to moderate sizes (35 to 50 cm depending on the species) but are generally caught at much smaller sizes in small-mesh gill nets, and other gear. For the most part large specimens are absent from the catches, but these species are still common.

Temunit: Still fairly common, but fishermen claim, and the data support this claim, that large specimens are no longer available. The largest individual recorded in our catches was less than half the maximum size.

Delak: One of several similar species Our data concerning it may not be accurate. This whole group (members of the genus *Channa*), including **toman**, are an important component of the hook fishery. As such they require further study.

Bauk ketup and **bauk tadung:** Very common both in cast nets and in jermal. It is not clear as to whether these are actually "over-fished" since they are both very 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.

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

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[22] 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. This is a relatively liberal value because the actual ratio is likely larger than 0.4.

Of the 17 listed species **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

In addition to the 17 species listed above, certain species, most notably **siluk**, are much less abundant than in the past. Other fishes reported as rare or of significantly lowered abundance, but not indicated by the size ratio above, are reported in Table 7.

Two occurrences of **siluk** (two individuals) were reported during our survey. The species was formerly common (also see page 2). Trade in the ornamental fish **siluk** is an extreme example of what can happen if adequate controls are not in place when a natural product increases in value. About 15 to 20 years ago fish traders discovered that the red phase of **siluk**, found primarily in DSWR and surrounding areas, was very much valued as a source of good luck in Singapore, Hong Kong, Japan and within Indonesia. By the mid to late 1980's individual fish sold for as much as $3,000. The resulting intensive fishery for this species almost exterminated it.[23]

Ulang uli are intensively harvested in Kalimantan and Sumatra for the ornamental fish trade. There are indications that the population in the Kapuas Hulu region is over-harvested. This is based on the fact that relatively few large specimens are encountered by fishermen. There is currently a local regulation which requires that **ulang uli** larger than 15 cm be released. Although the market for this species is primarily for smaller specimens caught mostly by jermal and bamboo tube traps, larger specimens are vulnerable to gill nets.

Ulang uli are migratory, but the exact nature of the migration is not known. The small fish first appear in December and January and a second peak in abundance usually occurs in April and May. Prasetyo and Ahmadi (1994) reported a similar catch pattern for **ulang uli** in the Batang Hari River in Sumatra. In that study, smaller fish (less than "2 inci") were caught downstream, implying that **ulang uli** might spawn in downstream areas and then migrate upstream. **Ulang uli** caught in DSWR are usually 2 to 6 cm and average somewhat less than 5 cm. Better information on the growth, migrations and breeding of **ulang uli** is essential to ensure that this species continues to provide income for fisherfolk.

According to fisherfolk large **jelawat** are no longer caught in DSWR area. Nevertheless, the size ratio used above did not detect **jelewat** as a species needing attention. The reason for this may be that the maximum size reported in the literature (41 cm cited in Kottelat *et al.*. 1993, and 60 cm in Giesen 1987) is perhaps smaller than the actual maximum size. Using a length-weight relationship reported in Christensen *et al.* (1986) and a length of 60 cm, the corresponding weight would be about 5 kg. However, Sachlan (1957) reported **jelawat** as large as 18 kg. It seems possible, then, that **jelawat** may be

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[23] 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**.

harvested at sub-optimal sizes. Juvenile **jelawat**, to be used in cage culture, are the target of a specialized fishery using seruak.

Toman, an important component of the hook fishery, occur in over 80 % of catches from fishing gear using large and medium size hooks, and comprise about 50 % of the catch by weight in those gears. This species is sold live to fish traders.

A recent[24] development in DSWR communities is the raising of **toman** in cages (see Dudley and Widjanarti, 1993; Aglionby 1995). This is a lucrative activity providing over US$0.7 million or almost one third of the total fish-related income in DSWR. 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. Dudley and Widjanarti (1993) and Aglionby (1995) estimated, independently, that about 4,000 tons of fish were fed to caged **toman** each year.

Two potential fishery problems arise from the **toman** industry. Firstly, large numbers of juvenile **toman** are taken from the wild[25], and secondly a large amount of fish is caught to feed **toman**.

Some have argued that cage culture of fish is less destructive of the overall resource than fishing for wild fish and thus is a reasonable money earning option for the reserve's human residents. However, both the cultured **toman** and all their food are taken from the wild. More importantly, **toman** culture is carried out in addition to, not instead of, fishing activities. While **toman** cage culture earns money for people who badly need it, uncontrolled growth of this activity could endanger DSWR resources. Consequently, it is necessary to limit, rather than promote, cage culture of **toman**. A reasonable approach would be to limit the number of **toman** cages per family.

Cage culture of **toman** relies exclusively on the capture of juveniles from the wild, and may eventually endanger the viability of **toman** populations. Although, there seem to be reasonable numbers of adult toman at present, as more young are taken from the wild, a negative impact on the overall **toman** population is likely. Villagers believe that the **toman** fishery is facing a problem, and many villages have instituted regulations limiting the capture of juvenile **toman** in one way or another. Most have limited the minimum size at which the juveniles can be kept.[26] In some villages (in 1995) the fishery for juvenile **toman** had been closed.

Ketutut are becoming increasingly important in the live food fish 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 for Rp10,000 per kg (at that time, 1992, about US$5.00), those between 0.4 and 0.5 kg for slightly less. Those under 0.4 kg are not sold, but some were held in cages and fed until

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

[25] 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.

[26] Apparently **toman** smaller than about 3 cm do not survive well in captivity.

they are bigger.[27] **Ketutut** apparently spawn in DSWR, 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 the cage culture of this species will be attempted.

Fish Movement

It is necessary to emphasize the fact that most fish leave DSWR during the dry season and these fish are available to fishers outside the reserve for part of the year. The actual flooded area at low water is often a small fraction of the high water area. Not only must fish leave most of DSWR, 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 reserve during rapidly rising water when the Tawang River flows into the reserve at rates exceeding 2,000 m^3 per second (Klepper 1994). Thus most fish within DSWR originate from and return to the Kapuas River.

Natural Mortality

It is likely that natural mortality of DSWR fish, particularly young, is closely linked to water season and to yearly variations in water level. During low water young (and other small) fish are, for example, vulnerable to predation. Another source of mortality is the relatively the low oxygen concentrations in the dropping waters. This affects species not having air breathing ability. Particularly low water years probably intensify these effects. It should be noted that predatory air breathers, such as **toman**, probably have more access to food during the low water period and are not affected by low oxygen concentrations.

Fish populations that experience high natural mortality are less affected by intense fishing because fish not caught will die of natural causes. This situation is typical of floodplains and implies that floodplain fisheries can be harvested fairly heavily, which they usually are because of the convenient (to the fisherfolk) concentration of fishes during the dry seasons.

Nevertheless, the ultimate ecological role of the dying fish needs to be examined, particularly in a wildlife reserve. Under natural circumstances these fish would be eaten by predator fishes or by other predators such as picivorous birds. A puzzling aspect of DSWR is the very low population of fish-eating birds, especially when compared to floodplains elsewhere. African flood plains, for example, are noted for their very high and diverse populations of water birds, including numerous fish-eaters. Also, Giesen (1987, citing a report from 1903, and comments from DSWR residents) reported evidence of formerly abundant waterbird populations.

