Marine Resource Utilization in Komodo National Park

Monitoring Report 1997-1998

Dr. J.S. Pet
E-mail: jpet@attglobal.net

Illustrations: Donald Bason/TNC

August 1999

YPAN Komodo Field Office
Labuan Bajo,
Flores Barat, Indonesia
tel. +62-(0)385-41214
fax. +62-(0)385-41225

Yayasan Pusaka Alam Nusantara

The Nature Conservancy®

NC Indonesia Field Office
Jl. Hang Tuah Raya 42
Kebayoran Baru 12120
akarta Selatan, Indonesia
tel. +62-(0)21-7206484
fax. +62-(0)21-7245092

TABLE OF CONTENTS

1. INTRODUCTION: A LONG TERM MANAGEMENT PLAN FOR KOMODO NATIONAL PARK

In October 1996, a draft management plan was completed for the marine component of Komodo National Park (KNP, Figure 1), which was (and is still) seriously threatened by destructive fishing practices such as dynamite fishing, cyanide fishing, reef gleaning and plain overfishing. Destructive fishing practices destroy both the habitat (coral reefs) and the resource itself (fish and invertebrate stocks). The most important recommendations in the management plan are that destruction and harvesting of sedentary marine resources in KNP should be greatly reduced and that decision making, implementation and enforcement should be carried out in collaboration with the local communities. The objective of the Park management is

"*To protect the demersal and sedentary marine life forms of Komodo National Park, their ecosystems and their habitats, and to maintain the natural population and community structures of these life forms*".

Key modules in the management plan are:

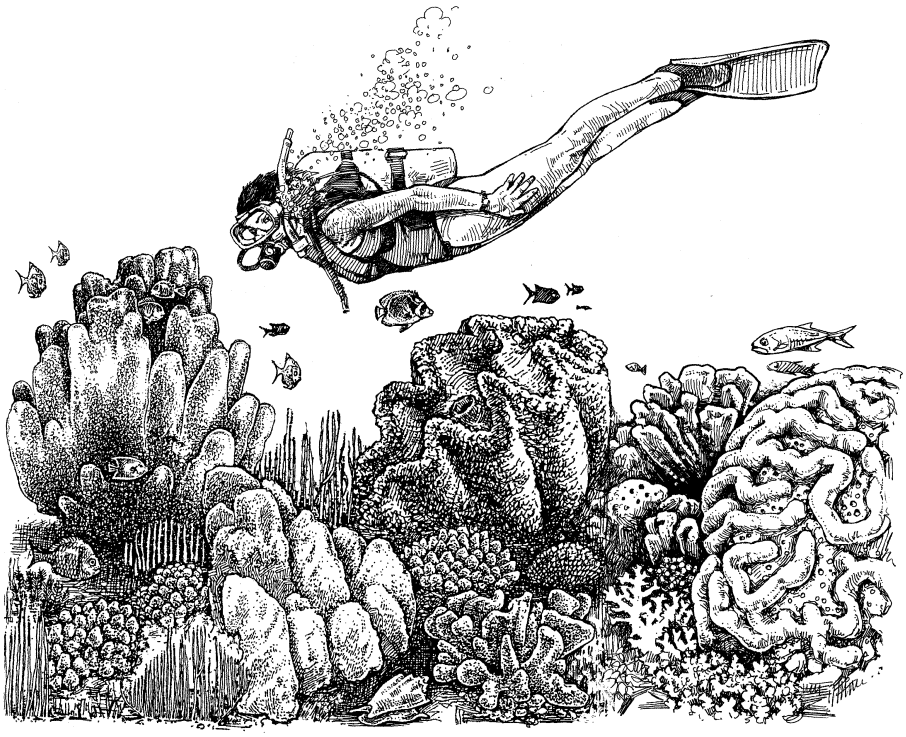
I. Design marine park zonation and specify regulations
II. Promote implementation of cross-sectoral enforcement program with
    a. Park Authorities
    b. Police, Army & Navy
    c. Fisheries Service
    d. Local Government and Communities
III. Involve local communities through:
    a. community awareness program
    b. participatory planning process
    c. establishment of a local NGO
IV. Work with business partners to develop alternative livelihoods in a variety of compatible enterprises such as:
    a. eco-tourism
    b. mariculture
    c. pelagic fisheries
V. Implement a comprehensive monitoring and research program to generate the data needed for project evaluation and provide guidance towards the most desirable and effective interventions. Program sub-modules:
    a. monitoring of the status of the coral reefs
    b. monitoring of the status of commercially targeted fish populations and their spawning aggregation sites
    c. monitoring of fisheries resource utilization patterns
    d. applied research on mariculture and fisheries
    e. applied research on coral reef rehabilitation

2. STATUS OF THE CORAL REEFS

The objective of the coral reef monitoring program is to obtain information on spatial and temporal patterns in coral reef status and rehabilitation inside and outside the park, with special attention for the percentage of damaged coral. Potential management responses to monitoring results include: a) Detailed update of the preliminary plan for zonation and regulations as drafted for the 25 years management plan (e.g., allocation of specific sites for dive-tourism, artisanal fisheries, full protection, or other purposes.) b) Adjustment of enforcement program in terms of effort allocation in space and/or time (adjustment of surveillance routine). c) Identification of locations and implementation of activities at places where active management is needed for reef rehabilitation.

