

AN INTEGRATED ASSESSMENT OF INDONESIAN RIVER FISHERY RESERVES. PART 3. BIOLOGICAL STUDIES.

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ABSTRACT

This paper describes the biological investigations made in three Indonesian provinces as part of an integrated, inter-disciplinary study of river fishery reserves (see companion 'Part 1' paper for study introduction and design). These biological studies showed that, in the two West Kalimantan sites where poaching levels were low, fish stocks in the partially closed, community-managed reserves were 5-21 times more abundant, comprised up to 31 more species and were 5-6 times larger by weight in the dry season, than at the poison-fished Pulau Majang comparison site. At the heavily poached Tengkidap site in W. Kalimantan, individual fish were larger and fish stocks were more diverse than in Pulau Majang, though they were not as abundant as in the other two reserves. In comparison, fish stocks in the fully closed, government-managed reserves in S. Sumatra were much more similar to their nearby comparison sites, both at the 35% poached Teluk Rasau reserve, and in the non-poached but remote Teluk Gelam reserve. The results suggest that reserves should be located in water bodies that are well connected with the floodplain river system and that reserves do not need to be permanently closed to all gears, so long as dry season fishing rules are effectively enforced.

Keywords: protected areas, co-management, floodplain river fisheries, illegal fishing

INTRODUCTION

This paper describes the biological investigations made in three Indonesian provinces as part of an integrated, inter-disciplinary study of river fishery reserves (see Part 1 for study introduction and design). The project's biological monitoring programme (BMP) was designed to generate the following simple but quantitative indices on the status of fish stocks inside the reserves and comparison water-bodies:

- relative fish abundance (number and total weight of fish caught per unit effort);
- number of different fish species caught per unit effort; and
- average weight of individual fish.

Such simple indices were preferred over more complicated ones (such as the 'spawning stock biomass as a percentage of the unexploited biomass') to ensure that the results would be meaningful to both artisanal fishers and fisheries extension staff.

Floodplain river fish abundance varies over time in an annual cycle driven by the seasonality of flooding. Most river fish species spawn at the beginning of the flood, and the overall abundance of the stock then rises during the flood season, and falls again as fish die in the

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environmentally stressful conditions of the dry season. In fished rivers, catches are usually particularly high in the drawdown (falling water) and dry seasons when gear efficiency is high. The long-term survival and productivity of river fish stocks is critically dependent on the survival of enough fish over the dry season to spawn at the beginning of each new flood season (Halls et al, 2001). The ecological benefit of river fishery reserves may therefore be particularly related to the numbers or biomass of fish that they sustain over the dry season.

This paper then describes the use of multi-mesh gill nets to estimate the relative abundance, diversity and mean weights of fish stocks in reserve and non-reserve sites during the dry and high water seasons. To ensure that fish stocks were sampled over the unpredictable months of the dry season, the BMP was designed to cover a full annual cycle in the main study sites.

MATERIALS AND METHODS

At each BMP study site (see Part 1, Table 1), fish stocks were sampled using two fleets of multi-meshed gill nets, each comprising 4 sections of 40m x 2m monofilament gill nets, with mesh sizes of 1", 2", 3.5" and 4.5" (2.5, 5.1, 8.9 and 11.4cm). Gill nets were set on 4 pre-specified days in each month, thereby generating 8 samples per month. The gill nets were set in the late afternoon, mostly between 16.00 and 18.00, and hauled in the early morning, mostly between 06.00 and 07.00. Two locally resident fishermen were employed by the project to set and haul the nets, and local enumerators were employed to record the data collected.

Since the effectiveness (or 'catchability') of fishing gears varies between different gears, and between different floodplain river habitats and fishing seasons, a number of precautions were taken to minimise bias. Firstly, identical gill nets were used at each site, and a master fisherman was employed to train the village samplers in standard setting and hauling practices. Secondly, in each study water-body, the nets were set in the same eight different positions in each month, thereby covering a range of different habitat types (see example in Figure 1). Thirdly, catches were only compared between sites during the dry season and the flood season (as identified by recording water height data from gauges at each site). In these seasons, catch rates are less affected by sudden migratory responses to rises and falls in water levels (see introduction). Due to the early flood in W. Kalimantan in 1998, no dry season estimates could be made for those study sites in that year.