Potentially Destructive Fishing Methods

Certain fishing methods are often viewed as destructive. The most widely cited example from DSWR is poison used by Dayak villagers (Giesen 1987, Aglionby 1995). However, other fishing gears are sometimes viewed as harmful. Within

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

DSWR 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 will depend on one's perspective. Dayak villagers catching fish in the traditional way (using poison) have a very different view than do Melayu villagers downstream who see their caged fish dying as a result. Villagers 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, certain characteristics may define particularly "destructive" fishing methods. These charactersitics might be:

1. Catch excessive numbers of young fish prior to their reaching spawning size.
2. Cause the death of numerous fish (including young) 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 could fall within these categories if used without regulation. Methods used within DSWR 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. Almost every year there are incidents in which fish poison causes death of excessive numbers of fish including those raised in cages by Melayu villagers living downstream. Although traditional law provides for village level sanctions for improper use and types of poisons, past incidents also 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 fully enforce existing traditional law to eliminate the use of non "natural" poisons, to restrict the poisoning to small areas, and to require agreement of other villages in the area. Realistic alternatives to poison are needed.

Jermal

Formerly, jermal were used primarily 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 could be fed to caged **toman**. 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 total annual catch from DSWR. This catch is taken by relatively few individuals (about 250), compared to perhaps 1,000 using gill net users. Jermal tend to catch mostly small fishes.

Numbers of jermal are, in theory, limited by a fisheries department permit requirement.[28] Many villages also have specific regulations related to seasons and places where jermal can be used. A number of villages ban jermal.

The current efforts to limit jermal are worthwhile and should be continued. In addition, an effort should be made to decrease the role of jermal in providing food for **toman**. Possible other approaches could include such things as limiting the size (mouth opening) of jermal, prohibiting jermal which block more than 20 % of a river, requiring one jermal to be at least 200 m from the next. Mesh size regulations for jermal are probably not realistic given their role in the **ulang uli** fishery.

Small-Mesh Gill Nets

Kelabau, **kelabau putih (= kebali)**, **tengadak** (= **suain**), **tengalan** and **umpan** were identified above 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 small-mesh gill nets are responsible for the 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[29]. It is probable that small-mesh gill nets when fished in large numbers are exerting a negative influence on DSWR fish populations.

Small-mesh nets have negative effect on larger fish species by a) catching young fish prior to their spawning and b) by preventing fish from reaching a larger size prior to harvest.

Very small-mesh nets (less than 1.75 inches) could be phased first because they comprise only about 3% of all gill nets. Because almost 55% of the 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 over a two or three year period to allow fishermen time to retire smaller mesh nets.

Large-mesh gill nets are also of interest because to a large extent they catch **belida**. Belida nets, especially those which are set across rivers, should have larger meshes so that only larger **belida** (say 50 cm or larger) are caught. The best mesh size for this approach is not 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. Thus a regulation requiring across river **belida** nets to have larger mesh size might be discussed.

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

[29] 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.

Other Gear Types

Procedures for regulating gear numbers of all types should be developed. As an example, the 500,000 hooks in use in DSWR contribute substantially to the fishery. Except for **belida**, no fish species believed to need special attention are caught by set hooks. However, excessive numbers of set hooks may have a negative impact on other reserve fauna (e.g. crocodiles and turtles) and limits on hook numbers might be considered. Traps, another example, are known to drown various air breathing wildlife, but can be set in safe way. Any management system for the reserve and fishery should incorporate procedures for developing realistic regulations with local communities on an ongoing basis.

The Fishery Management System

Effects of the Reserve on the Fishery

At present there is little or no effect of DSWR on the fishery. No new regulations specifically associated with the existence of the reserve have been implemented.[30] Because the reserve could act as a fish refuge during much of the flood season, and because several fish species are rare or said to be less abundant than in previous years, consideration must be given to the possibility that a fishery reserve, and / or more restrictive fishing policies, would actually benefit villagers, including those in areas outside DSWR. Conversely, overly strict regulation of fishing activity would certainly limit the fish harvest and the livelihood of local people.

Although considerable attention has been given to sustaining the fish harvest for residents within the reserve, consideration also needs to be given to the role the reserve can play in protecting fishery resources. Several indicators suggest that the fishery resource is over-harvested. If this is the case, then fisherfolk will benefit if more restrictive regulations are placed on the fishery.

Since regulations are rarely enforced except at the local level, two important points emerge:

1. enforcement will probably have to take place at the local level, and
2. the existence of DSWR can be used to enhance protection and management of the fishery resource.

Impacts of Fishing on the Wildlife Reserve

Human activities directly related to fishing have a direct effect on the integrity of DSWR as a wildlife reserve. The large amount of fishing gear (especially hooks, traps and gill nets) used in the reserve has a significant impact on both fish and other fauna (e.g. birds, turtles, crocodiles, snakes). The extent of this effect is very difficult to gauge since these organisms are already severely depleted

[30] Although fishery regulations related to reserve management have not yet been implemented, it is likely that the project and its activities have focused attention on existing regulations and controversies needing solutions. Local communities have, for example, been asked to present their village level regulations at a series of meetings, and this request focused attention on the content of these regulations. Also, a significant controversy over fish poisoning in 1994 attracted wider attention than would have been the case if DSWR and the ODA project had not existed.

through many years of fishing activity. Some of this impact, such as the entanglement of birds in fishing nets, is inadvertent. However, intentional activities with adverse impacts also take place. These include such activities as fishing directed specifically at the endangered **siluk**, and the continued use of poison for fishing (see Giesen 1995, Aglionby 1995). Excessive harvest of forest products for use in fishing may also contribute to adverse effects of fishing on DSWR habitat. The harvest of rattan for making fish traps (and for other uses) is one example of human induced changes to DSWR flora (Peters 1993, 1994, 1995a, 1995b).

In general, however, it is primarily the more general impacts associated with the people and their livelihood that are the major factors affecting the habitats within DSWR. The major activities of this type are fire (Luttrell 1994), some 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 reserve having been burnt in recent years.[31] For a summary of human impacts on DSWR see Giesen (1995).

Fishery and Reserve Management: Starting Points

The overall philosophy that management of DSWR would be best carried out via co-management with villagers has already been discussed by xxx, xxx, xxx(this volume). The following suggestions are in keeping with that philosophy.

Residence Permits / Kartu Penduduk

Of primary importance for reserve protection and better fishery management within DSWR is the need to limit the number of people living within the reserve. This is true because the resource base is limited, and also because a large human population has adverse effects on wildlife and its habitat. This is a sensitive issue and as a result, discussion of it has been avoided. The first step toward limiting the number of residents would be to provide current residents with a exclusive right to live within the reserve and harvest specified reserve resources. Residence permits might be issued in several forms. Some suggestions are indicated in Table 8. In exchange for the exclusive, but limited, rights provided by these permits, recipients would be obligated to abide by conservation regulations developed by the DSWR community.

Other Follow-up Related to Fishery Management and Monitoring

For better management of the reserve, 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) would be important for fishery management.

Species most important for further study are those abundant in, or otherwise important to, the fishery. Clearly some less abundant species have a need for protection specifically because of their low abundance. Continuing studies of fish diversity within the reserve and nearby areas is also important.