Significant natural rehabilitation of the coral reefs has occurred between 1996 and 1998 in the following areas in and around KNP: 1. Labuan Bajo, 2. Buffer zone, 3. KNP Rinca, and 4. KNP Komodo (Figure 2). The overall means over 185 coral monitoring sites show that live hard coral cover has increased between 1996 and 1998 from 16 to 20%. Soft coral cover also showed a slight increase from 22 to 24% and the hard coral mortality coefficient decreased from 63% to 52%. Inside Komodo National Park the live coral cover increased from 15% in 1996 to 19% in 1998. Outside the Park an increase was recorded from 17% to 23%. The coral mortality coefficient decreased inside the Park from 51% to 48% and outside the Park from 65% to 51%.

It can therefore be concluded that the overall destruction of the coral reefs in and around Komodo National Park has been stopped and that a slow rehabilitation (2% increase in hard coral cover per year) has started. This rehabilitation of the coral reefs is explained by a dramatic decline in dynamite fishing (since 1996), caused by a combination of enforcement, community awareness and a shift from low-income fishing for local markets (dynamited fish) to high-income fishing for export markets (live reef fish). The results also show that rehabilitation is fastest near the center of protective activity, which is in the town of Labuan Bajo. Rehabilitation, on average is slower inside the Park, where many remote areas are still difficult to control.

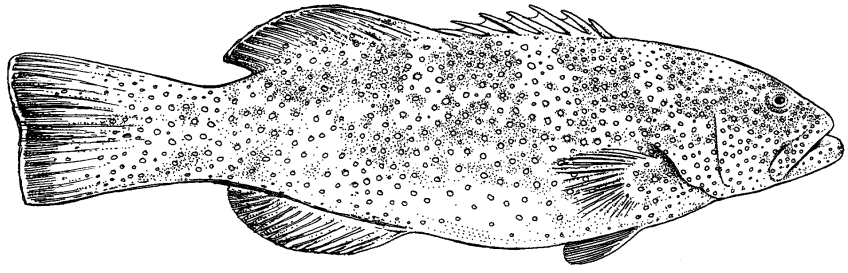


3. MONITORING OF FISH SPAWNING AGGREGATION SITES

The objective of the fish monitoring program in Komodo National Park is to establish a data set on relative changes in selected reef fish abundance and body size between sites and over time. Data are collected to a) Determine if and how fish populations are changing over time and space and b) Identify spawning locations for key fish species. Potential management responses include a) Adjustment of zonation and regulations for fisheries and other activities and b) Closure of spawning locations for capture fisheries. By monitoring the size frequencies of a number of commercially targeted fish species on a number of known aggregation sites, it will be possible to evaluate developments in the fish populations in a cost-effective manner. By identifying mass spawning sites for important fish species it will be possible to select areas which need special protection. Preliminary results show that a number of aggregation and spawning sites have been positively identified in Komodo National Park (Figure 3).

Spawning concentrations of target species in Komodo National Park contain relatively low numbers of fish, compared to aggregations of the same species in other locations. Only two larger aggregations, one with mainly *E. fuscoguttatus* and one with mainly *P. areolatus*, have been identified within the borders of Komodo National Park, although hundreds of sites have been looked at. In the case of the spawning populations of *P. laevis* and *C. undulatus* we are truly looking at some of the last great fish in the Park and even in the region (Squire, 1999). Spawning seasons and timing in the lunar phases have been identified for the most important target species and the overall main spawning season for these species is from October to January, with small differences between species. Different species use the spawning sites at different moon phases and many other reef species, including important food and ornamental fishes use the same spawning sites.

All spawning sites in Komodo National Park are targeted by fishermen supplying the Live Reef Fish Trade and they are especially active during the spawning season. The few sites with spawning groups of the main target species in the LRFT are of great importance for the function of Komodo National Park as a source of recruits for surrounding fishing grounds. These sites need to be fully protected and therefore need to be embedded well within the borders of the core zones of the Park. A preliminary recommendation for closed areas within Komodo National Park has been designed. All reef fish spawning sites need to be protected urgently against all forms of fishing and a closed season for reef fisheries may be a useful addition to the proposed closed areas. With a closed season of only 4 months for reef fisheries, in major parts of the multiple use zones, from October through January, many reef fishes will be protected during their peak spawning season.