To reduce the villager's concerns about the depletion of fish stocks in their reserves, payments of Rp500,000 to Rp1,000,000 were made to village development funds at each study village. To avoid any misunderstandings about the legality of fishing in the reserves during the sampling period, publicity materials were distributed among village members, describing the scientific nature of the survey, the objectives of the project and the compensation paid to the village.

The BMP was implemented from August 1998 at the Jambi and S. Sumatra sites, and from September 1998 in W. Kalimantan. The programme ran until the end of September 1999, giving 13 or 14 months of data at each site. The sampling period was scheduled to give coverage of at least one dry season period at each site, and hopefully two.

For each gill net sample, data were recorded on the total numbers and weights of each different species of fish caught from all four of the different mesh panels combined. To assist interpretation of the data, notes were made of any occurrences of low water quality or poaching (all forms of illegal fishing) in the reserve since the last sample. Poor water quality

may be responsible for sudden losses of fish, particularly over the dry season and early flood, but no such losses were observed during the sampling period.

The 'full' BMP (i.e. sampling in all months, see Part 1, Table 1) was undertaken in seven different locations. Additional 'partial' sampling was conducted for the dry season months of September and October 1998, and August and September 1999 at two sites in S. Sumatra (see Part 1, Table 1), to allow comparisons to be made between reserve and non-reserve sites in this most important season.

RESULTS

BMP indices of the health of fish stocks in the different study sites are presented for the 1998 dry season, the 1998/1999 wet season and the 1999 dry season in Figures 2a, 2b and 2c respectively.

In W. Kalimantan, fish abundances (total numbers and weights of fish per gill net per night) were 5 to 21 times higher in two of the community-managed reserves (Meliau and Sekolat), than those at the Pulau Majang comparison site, having no reserves and fished by poison in the dry season (Figures 2b, 2c, top row plots). Poaching was reported at these sites on only 0-6% of sampled nights (Table 1).

At the other W. Kalimantan reserve study site (Tengkidap), poaching was reported on 78% of the sampled nights (Table 1), and fish stock abundances in the wet season were between the high levels at Meliau and Sekolat and the low levels at Pulau Majang (Figure 2b). In the 1999 dry season, lower numbers of fish were caught at Tengkidap than at Pulau Majang, while similar total weights were caught at each site (Figure 2c – noting the overlapping confidence intervals for these sites in the middle-right plot).

All three of the reserve sites in W. Kalimantan had more fish species than at the Pulau Majang comparison site (Table 2). Between 60 and 77 known species were found in the reserve sites, compared to only 46 species at Pulau Majang. It is possible that several more species were caught at the reserve sites with distinct local names and morphological differences (Table 2), or that some of these fish may have been the juveniles of the other known species. The mean numbers of fish species caught per net per night were 1.2 to 2.4 times higher in the reserves than at Pulau Majang (Figures 2b, 2c, bottom-left plots).

The 'missing' species at the poison-fished Pulau Majang site were largely non-migratory floodplain-dwelling 'blackfish' species. Of the fish species that were recognised by project staff as either local 'blackfish' or migrant, riverine 'whitefish' (48 out of the total of 103 known species at all of the sites), the Pulau Majang fish catches comprised ten times as many whitefish by numbers, and 14 times as many by weight (original data in project Final Technical Report, see FMSP web site - <http://www.fmosp.org.uk/>). Black fish stocks were more abundant at the other W. Kalimantan reserve sites, with only 1.2 to 5.8 times as many known whitefish as blackfish. Twenty five fish species were absent from the Pulau Majang site, but present in at least two of the three W. Kalimantan reserve sites. These included the following large and/or valuable species: *Botia macracanthus*, *Channa micropeltes*, *Oxyeleotris marmoratus* and *Wallago leeri*.

The average weights of individual fish in the wet season were similar between all of the W. Kalimantan sites (Figure 2b, bottom-right plot). In the 1999 dry season, however, fish in the Sekolat and Tengkidap reserves were 4.6 and 6.0 times heavier respectively than those in Pulau Majang (Figure 2c).