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

An Option for Cooperative Management

Local Management Systems

Although few effective means of governmental fishery regulation and enforcement exist at DSWR, this need is fulfilled, to a certain extent, by a system of village-level rules regarding fishing access, sites, and gear. These rules tend to be based both on the perceived amount of fish available and on the relation between fishing sites available and the village population. In some cases specific gear types are not allowed (e.g. gill nets in Laboyan) or certain types of fish cannot be captured (e.g. **toman** smaller than 3 cm in Suhaid). These 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) and….. Nevertheless, regulations in a single village can have little effect on the fish population of DSWR as a whole unless other villages have similar regulations. If rules are coordinated among all villages, then an effective management strategy can evolve.

A Suggested Framework for Cooperative Management of Fisheries within DSWR

Basis of Cooperative Management

The existence of local management systems at the village level within DSWR points the way to an overall strategy for fishery management there. Managers of DSWR can build on existing local management of the resource, and at the same time can also incorporate conservation needs and actions into that new management system. Among the many investigators who have examined cooperative management of common property resources, Ostrom (1990) has suggested a framework of "design principles" upon which successful cooperative management of such resources can be based. Ostrom believes that if these principles are in place then there is a good chance that long-term local management of the resource can be successful.

Table 9 shows the eight design principles for successful management of common property resources. Shown next to each principle is the current situation with regard to the DSWR fishery and, in the third column, probable actions needed to bring the DSWR situation into line with the principles. In the specific case of DSWR the design principles need to be applied within a conservation framework. Suggested rules for such a conservation framework appear at the bottom of Table 9.

A number of actions are needed to increase the likelihood of success of local management of the fishery resource. Chief among these is the need to formally recognize the rights of the local people to exclusively use and manage their resource.

There is also the need to define the extent of the fishery resource to which management rights are recognized. Because fish leave the reserve during the dry season there is a reasonable concern that management only within the reserve is inadequate. However, fishing outside the reserve seems to be a less important, and the main river channel is not a suitable site for many types of fishing equipment. At present it is probably sufficient to define the resource as the fishery within DSWR boundaries. Nevertheless the need to expand this definition in the future should be investigated.

The ability of the people to make reasonable rules about their fishery also needs to be strengthened. Although local people already make rules at the village level there is no reserve-wide mechanism for making fishing (and other resource[32]) rules. Working with local people to establish such a mechanism should be a top priority, and efforts to establish committees covering groups of villages was an excellent start. Such groupings should attempt to create standardized regulations throughout the reserve.

Good information about biology and ecology of fishes is also helpful for management, yet this type of detail is not available for many of DSWR species. Local people have a vast store of traditional knowledge, and this is one source of information. This knowledge can be supplemented with scientific studies of DSWR fish species. Of particular concern is knowledge from both sources related to breeding, migration, and growth of important fish species.

Within a Conservation Framework

A locally managed fishery within DSWR must be incorporated into an overall conservation framework if the functioning of DSWR as a wildlife reserve is to be successful. That is, the local rules for fishery management should also comply with a larger set of conservation rules designed to protect DSWR and its biota. Some suggested starting points have been listed in Table 9. Certainly, one essential is that the conservation rules be clarified, formalized, and disseminated so that people know what they are. Very probably local people will have to discuss and explain each rule, its timetable for implementation, and possible exceptions to its implementation.[33]

A second link between conservation and fishery management is the need to stabilize and decrease the human population of the reserve. 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 DSWR fishery, these people could be given special permission to live in the reserve. A permit system like that suggested above can be attempted. Also, more consideration should be given to activities and better public facilities in villages outside DSWR so people have more incentive to move there.

A third step in implementing a conservation framework for cooperative management of the DSWR fishery is to provide an assurance to local people that benefits that might result from better management of DSWR will go to people who had prior resource use rights. For example, programs for eco-tourism should be arranged in such a manner that local people, rather than outsiders, are the

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[32]The discussion herein centers on fisheries and their management within DSWR. However, these same principles can be applied to other resources as deemed appropriate within the conservation framework. For example, honey and selected forest products could also be managed in the same way.

[33]For example, the important fish species **belida** is protected under Indonesian law and accordingly should not be harvested. Nevertheless it is harvested within DSWR, 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 better protection for **belida**.

ones employed. If restrictions on fisheries become necessary then the traditional resource users should have other options. However, this approach should avoid representing the primary role of the reserve as a source of income, but income which may derive from the reserve in the course of good conservation management should, as a first priority, go to people who have prior resource use rights.

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

	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 2. Comparison of estimates of numbers of fishing gears per family within DSWR based on two fishing gear surveys.

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

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. Coding used during gear use surveys.

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

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 6. Fishes commonly caught in DSWR 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 and the possible effect that fishing might have on each species. Common names of fishes for which this indicator was considered too small are underlined. Maximum size was taken from the literature. If maximum size in our samples (max) exceeded the value from the literature then the size from our samples was used in calculating the indicator. (That is, the indicator of possible problems was taken to be the ave/lit unless max was bigger than lit in which case ave/max was used.) If the indicator was less than 0.35 it was taken as a suggestion that the average size was relatively small compared to the potential maximum size.

Another indicator (ave L/ max or ave L/ lit) using the average of typical large fish in each catch is provided for comparison. 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).

Family	Genus	Species	Common Name		Lengths (cm): literature	Data from DSWR: ave	ave L	max	max/ lit	Possible Indicators: ave/ lit	ave L/ lit	ave/ max	ave L/ max	
Cyprinidae	Osteochilus	microcephalus	Bantak		14.2	6.6	8	17	1.20	0.46	0.56	0.39	0.47	
Cyprinidae	Thynnichthys	polylepis	Bauk ketup		18	6.4	8.8	24	1.33	0.36	0.49	0.27	0.37	x
Cyprinidae	Labiobarbus	ocellatus	Bauk tadung		22	7	8.6	25	1.14	0.32	0.39	0.28	0.34	x
Cyprinidae	Macrochirichthys	macrochirus	Belantau		100	26.0	25.6	42	0.42	0.26	0.26	0.62	0.61	x
Notopteridae	Chitala	lopis	Belida		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	Delak		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	Engkadik		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	Kelabau		37	14.7	19.0	47	1.27	0.40	0.51	0.31	0.40	x
Cyprinidae	Osteochilus	schlegelii	Kelabau putih=kebali		40	13.6	19.2	36	0.90	0.34	0.48	0.38	0.53	x
Cyprinidae	Parachela	oxygastroides	Kelampak		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	Lais jungang		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	Patik / baung		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	Ringau		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	Temunit		80	13.8	18.5	34	0.43	0.17	0.23	0.40	0.54	x
Cyprinidae	Barbodes	schwanenfeldii	Tengadak (=suain)		35	7.1	8.1	23	0.66	0.20	0.23	0.31	0.35	x
Cyprinidae	Puntioplites	bulu	Tengalan		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	Ulang uli		30	4.4	5.9	20	0.67	0.15	0.20	0.22	0.29	x
Cyprinidae	Puntioplites	waandersii	Umpan		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 7. Some types of fish reported as rare by DSWR fisherfolk. Based on field notes, especially discussions with fishermen in Nanga Kenelang, 5 November 1992.

siluk (=arowana)	Very high price and resulting intensive fishing has almost exterminated this species from the wild.
bubuk (=paku)	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 8. Some suggested types of residence permits for DSWR. The concept of residence permits, and a target reserve human population, may have to come from outside the DSWR community, but the actual details of its implementation should come from the villagers themselves (see page 22).