4. MARINE RESOURCE UTILIZATION PATTERNS IN KOMODO NATIONAL PARK

Based on information from earlier reports such as Rapid Rural Appraisals, Ecological Assessments and fisheries studies, it was clear that the threat of illegal destructive fishing methods was the first major problem that needed to be addressed in order to protect the marine habitats of KNP. It was therefore decided that a cooperative enforcement team would be formed in which park authorities, police, army, fisheries services and local governments work together to carry out a routine patrolling program, investigating all fisheries activities. Earlier enforcement activities (before June 1996) were restricted to operations carried out on the basis of specific information on ongoing illegal activities in the park. Sending out this kind of patrol was often difficult due to the short notice, lack of infrastructure available to park authorities, and lack of funds for operational costs.

The routine patrolling program started on 28 May 1996, with the intention to have 2-day patrols covering the entire park area on a weekly basis. In 1996 patrols took place almost on a weekly basis but the frequency dropped to an average of only 1.5 patrol per month in 1997 (Table 1). In total 38 patrols were organized between May 1996 and December 1997. The patrolling frequency was high in 1998, with a total of 40 patrols and an average frequency of 3.3 patrols per month in that year. The incidence of dynamite and cyanide fishing dropped significantly during the first period of intensive patrolling in 1996. The routine patrolling program has led to several arrests of fishermen using destructive fishing methods in and around the park. A reduction of more than 75% was recorded for dynamite incidents. Developments in 1997, however, showed that the routine patrolling program should be kept up to prevent a return of destructive fishing, especially cyanide fishing for aquarium fish and for lobster, live groupers and napoleon wrasse.

KFO and PHPA staff have been trained to record data on resource utilization patterns during routine patrols in the KNP area. This data includes number, type and origin of fishing crafts, their catches and their distribution in space and time. All fishing activities are recorded on standard data sheets during the routine patrols. A data base on temporal and spatial patterns in resource utilization has been established at the Komodo Field Office. The present report discusses marine resource utilization in 1997 and 1998.

4.1 Objective and Potential Management Response

The objective of this monitoring program is to determine who is doing what, where and when in the Park. (This is in a situation which is preceding any implementation of marine zonation or regulations other than a ban on dynamite and cyanide fishing). The data base on resource utilization patterns shows Park Managers which community groups are involved in which fishing activities, where they fish, and when they fish. Over time this data will also show any changes in the behavior of fishermen due to management measures and it will indicate which groups of fishermen or areas in the Park may need extra attention.

Potential management responses include: a) Design zonation and

regulations in such a way that objectives can be achieved with a minimum of conflict with local resource users, b) Determining which fishing groups pose threats to the park and should therefore be targeted by enforcement programs and alternative livelihood projects and c) Determine which type of fishing activities are particularly threatening and should be prohibited in the Park.

4.2 The Monitoring Program

Each non-bagan (non lift net) fishing vessel or fishing group encountered during the routine patrols was investigated and a standard data sheet was filled out. Bagan were excluded since they operated only at night (with light attraction) and they formed a separate type of pelagic fishery which was not considered threatening to the demersal and sedentary marine resources of Komodo National Park. Bagan boats were investigated whenever they engaged in non-bagan activities during the day. The monitoring program started with the first routine patrol in May 1996 and this report covers the period until the last patrol in December 1998, during which 78 patrols were undertaken. Preliminary data were used to design categories of fishing gear, origin and catch. Data collected from fishing vessels encountered during patrols included:

a. date
b. position (using GPS coordinates)
c. type of boat and engine according to categories:
    1. inboard engine
    2. outboard engine
    3. no engine
    4. no boat

d. number of fishermen on the boat or in the fishing group
e. method or fishing gear according to categories:
    1. trolling lines (both pelagic and steel demersal gear)
    2. bottom hook and line (handline and bottom longline)
    3. gillnet (set and drift gillnet)
    4. fish trap (bubu)
    5. compressor and dive gear
    6. meting (without dive gear)
    7. jaring nener and pukat udang
    8. other gear (incl. fish bomb)

f. species in the catch according to categories:
    0. no catch
    1. fish
    2. sea cucumber
    3. bandeng fry **(estimated in numbers)**
    4. small shrimp
    5. lobster **(2 animals in 1 kg)**
    6. shellfish **(2 pearl oysters or 10 abalone in 1 kg)**
    7. seaweed
    8. any mixture or other catch

g. quantity of the catch:
   * only bandeng fry in estimated numbers
   * any other category in estimated kg

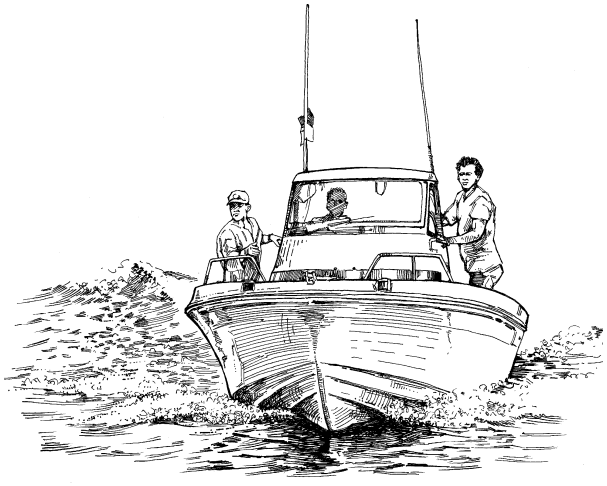
h. quality of the catch according to categories:
   0. no catch
   1. wet or dry weight **(wet weight = 2 * dry weight)**
   2. numbers ('ekor', only for bandeng larvae or 'nener')

i. origin of the fishing vessel or group according to categories:
   1. Komodo
   2. Rinca and Kerora
   3. Papagarang
   4. Warloka and Golohmori
   5. Mesa
   6. Labuan Bajo and Seraya
   7. Sape
   8. Outsiders (any other origin)