In the Pedamaran comparison group in S. Sumatra, the government-managed, fully-closed reserve, Teluk Rasau, was illegally fished on 35% of the sampled nights (Table 1). Fish abundances (by numbers and weights) inside the reserve were 1.9 to 2.2 times higher than in the nearby, fished, 'control' Teluk Toman water-body in the 1998 dry season (Figure 2a, top row plots), but were 16 to 32% lower in the 1999 dry season (Figure 2c). The overlapping confidence intervals for these results (see the figures) further indicate their relative insignificance compared to the large differences seen in the W. Kalimantan sites. The numbers of fish species caught in these two S. Sumatra sites was also approximately equal, both as the total numbers caught over the year (36 and 37 for the comparable dry season 'partial' months, see Table 2) and as the mean numbers per gill net per night (Figures 2a and 2c, bottom-left plots). The average weights of individual fish were similar in 1998, but were 1.6 times heavier in Teluk Rasau in 1999 (Figure 2c, bottom-right plot).

In the Benawa comparison group in S. Sumatra, the full reserve site, Teluk Gelam, was not reported as being illegally fished on any night, but still did *not* contain more or larger fish than the nearby fished 'control' site, Lebak Nilang. Teluk Gelam fish stocks had only similar abundances to those in Lebak Nilang (and overlapping confidence intervals) in both 1998 and 1999 (Figures 2a, 2c, top-row plots). Mean sizes of fish in Teluk Gelam were also similar to those in Lebak Nilang in 1998 and were 47% *smaller* than in the fished site in 1999 (Figures 2a, 2c, bottom-right plots). Furthermore, in the 'partial' dry season months, only 21 fish species were caught in Teluk Gelam reserve, compared to 31 in the fished site (Table 2). The average numbers of fish species caught per net in the reserve were also lower, at 4.6 per gill net per night in 1998 and 5.8 in 1999, compared to 9.1 and 9.4 species in the fished site (Figures 2a, 2c, bottom-left plots). The missing species at the Teluk Gelam reserve included many of the more common flood-plain 'blackfish', such as *Channa striatus*, *Notopterus notopterus*, *Clarias* spp, and *Trichogaster pectoralis*.

In Jambi, the Arang Arang reserve site had similar fish stocks to those in S. Sumatra, with fish abundances and total numbers of fish species (34) again well below those found at the W. Kalimantan reserve sites. As mentioned in Part 1, no suitable biological 'control' site was available for Arang Arang.

DISCUSSION

In summary, this study found that, in W. Kalimantan, at the two sites where poaching levels were low, fish stocks in the partially closed, community-managed reserves were 5-21 times more abundant, comprised 14-31 more species and were 5-6 times larger in the dry season, than at the poison-fished Pulau Majang comparison site. At the heavily poached Tengkidap site in W. Kalimantan, individual fish were larger and fish stocks were more diverse than in Pulau Majang, though they were not as abundant as in the other two reserves. In comparison, fish stocks in the fully closed, government-managed reserves in S. Sumatra were much more similar to their nearby comparison sites, both at the 35% poached Teluk Rasau reserve, and the non-poached Teluk Gelam reserve. These wide differences between the sites may be due to several different causes, including the following:

1. reserves may give biological benefits to the fish stocks they contain, but only when they are well enforced, as by the Meliau and Sekolat communities in W. Kalimantan;
2. the high indices at Meliau and Sekolat may be due to the greater management restrictions in place at these sites, compared to Tengkidap;
3. the use of poison fishing at the Pulau Majang 'control' site may have inflated the apparent benefit of the reserves in W. Kalimantan, compared to S. Sumatra;

4. the close proximity of Teluk Rasau and its 'control' site may have reduced the difference in their stock abundances, due to 'spillover' of fish from the reserve to the 'control' site; and
5. the low indices at the Teluk Gelam reserve may reflect its relatively remote location and limited connections with the adjacent floodplain system.

On the first point, the relatively small difference between the Teluk Rasau reserve and its comparison site in S. Sumatra may be due to the ineffective enforcement observed at this site (see also Part 2). The low enforcement at the W. Kalimantan reserve in Tengkidap village (poached on 78% of nights sampled) may also partly explain its relatively poor fish stocks compared with the high BMP indices found at Meliau and Sekolat. Such enforcement problems may reflect the close proximity of the Tengkidap reserve to the district town of Suhaid, and the lack of a permanently settled community at the lake (see Part 2, Institutional Analyses).