Suggested Permit Type	Purpose	Time Limit
Permanent stay permit to be issued to long-term residents only (have lived in DSWR more than 8 years).	To provide a fixed number of long-term DSWR residents with the assurance that they can stay within DSWR.	No time limit.
Limited stay permit for persons who have lived within DSWR only a few years (have lived in DSWR 3 to 8 years).	To give shorter term residents an opportunity to remain in DSWR for a limited number of years.	3 to 5 years (not renewable)
Temporary permit for other short-term residents (have lived in the reserve less than 3 years) and those who traditionally have entered the reserve for fishing or other DSWR management purposes, provided those purposes are in agreement with the plan.	To provide a legal means for persons to carry out some traditional activities within the reserve. Should be limited to those people who have traditionally had access to these resources.	1 to 5 months Renewable each year but not renewable within a year.

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

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

Design Principles for Collective Management of a Common Property Resource *	Current DSWR Situation	Necessary 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 DSWR 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 DSWR 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 reserve along the Kapuas. It is possible that people from these Kapuas towns might also claim reserve resources.	Clarify other possible claims on reserve fishery resources and attempt to strengthen claims of villages within the reserve.
	In addition, there have been some statements from higher officials that the reserve's fishery is open to everyone.	Work to assure that officials at various levels recognize the claims of DSWR 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 reserve 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 reserve. If necessary implement rules at a level which includes areas outside the reserve. (see Number 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 area are needed, but do not exist. Village level rules differ from village to village.	Work toward improved understanding of the need for fishery management over the entire reserve and surrounding area. Also see Numbers 3 and 8.
	Villagers may have some limitations on their understanding of fish populations (as do managers) and thus may not have enough information to make 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 are currently 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 reserve wide (and perhaps wider) rules regarding fish catching. See actions under number 8.

Table 9 (continued)**.** Actions needed at DSWR in relation to management of the fishery as a locally managed common property resource.

Design Principles for Collective Management of a Common Property Resource *	Current DSWR Situation	Necessary Actions
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 neighbours. Monitoring is done by the fishers themselves, at least at the village level.	
5. Graduated sanctions : There is a series of gradually increasing punishments for violation of the rules. These depend on the seriousness and the context of the offence.	Most villages have fines or other measures to punish violators within the village work area. However, there are no mechanisms for reserve-wide rule making or sanctions.	Establish a reserve-wide system of sanctions for reserve wide rules. These can probably be monitored at the village level since most fishing 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.	Establish, or improve existing, conflict resolution mechanisms, especially those for solving inter-village conflicts if they should arise.
	Such disputes are sometimes brought to local police or government officials.	
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 reserve 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 DSWR, and perhaps 3) DSWR plus surrounding villages where fishing is important.
	Note: Five sub-districts (Kecamatans) form the next higher legal entity above the village level. However, use of these as resource management units may divide rather than unite the DSWR villages. Nevertheless their cooperation is needed.	Work to ensure that higher level mechanisms operate to unite reserve villages in their management of the fishery (for example across Kecamatan boundaries).

*These eight principles are adapted from Ostrom, E. 1990. Governing the commons. Cambridge University Press. 280p.

Table 9 (continued)**.** Actions needed at DSWR in relation to management of the fishery as a locally managed common property resource. Conservation considerations.

Additional Suggested Needs for Collective Management of a Common Property Resource within a Conservation Area	Current DSWR Situation	Necessary 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 reserve fishery management programme.
	Residents are generally aware of the status of the area as a wildlife reserve. They are also reasonably aware of the overall goals of conservation.	There is a need to continue awarness programs related to conservation goals, and to incorporate conservation enforcement into the fishery management package.
	Nevertheless, 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 rules.
2. The number of people living in a conservation area must be limited and, over time, reduced.	The DSWR population has grown by over 40% in the past 10 years.	There is a serious need to stabilize the population of the reserve. A system of (a fixed number) of residence permits is suggested.
3. Any benefits which might accompany conservation activity (e.g. better fishing, eco-tourism) should go to those who had prior resource use 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 reserve 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 reserve, 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 reserve formalized and recognized.

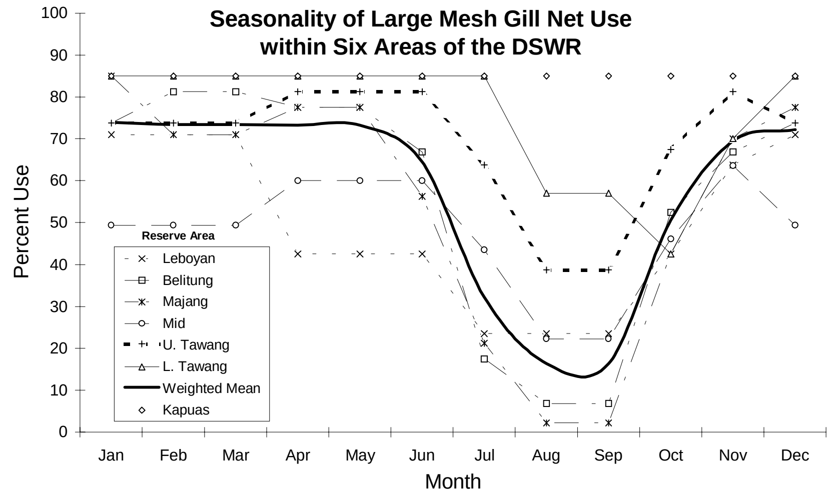

Figure 1. An example of intensity of use data. This information represents the responses of villagers to inquiries regarding how often they used large-mesh gill nets during each month. The weighted mean value, excluding the Kapuas area, was used in calculating catch estimates. In most cases weighting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

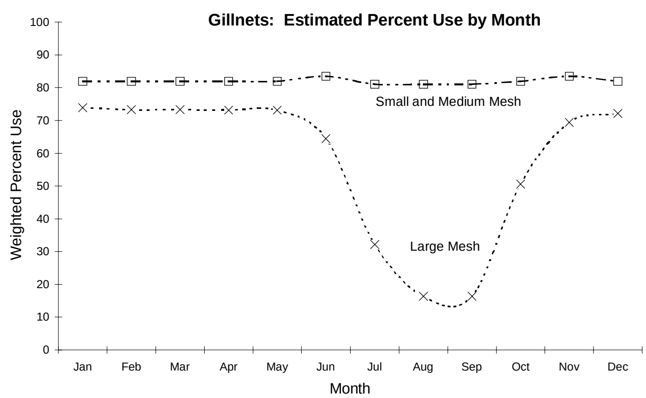

Figure 2. Seasonality of gill net use.

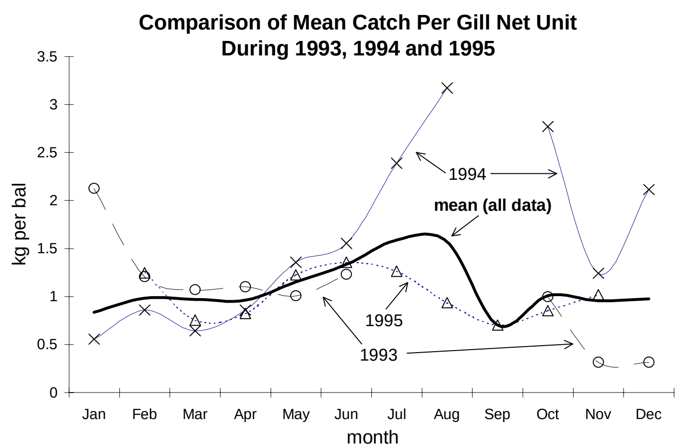

Figure 3. Monthly mean catch rate from gill nets during a three year period. Mean for each month within each year shown separately. Overall within month means spanning three years also shown.