The landed yield was assumed to be twice as high as the catch observed in the fishing vessels at sea. Fishing vessels encountered could be just starting or almost finishing their fishing operation. It was assumed that on average they were halfway through their operation and that their catches were on average around half the catch at eventual landing. The annual catch was therefore estimated with:

Annual Catch = 2 * 365 days * total observed catch in n patrolling days / n patrolling days

Each patrol covered most of the Park's waters in 2 days and monitoring results of a single patrol were used as representative for 1 day of fishing operations in the park. This is an underestimation of the actual effort since not all fishing boats were seen when they were inside bays or behind islands. The mean daily effort was calculated for each year as the total recorded effort per year, divided by the number of patrols in that year. The annual effort was calculated as the mean daily effort times 365 days. Only for the first full year (1997) data have been combined with data from the second half of 1996. Results were adjusted for a 1 year period (1997). Results as discussed below were based on these assumptions and calculations. Spatial distribution was expressed as distribution per 25 square mile area and seasonal patterns were expressed per 3 month season being the North West (December through February), the Inter Monsoon 1 (March through May), the South East (June through August) and the Inter Monsoon 2 (September through November).



5. RESULTS

A total of 38 patrols was carried out between May 1996 and December 1997, and a total of 40 patrols was carried out in 1998. The frequency of 3.3 patrols per month in 1998 was satisfactory but the patrols tended to be organized during mid-week days (Figure 4), which made them predictable and therefore less effective. Future patrols will be organized with departure dates chosen more randomly out of the week-days.

5.1 Spatial distribution of fishing effort

Non-bagan fishing effort in the Park was comparable in 1997 and 1998 with an estimated total of between 9000 and 9500 trips per year (Figure 5). Distribution of this effort changed from 1997 to 1998. In 1997 the effort ranged from less than 300 boats per 25 square miles per year in the South to more than 1000 boats off Pulau Sebita in North East Komodo. In 1998 the fishing effort on the reefs off North West Komodo (a central area with high frequency of 'conservation activity') was somewhat reduced but effort increased in the more remote northern, western and southern areas. The most heavily fished areas in 1998 were North and West Komodo and North Padar / North West Rinca.

The area with the highest fishing effort in 1997 was also the area with the highest coral mortality in that year. Areas with low coral mortality were typically those areas where fishing effort was low, although high coral mortality was also found in a few areas where fishing effort was relatively low. It is also clear that fishing effort is relatively high in areas where fish spawning aggregation sites are located and fishing therefore forms a direct threat to the fish species aggregating at these sites. In 1998 the highest fishing effort was concentrated in the same area as where the most important grouper spawning aggregations are found.

5.2 Catch and Effort per Gear Type and per Fishing Community

Around 1000 tons of fish, lobster, shrimp, pearl oyster and abalone were harvested from Komodo National Park in 1997 (Figure 6). In comparison, this is about the same amount in weight as the pelagic bagan yield from Park inhabitants (Komodo and Rinca) alone. In 1998 the total yield was much (50%) lower at around 500 tons. This may be partly caused by a "La Nina" effect which is notorious for causing reduced fish catches in the area. Quality long term official data on landings are not available for the Komodo district. Both in 1997 and in 1998, between 90% and 95% of the non-bagan yield consisted of various species of fish, mostly caught with gillnets, bottom hook & line and trolling lines. Smaller quantities of high value live reef fish were caught with fish traps (bubu) and with compressors (using cyanide).

Small shrimp harvest with "pukat udang" increased from 7.000 kg in 1997 to 15.000 kg 1999. Sea cucumber harvest went down from 13.000 kg in 1997 to 10.000 kg in 1998. Lobster catches went up from 5.000 kg to 9.000 kg and shellfish yields (mostly abalone) collapsed from 20.000 kg in 1997 to 2.000 kg in 1998. Sea weed harvest yielded around 5.000 kg in KNP in 1997 and 3.000 kg in 1998. Catches recorded as "mixed", mostly from reef

gleaning or "meting" and including a large percentage abalone, went down from 14.000
kg in 1997 to 1.000 kg in 1998. In addition around 2 million bandeng fry were harvested in the Park in 1997 and exported for use in aquaculture in other regions in Indonesia. Bandeng fry are mostly caught by fishing families from Sape (66%), Komodo (16%) and Rinca (12%). This type of activity was not recorded in 1998, supposedly since bandeng fry (nener) were hardly present in the area. This type of fishing takes place from the beach, without the use of boats. Local communities are eagerly waiting for the nener "to rise again".