As noted in point 2 above, the relatively poor performance of the Tengkidap site may also be due to the less restrictive fishing regulations in place at this site. As indicated in Part 1 - Table 2, only *some* gears (gill nets and barrier traps) are restricted in the Tengkidap reserve and only in the dry season. In Sekolat, no fishing at all is allowed in the reserve in the dry season; while in Meliau, gill nets and other gears are restricted in the reserve all year. In both the latter two sites, various other regulations also apply to other fishing practices outside the reserves. While the regulations at these two 'healthy' sites are thus more restrictive than at Tengkidap, they are still less restrictive than the fully closed (but less enforced) government reserves in S. Sumatra.

On the third point, from the available data, it is impossible to separate any positive effects of the reserves in W. Kalimantan from the negative effects of the poison fishing in the Pulau Majang 'control' site. The W. Kalimantan 'control' is thus more thoroughly fished than the S. Sumatra 'controls', and this alone may give a larger 'benefit' for the former province. Considering the W. Kalimantan results on their own, the results suggest that these reserves can give effective protection to flood plain fish stocks, at least compared to the most dangerous form of dry season fishing (using poison).

The fourth point re-emphasizes the difficulty of finding comparable control sites for studies such as these (see Part 1 Introduction). Since the two Pedamaran study sites are only about 3km apart, fish stocks in the fished Teluk Toman site may be as high as in the Teluk Rasau reserve simply because they are close to the reserve and receive fish recruitment from it. In W. Kalimantan, the reserve water bodies are a much greater 8-30km from the fished Pulau Majang site, on opposite sides of the extensive Danau Sentarum lake system. The actual differences between fish stocks at these sites may also be partly due to subtle hydrological differences between them (particularly in dry season water depths). The dry season fishing in Teluk Toman may also have been less extreme than usual in the years of the study, due to the abnormally high water levels in S. Sumatra. In other years, the Teluk Rasau reserve may show relatively higher fish stocks, compared to the fished waters nearby.

Finally, on the fifth point, the extremely low numbers of fish and the impoverished species compositions in the Teluk Gelam reserve may be due to the hydrologically remote position of this site, and its poor connections with adjacent flood-plain waters. Such an unconnected 'reserve' is unlikely to provide either conservation benefits to fished stocks in the nearby floodplains or economic benefits to fishing communities. This water body may be better classified as a recreation park or picnic site, rather than as a 'harvest' reserve. The relatively low catch rates in both Teluk Gelam and the nearby 'control' site Lebak Nilang, compared to the two Pedamaran sites in an adjacent sub-catchment, may be due both to these 'location'

factors, and to the fact that much of Benawa's surrounding swamp forest has been drained and planted for oil palm production.

The full explanation for these results probably involves some combination of each of the points discussed above. While the study leaves much uncertainty over the actual impact of reserves and the relative benefits of different designs, the overall results suggest that the careful placement of reserves in suitable water-bodies and effective enforcement of rules (see also Part 2) may be more important factors than the permanence of closure. The high stock levels in the partially closed, community reserves in W. Kalimantan thus suggest that reserves do not need to be fully closed all year, so long as effective restrictions are in place over the dry season or against the most destructive gears.

The missing floodplain 'blackfish' species at the poison-fished Pulau Majang site also indicate that the main potential of harvest reserves (or at least the avoidance of poison fishing) is for the protection of these least mobile species. Migratory 'whitefish' species may still be recruited from external sources, at least until they also become depleted by the competitive fishing in the many villages throughout their range.

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Table 1. Percentage of BMP-sampled nights on which illegal fishing gears were observed at the reserve study sites.

Comparison Group (province / catchment / sub-catchment)	Study Site (village)	Percentage of nights illegally fished
Jambi	Arang Arang	0%
West Kalimantan	Meliau	0%
	Sekolat	6%
	Tengkidap	78%
Benawa (S. Sumatra)	Teluk Gelam	0%
Pedamaran (S. Sumatra)	Teluk Rasau	35%

Table 2. Total numbers of different fish species caught at each study site.