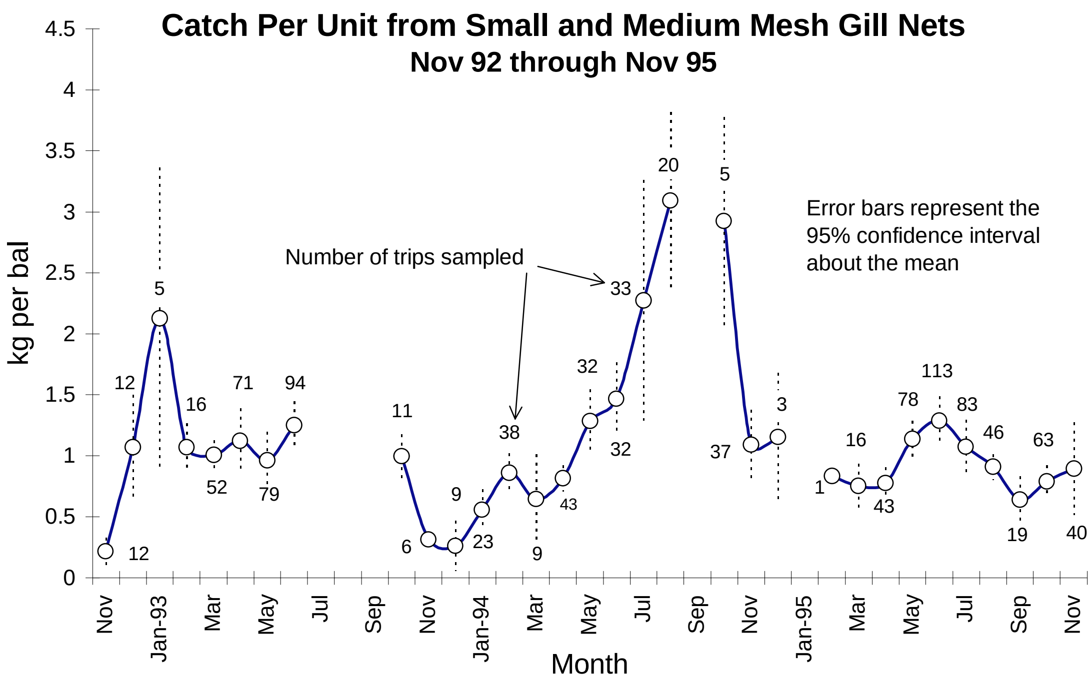

Figure 4. Monthly catch rates from small and medium mesh gillnets. Each point represents the mean catch per fishing gear unit (bal) from the number of fishing trips shown. The number of bals within each trip varied.

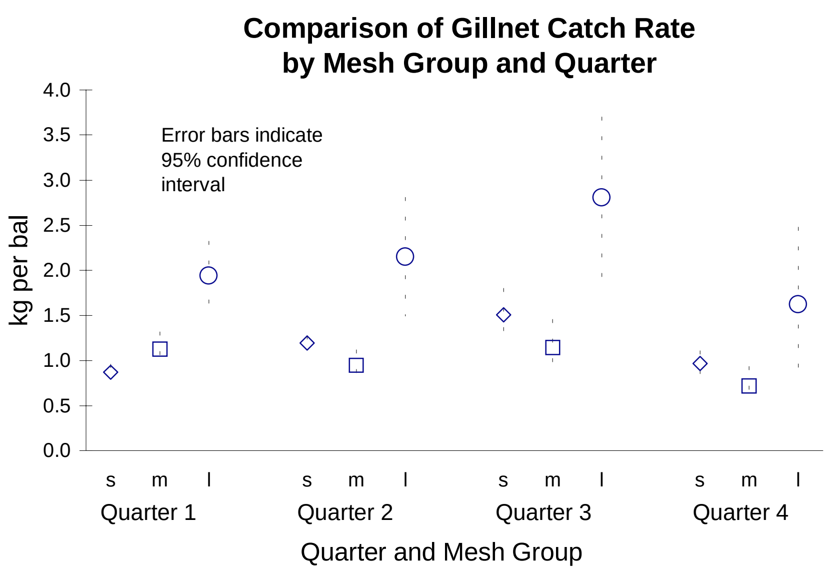

Figure 5. A comparison of catch rates by gill nets of differing mesh size groups. Because of the relatively small number of large mesh nets sampled, the rates have been compared on a quarterly basis.

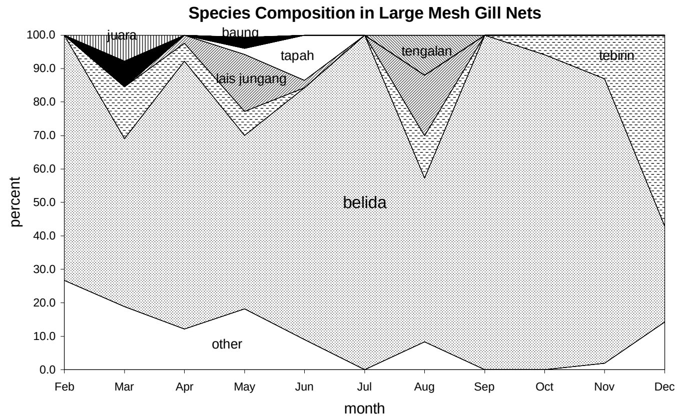

Figure 6. Species composition in large mesh gill nets by month

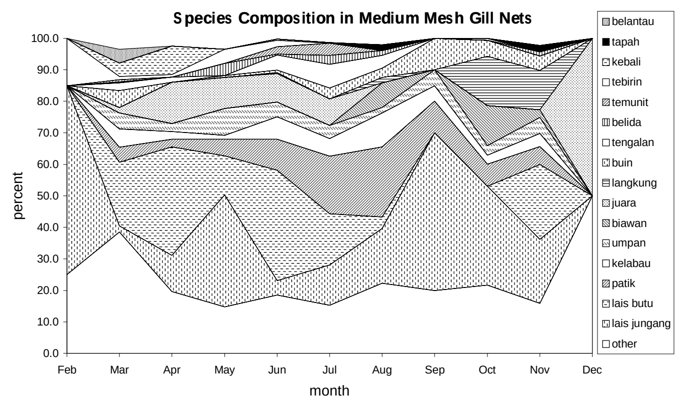

Figure 7. Species composition in medium mesh gill nets by month

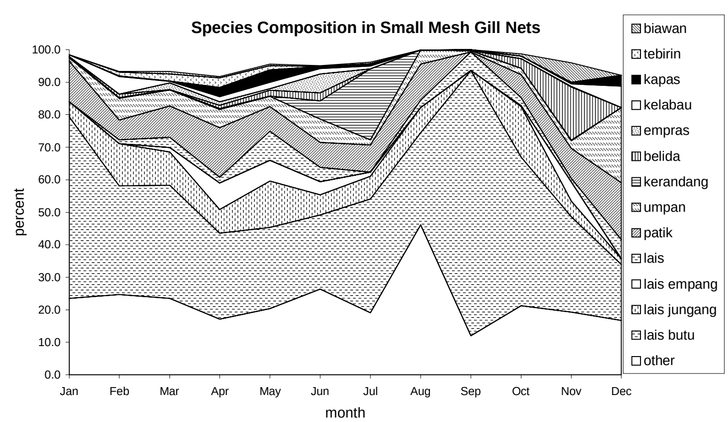

Figure 8. Species composition in small mesh gill nets by month.[34]

[34] The total does not always sum to 100 percent because some other species are not show here. Note that the category 'other' refers to information listed on the data collection forms as other, and thus also includes some additional instances of species already listed.