The most important gear types used in the park in terms of catch and effort are gillnets, bottom hook and lines and trolling lines. These gear types together accounted for 70% of the catch and 58% of the effort in 1997, and 89% of the catch and 79% of the effort in 1998. Gillnets are the single most important gear type in terms of catch with 60% of the total yield in 1998. In 1997, 18% of the total yield was harvested with "other gear types", including fish bombs. This type of yield was not encountered during the routine patrols in 1998 (although bombing still occurred and was observed during specific enforcement activities). Bottom hook and line has become less important with slightly decreasing effort and strongly decreasing catches from 1997 to 1998. The effort of trolling lines has more than doubled from 1997 to 1998, partly due to larger numbers of pelagic fishers but mostly due to the introduction of "kedo kedo" fishing or demersal trolling with steel wire for live groupers (mostly coral trout). These fish are highly valuable and decreasing catches per unit effort have not discouraged the fishermen to engage in this activity. The "kedo kedo" trolling boats are successfully targeting grouper spawning aggregation sites.

Catch and effort has reduced strongly for reef gleaning or 'meting'. This is partly due to increased enforcement but partly also due to collapse of the main target stocks such as abalone. The effort of compressor fishing has unfortunately again increased from 1997 to 1998, although catches per unit effort (CpUE) went down slightly. CpUE went down dramatically from 1997 to 1998 for trolling, bottom lines, gillnets and fish traps. Gillnets show the highest CpUE both in 1997 and in 1998 and far outperformed hook and line fishing in terms of catch per trip. The value of gillnet catches (a variety of reef fish species, sun-dried for preservation) is usually low however, especially compared to the catches by trolling lines (spanish mackerel on ice and live groupers).

The Park inhabiting communities of Komodo and Rinca represent only a minor and decreasing percentage of the non-bagan fishing effort in the Park (Figure 7), both in terms of fishermen and boat trips. Even Communities directly surrounding the Park (Papagarang, Warloka, Mesa and Labuan Bajo) are not dominant and show decreasing activity on the reefs of the Park. Only the communities of Mesa and Warloka (out of all surrounding villages) seem to be maintaining their activity in the Park. Communities from East Sumbawa (around Sape) are the most important users of the Parks resources in terms of effort (50% in 1998!). Outsiders from even further away, mainly from South Flores (Pulau Ramut and Ende) and from Sulawesi claim the bulk of the catch with 46% in 1998. A stunning 83% of the yield is harvested by the combined fishing effort from Sape and other

outside communities.

Most fishing communities harvest mainly fish from the Park waters and only the non-bagan yields from the inhabiting communities, Komodo and Rinca, were more diverse (Figure 8). Absolute figures may be underestimates but relative impact of specific gear types on different yield categories could be derived accurately from the available data. Yield by Komodo fishing folk was very diverse in 1997 when meting was the major activity. In 1998 99% of the yield was small shrimp caught with "pukat udang". Rinca yield typically contains 60% to 65% fish and 35% to 40% other yield categories. Seaweed harvesting is an increasingly important activity in Rinca.

Trolling, bottom lines, gillnets and traps catch almost only fish. Other gear types are also specifically yielding single yield categories except for 'compressor' and 'meting' (Figure 9). The latter two gear types were typically yielding a widely varied catch, ranging from live fish and lobster (caught with cyanide) to sea cucumber, shellfish, coral and seaweed. Compressor yields of sea cucumber and lobster have gone up from 1997 to 1998 whereas yields of live fish were slightly reduced and yields of shellfish seem to have collapsed. Yields of seacucumber and shellfish by meting (shallow water) have also gone down dramatically. Compressor fishing and meting form major threats to the marine ecosystem of Komodo National Park. It should be added here that fish bomb and cyanide fishermen use compressors to bring divers down and to collect their catch.

5.3 Gear Types used by Fishing Communities in and around KNP

Fishermen from Komodo were mainly involved in reef gleaning in 1997 (Figure 10), but their activity in demersal harvesting activities seems to have greatly reduced in 1998. Their main activity in 1998 was the fishery for small shrimp ('udang halus' or 'udang kecil'). Fishermen from Rinca were mainly involved in reef gleaning and bottom line fishing in 1997, but reef gleaning activity was greatly reduced in 1998. Papagarang was mainly involved in trap fishing and bottom line fishing in 1997, but the activity of this community inside the Park was strongly reduced in 1998. Warloka was mostly active in bottom line fishing in 1997, but diversified its activities in the Park in 1998 to trolling, bottom line and gillnet fishing. This community is located at Selat Molo where it witnessed the large catches by outsiders with monofilament gillnets. Mesa decreased its activity in bottom line fishing and 'hookah' compressor fishing from 1997 to 1998, but increased its activity in trolling, both pelagic (spanish mackerel) and demersal (live groupers), and in gillnet fishing. Labuan Bajo was mainly active in bottom line fishing in 1997, but this community also reduced its activity inside the Park and diversified to gillnets and fish traps (live groupers). Sape increased its activities in the Park from 1997 to 1998 with trolling, bottom lines, gillnets and compressor fishing). The outsiders from Ramut and Ende mostly work with gillnets but the activity of (demersal) trolling lines is also increasing (Sulawesi live grouper fishermen), as is the activity of compressor fishing (aquarium fish operations from Banyuwangi). *Sape and Outsiders are the only community groups which show increasing compressor activity*.