Comparison Group (province / catchment / sub-catchment)	Jambi		West Kalimantan			Benawa (S. Sumatra)		Pedamaran (S. Sumatra)	
	Arang Arang	Meliau	Sekolat	Pulau Majang ^c	Teng-kidap	Lebak Nilang ^c	Teluk Gelam	Teluk Rasau	Teluk Toman ^c
Number of species caught									
Total of all known species	34	63	60	46	77	40		50	
Total of different local names	35	69	64	46	95	41		51	
Totals for 'partial' months						31	21	36	37

Notes: ^c 'Control' or non-reserve sites

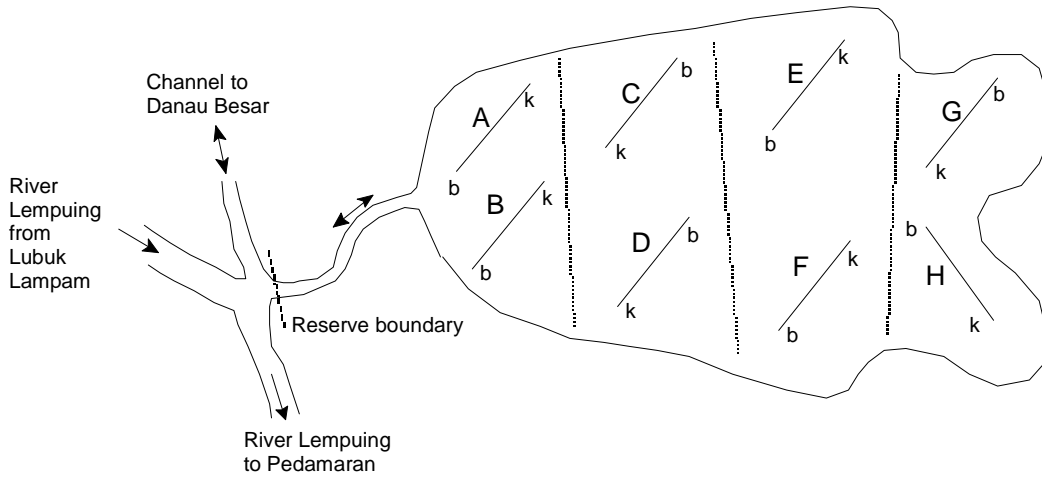


Figure 1. Illustration of experimental gill net setting positions, as used in Teluk Rasau reserve water body, Pedamaran village, S. Sumatra. Gill net positions are numbered A to H. The codes 'b' and 'k' indicate the small-meshed and large-meshed ends of the net respectively.