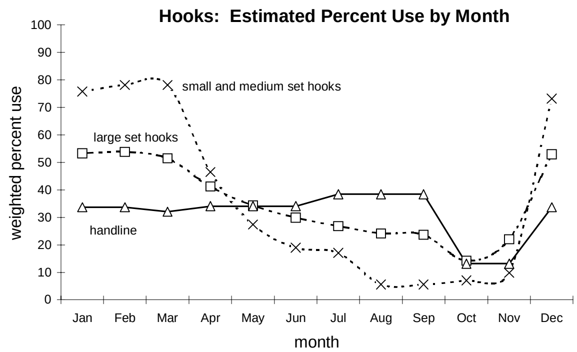

Figure 9. Seasonality of set hook and hand line use.

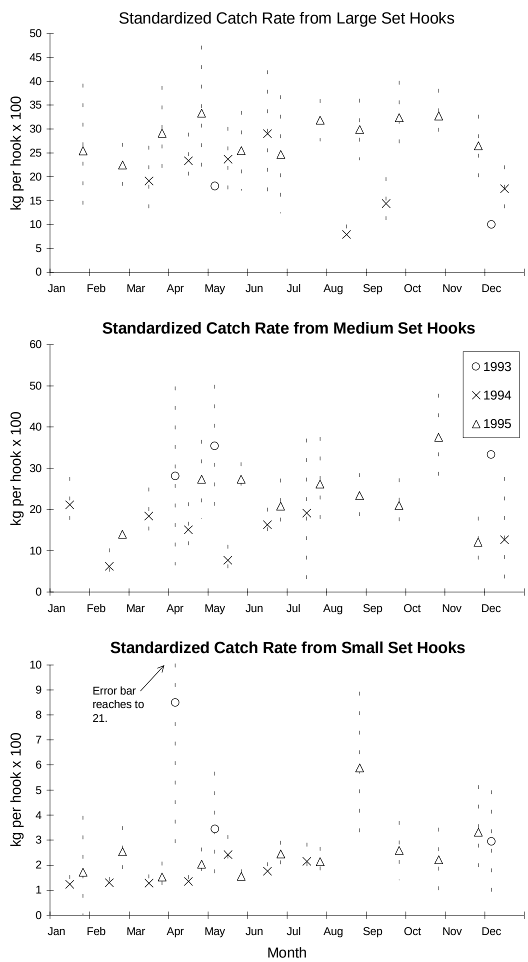

Figure 10. Catch rates from set hooks.

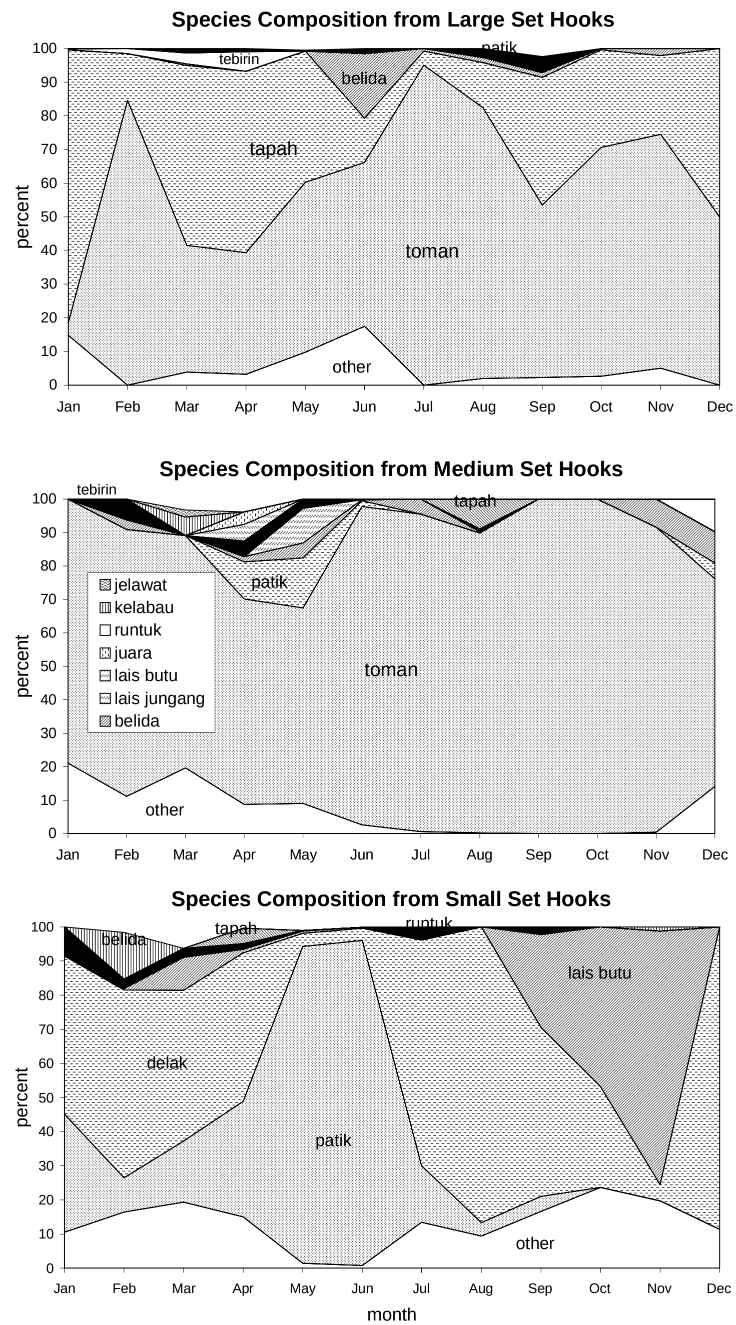

Figure 11. Species composition from set hooks.

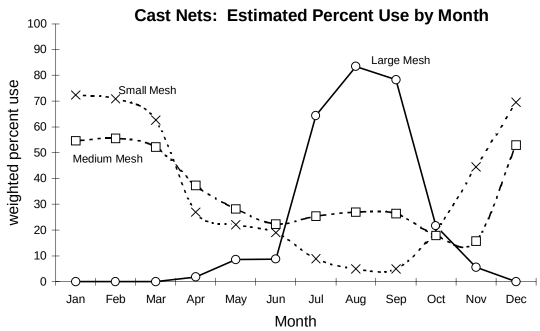

Figure 12. Seasonality of fishing effort with cast nets of differing mesh sizes.