Trolling line is mostly used by fishermen from Sape (Figure 11) which represented 92% of this activity in 1997 and 77% in 1998. This activity is

strongly on the increase, also among fishermen from Warloka, Mesa and by outsiders (Sulawesi). The activity with bottom hook and line is common among all communities but decreasing for most except Rinca (stable and Sape (strong increase). Sape and Mesa together represented 50% of the bottom hook and line fishing in 1997 and 72% in 1998. Gillnets are mainly used by outsiders from Pulau Ramut, Ende and other origins, whereas most local communities are also using more and more gillnets. This is a type of fishery which may not seem very harmful but which is in fact one of the main (and growing) threats to the sedentary fish stocks in the Park.

Papagarang was the major source of fish traps in the Park, with 88% stemming from that origin in 1997. Trap fishing by this community was greatly reduced in 1998 but increasing activity was recorded for Labuan Bajo (live groupers). This community is presently still forming an important threat to the Park's reefs with this practice. Even larger threats are formed by the compressor fisheries originating from Mesa and Sape (together accounting for 80% to 85% of compressor use in the Park). Reef gleaning activity was greatly reduced for all communities, although to a lesser extend for Sape. This practice seems to be a diminishing threat to the Park's coral reefs although it can and will return under circumstances of reduced enforcement activity and rehabilitation of the coral reefs.

Jaring nener and pukat udang are gear types traditionally operated by Park inhabitants (Komodo and Rinca together accounted for more than 50% in 1997 and Komodo alone represented 90% of this activity in 1998). The community of Sape was strongly involved in 1997 but not in 1998. This change was caused by the fact that nener were rare in 1998 and only Komodo was active in the fishery for small shrimp in 1998. "Other methods", including dynamite fishing, were mainly practiced by outsiders and Sape fishermen (together accounting for 65% in 1997), although Mesa was also an important source for this threat (21% in 1997). Villages from inside the Park and the direct surroundings together account for only 14% of the effort described with "other methods" in 1997. In 1998 this type of activity was not recorded during the routine patrols in Komodo National Park.

5.4 Distribution of Fishing Effort per Fishing Community and Gear Type

Mapping of distribution of fishing effort per fishing community shows that most communities stick rather strictly to their "traditional" fishing grounds (Figures 12 to 15).

Kampong Komodo is concentrating (but reducing) its effort near Pulau Sebita and around Tanjung Kuning (Figure 12) where they have had a major impact on the reefs with their reef gleaning practices. Rinca concentrates it's effort around North East Rinca where the reefs are also in a very bad condition.

Papagarang is utilizing the same fishing grounds as Kampong Komodo and their fish traps formed a major additional threat in 1997 since these traps are covered with pieces of live coral when they are set at the bottom. Fortunately this activity was also greatly reduced in 1998 (Figure 13). Warloka fishermen work around North Padar and North West Rinca, where the reefs are also in bad condition although these fishermen are using mainly hook and line which suggests that their impact on the reefs may be limited.

Fishermen from Pulau Mesa are working in the same area as Komodo and Papagarang, where they form yet another major threat with their compressor gear which is used in a variety of destructive practices. These fishermen are also very active around the Gililawa Islands (Figure 14) where fish spawning aggregation sites are located. Mesa fishermen with their compressors and bottom lines form a major threat, especially for the groupers and napoleon wrasse which they are heavily targeting and selling at Pulau Kanawa, in Labuan Bajo and in Sape. Fishermen from Labuan Bajo and Seraya are putting additional pressure on the latter area (Gililawa Islands) and species (grouper) in their hook and line operations which are supplying the live fish traders from Pulau Mesa and Labuan Bajo.

The effort of Sape fishermen is increasing and spreading from the western coastline of Komodo in 1997 to include the northern coast of Komodo and southern coastlines of Komodo and Rinca in 1998 (Figure 15). Their pelagic trolling operations do not form a direct threat to the Park but their demersal trolling for groupers and bottom line operations put heavy pressure on the sedentary stocks. Especially their compressor activities, targeting mainly lobster and live reef fish, are destructive and form a major threat to the sedentary resources of the Park. The outsiders from Pulau Ramut, Ende and other origins are concentrated mostly in Selat Molo in 1997, the South Coast of Rinca in 1998 and around the Gililawa Islands (spawning aggregation sites) in both years. The shift of gillnet operations from Selat Molo to the south coast of Rinca has probably been caused by depletion of fish stocks in Selat Molo.