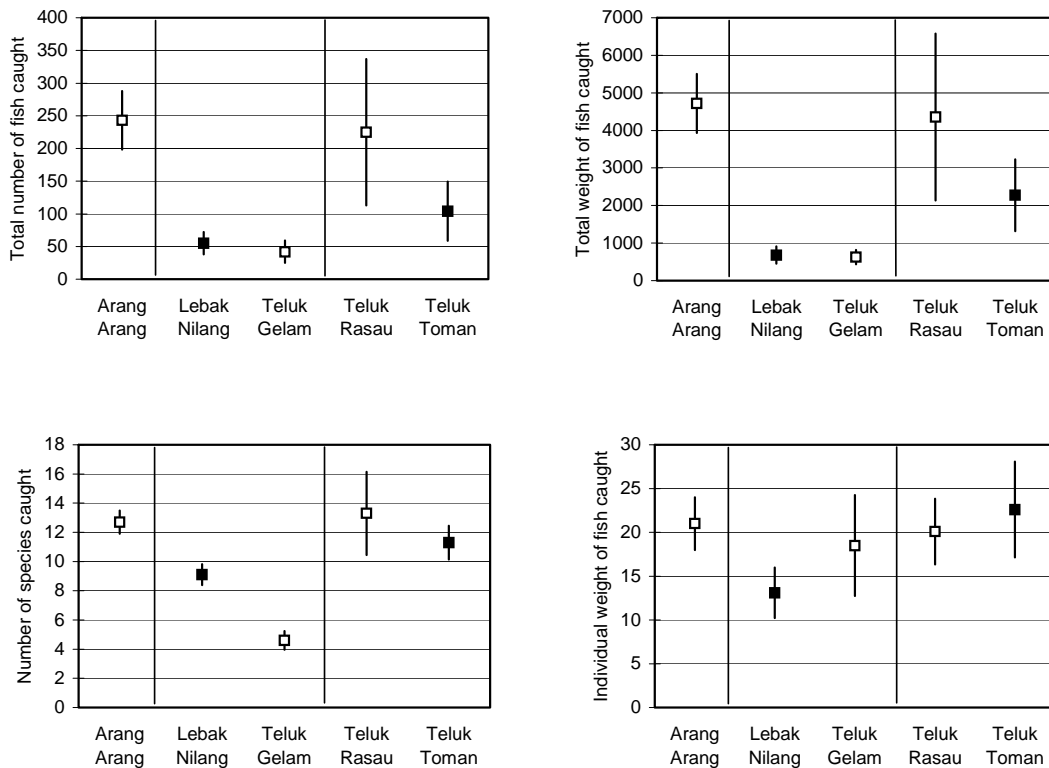


Figure 2a. Mean catches per night per multi-mesh gill net from the BMP study sites sampled in the 1998 dry season. Open boxes are reserves; filled boxes are fished water bodies. Vertical lines separate catchment 'comparison groups'. Bars around points are 95% confidence intervals.

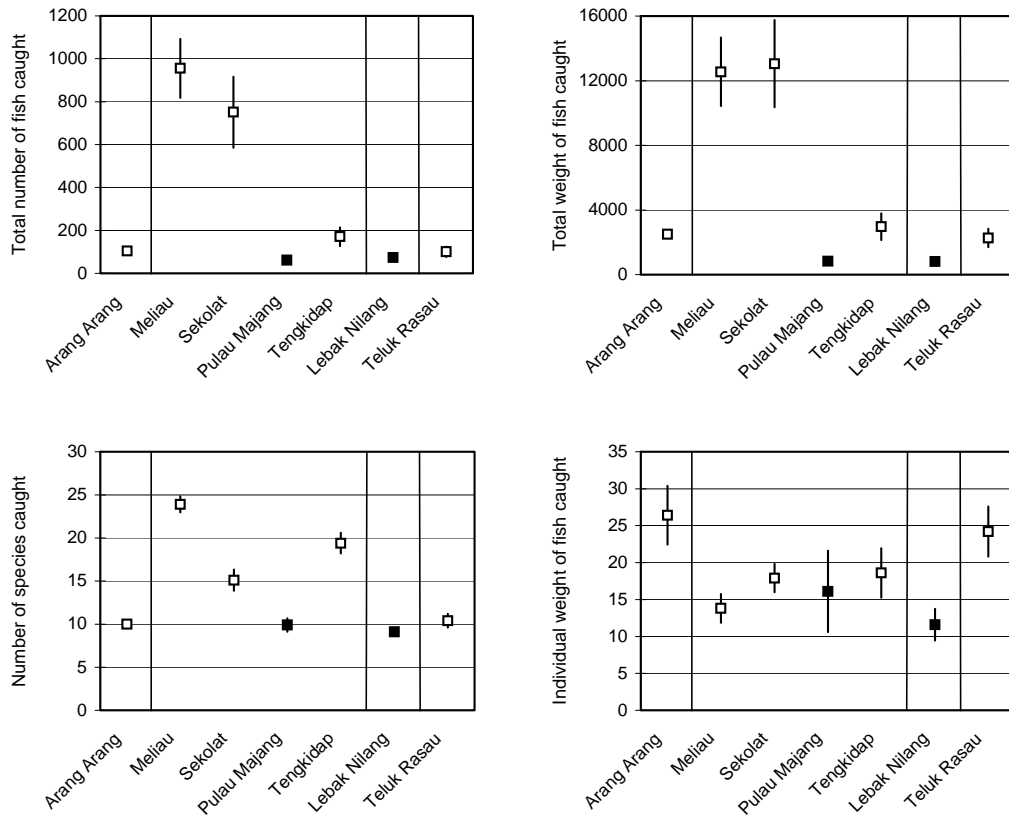


Figure 2b. Mean catches per night per multi-mesh gill net from the BMP study sites sampled in the 1998/99 wet season.