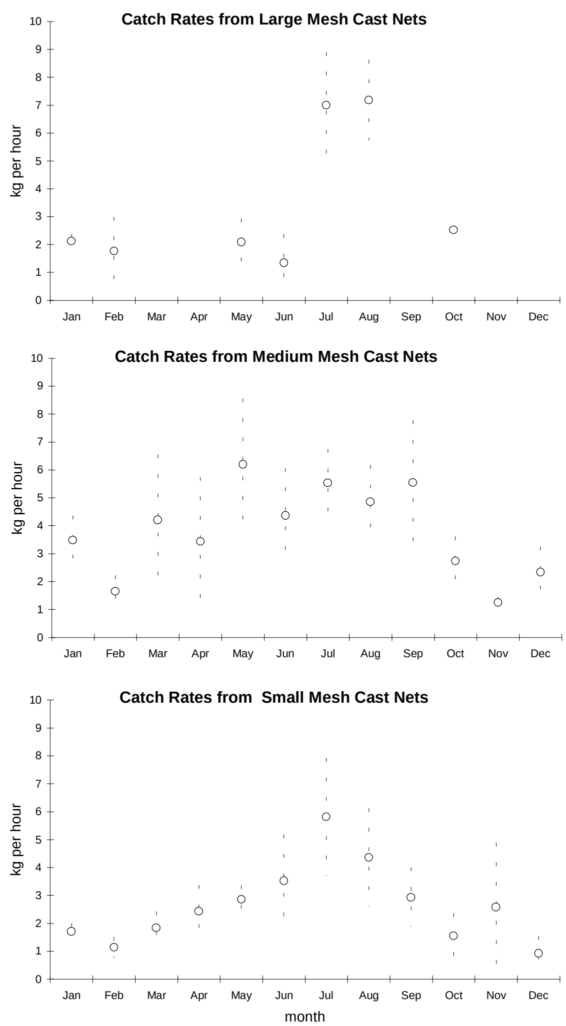

Figure 13. Catch rates from cast nets.

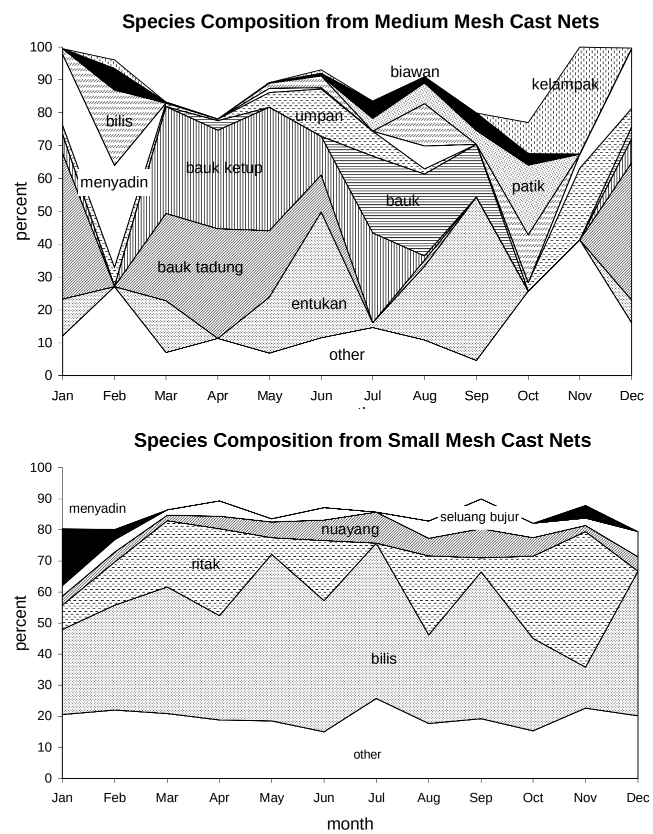

Figure 14. Species composition from cast nets.

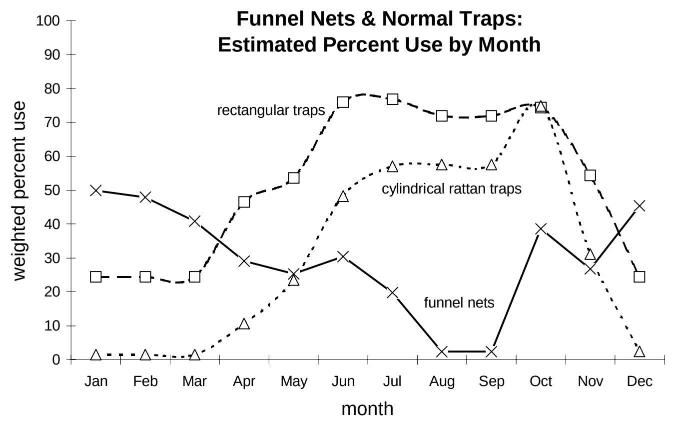

Figure 15. Seasonality of fishing effort with jermal and normal traps.

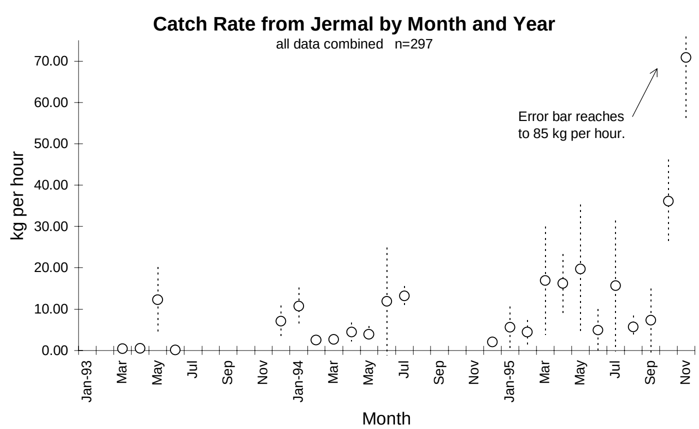

Figure 16. Mean monthly catch rates from jermal.

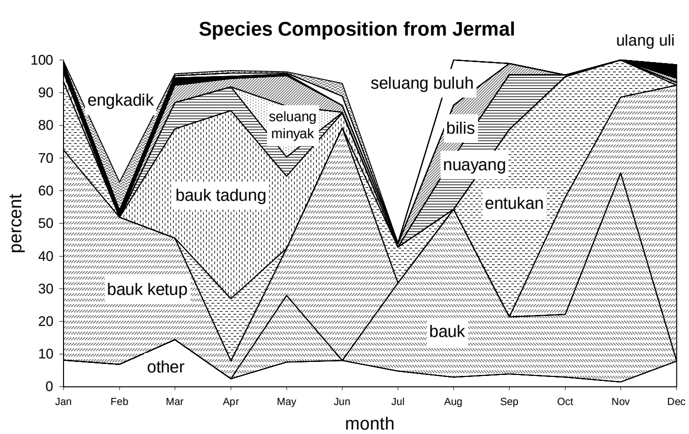

Figure 17. Species composition in jermal catches.

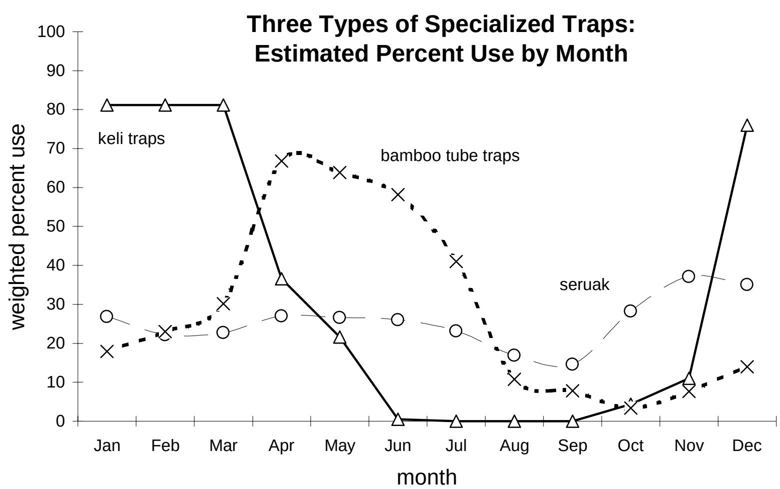

Figure 18. Seasonality of fishing effort with three types of specialized traps.