The distribution of the various gear types used in KNP (Figures 16 to 19) differs much more from year to year than the distribution of the fishing communities. Trolling lines in 1997 (mostly pelagic in that year) were used around the West and South coast of Komodo and around the South West coast of Rinca (Figure 16). This method spread to other areas of the Park (mostly with the Sape fishermen) and started to include demersal trolling with steel wire for live coral trout in 1998. Bottom hook and line was mostly operated in the heavily fished areas of North East and North West Komodo in 1997 but increased effort was recorded in South Komodo and South Rinca in 1998. In the area around the Gililawa Islands this practice forms a serious threat to spawning aggregations of coral trout and groupers.

Gillnets were mostly operated around North East Komodo and in the Northern part of Selat Molo in 1997 (Figure 17), where they have been putting heavy pressure on the demersal and sedentary fish stocks. Gillnet activity unfortunately increased in 1998 and spread to many areas of the Park, including areas with important spawning aggregation sites. It is also suspected that gillnetters and bottom hook and liners are using "other methods" when there are no patrols in sight. Fish traps were mostly operated in the area off Pulau Sebita in 1997, where they contribute seriously to the destruction of the coral reefs. This activity was greatly reduced in 1998.

Compressors (operated by Mesa and Sape fishermen) were concentrated in the center of the area in 1997 (Figure 18) but moved to the Westcoast of Komodo and the Southcoast of Rinca in 1998, except for one intensively fished pocket near North Padar. Reef gleaning (meting, mostly by Komodo and Rinca fishermen) caused major damage until 1997, to the reefs of North East Komodo in the area ranging from Pantai Merah to North

of Pulau Sebita. This activity still occurs throughout the Park but with much lower incidence in 1998.

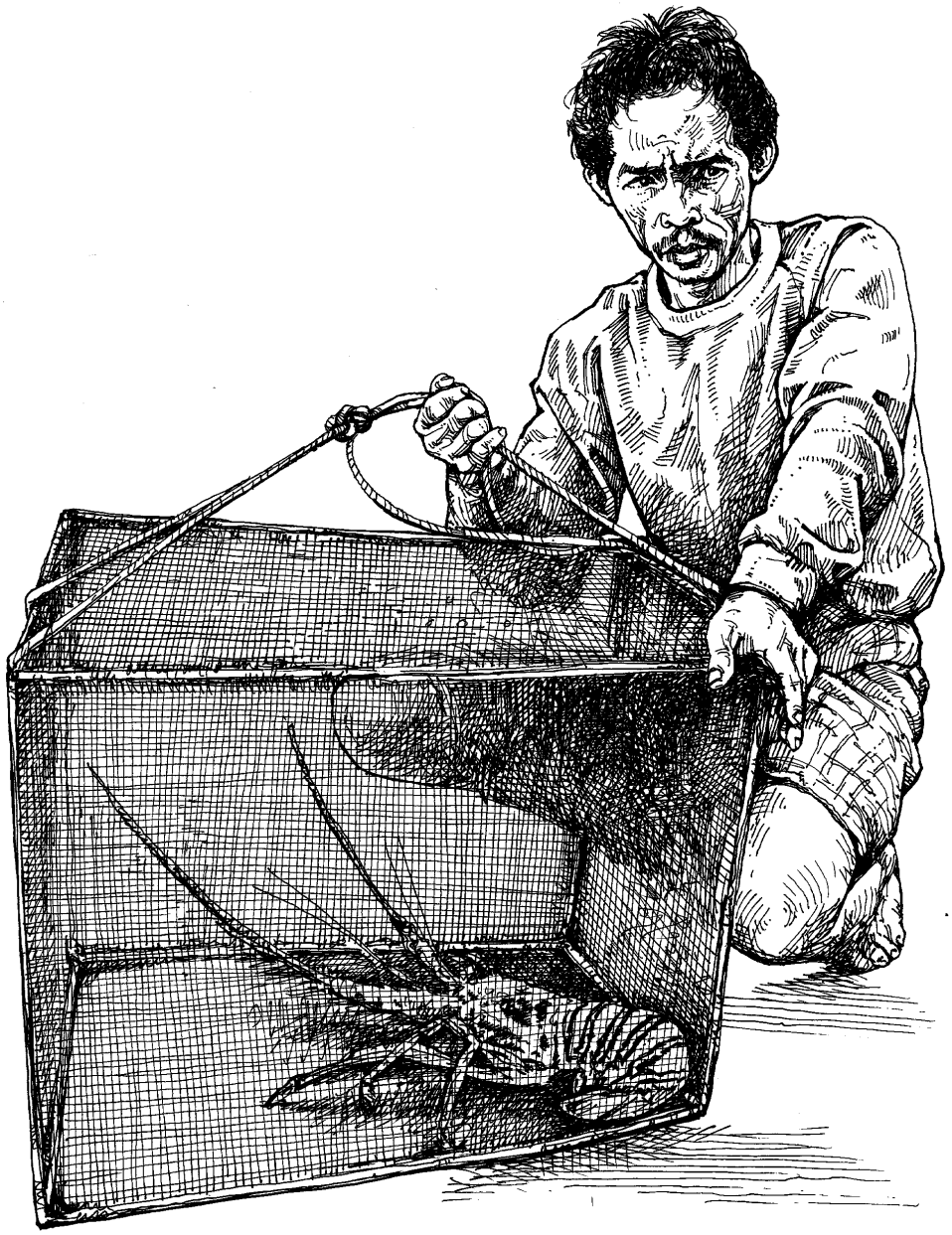
Jaring nener, a geartype (net) operated from the beach to catch milkfish or bandeng larvae, and pukat udang, a geartype (net) operate from the beach to catch small shrimp, are mostly used in the bays of North West, East and South East Komodo and in Loh Baru bay on the East coast of Rinca (Figure 19). This method is not destructive and should be tolerated as a traditional occupation of Park inhabitants. Special zonation for this practice could easily be implemented. Nener activity ceased in 1998 because the larvae were not found. Activity in 1998 was concentrated near Sebita where people from Komodo fished for small shrimp. "Other gear types" were encountered throughout the park area with a focus around North Padar and North West Rinca in 1997. This activity was not recorded in 1998.