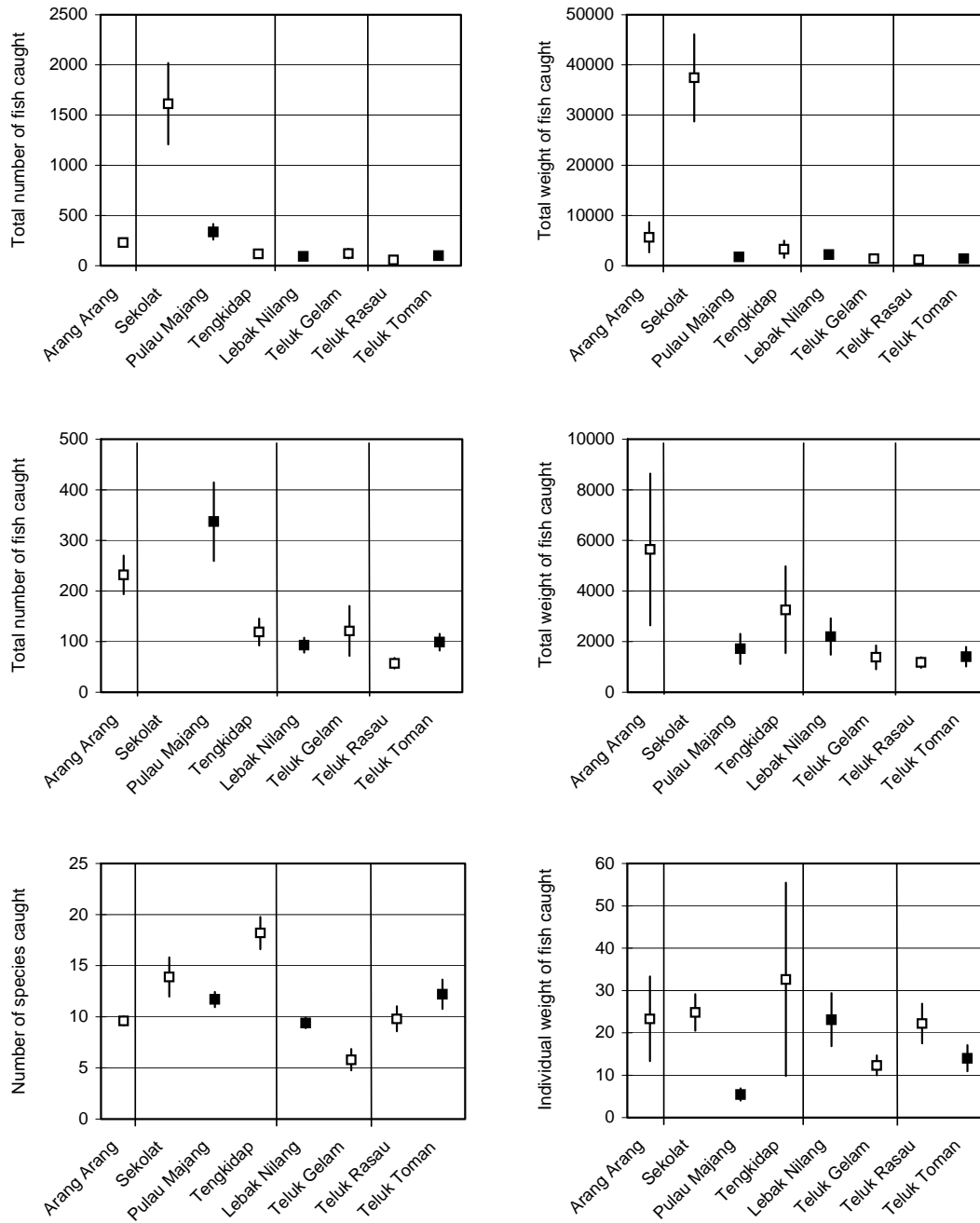


Figure 2c. Mean catches per night per multi-mesh gill net from the BMP study sites sampled in the 1999 dry season. Note that the middle row of figures re-present the data shown in the top row, but excluding the extreme Sekolat data. BMP data for Meliau were unreliable for this season and excluded from the analysis.