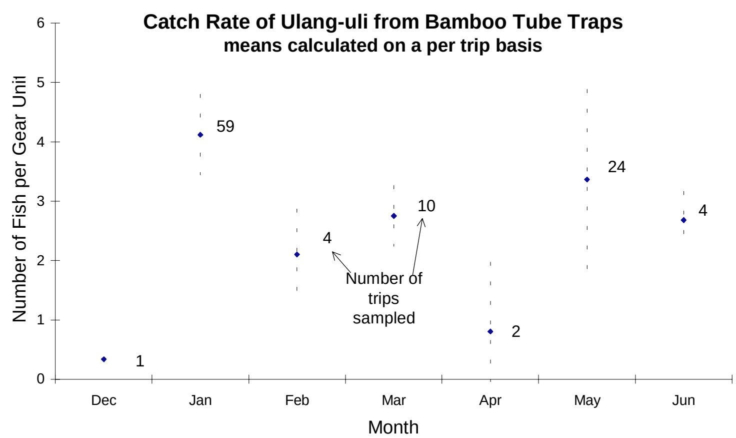

Figure 19. Catch rate of ulang uli from bamboo tube traps.

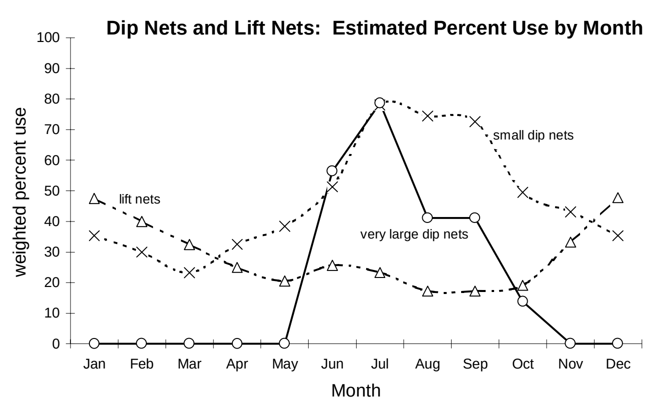

Figure 20. Seasonality of use of dip and lift nets.

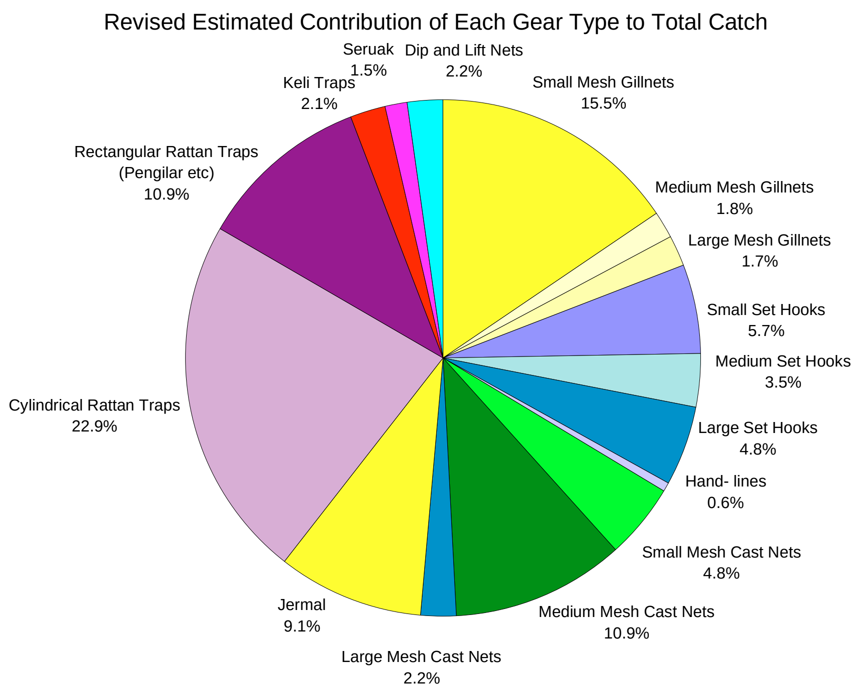

Figure 21. Catch composition by fishing gear type for the revised catch estimate.

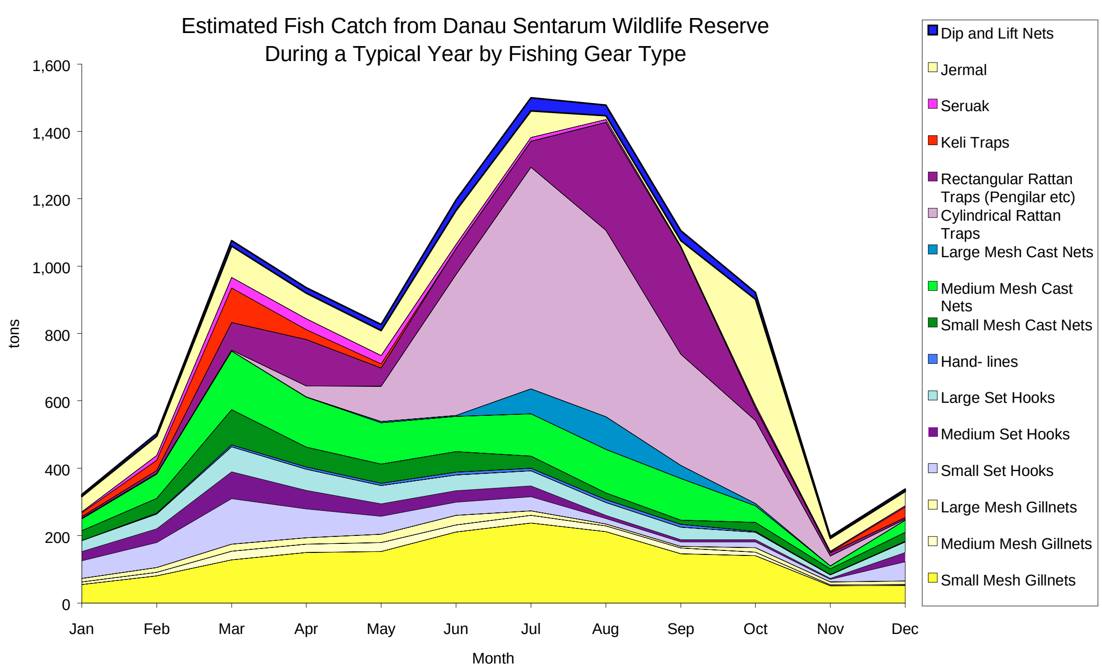

Figure 22. Revised catch estimate from DSWR by month during a typical year showing the contribution of each type of fishing gear. Based on catch survey data after adjustments to lower the overall catch and to lower catches during November through February. The revised total catch estimate is between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

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
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.**