5.5 Seasonality

Seasonal patterns in fishing effort per gear type (Figure 20) are somewhat obscured since individual patrols were less efficient in recording fishing operations in the Park in late 1997. The available data seem to show a decreasing fishing effort during this period but it is argued that this is partly explained by less rigorous recording during the patrols in late '97. This has to be kept in mind when seasonal patterns for individual gear types are studied in detail.

Fishing with trolling shows a seasonal pattern with peak activity during in Inter Monsoon 1, which lasts from March through May. This is the main fishing season for spanish mackerel, yellowfin tuna and many other pelagic species. Demersal trolling was introduced in 1998 and since it was difficult for the field operators to see the difference between pelagic and demersal trolling gear, they have been recorded as 1 category ("pancing tonda"). Increased activity is clear since mid 1998. Bottom hook and line fishing activity peaks around the North West monsoon, from November to February which is related to the spawning aggregation seasons of groupers in the Inter Monsoon 2 and difficulties for pelagic fishing during the North West Monsoon. Gillnet activity does not seem to be seasonal which can be explained by the fact that this geartype basically catches any kind of reef fish, and some fish are always present.

Trap fishermen seemed to be most active during the monsoon seasons in '96/'97 but were more active during the inter-monsoons in '97/'98. There is no explanation for the pattern in '96/'97 but after that the fishermen used hook and line during the monsoons on the spawning aggregations and traps were spread out over the reef when the coral trout and groupers were also spread thinly. Compressors are typically used during the monsoons when the whether is bad. This is partly because less enforcement activity is expected during these periods and partly since the NW monsoon is when cyanide fishermen target the spawning aggregation sites. Meting used to peak during the South East monsoon, before the fishermen from Komodo and Rinca start their bagan season. This activity has strongly reduced in recent years. Bandeng fry and small shrimp seem to be targeted at irregular intervals, whenever strong year-classes are available.



6. CONCLUSIONS AND DISCUSSION

The most important conclusion from this report is perhaps that the resources in KNP are most seriously threatened by outside communities from Sape, South Flores and Sulawesi. Park inhabitants and communities from the direct surroundings are a smaller threat which is reduced from year to year. Although the latter fact is encouraging, activity from outsiders needs to be stopped in order not to loose the goodwill of the local communities. There is a good scope for protection of the coral reefs in the area in cooperation with the local communities since Park inhabitants and surrounding communities earn most of their living with 'bagan' lift-nets (Abu Bakar, 1996) which are not destructive to the coral reef ecosystem. The bagan fishery of local communities does need protection against overfishing so that this advantage is not lost through collapse of stocks of small pelagics. Non-bagan yields represent only some 5% in terms of weight of the total yield (bagan + non-bagan) landed by park inhabitants (Komodo and Rinca). Fishermen comment that non-bagan activities are still important to them since the bagan fishery is exploited by middlemen which leave very little of the profits for local fishermen. Freeing the fishermen from the claws of these middlemen may be an important strategy keeping them from destroying the reefs.

The most important threat to the coral reef ecosystem is presently still the use of hookah compressors and this an increasing threat which needs to be addressed immediately. Shellfish such as abalone and pearl oysters are caught with compressors and by reef gleaning, both destructive methods. The same holds true for sea cucumber, whereas lobster are almost entirely caught by compressor fishing. Komodo National Park can not allow the compressor fishing to continue. There is no reasonable argument why the lobsters have to fished out from this World Heritage Site and Man and Biosphere Reserve. Compressor fishing is also strongly reducing the value of the National Park's coral reefs as a tourism destination. The use of compressors would best be prohibited from all areas of Komodo National Park as soon as possible. Park inhabitants and surrounding communities will be little affected by a compressor ban since this a minor activity for these communities except perhaps for Pulau Mesa.

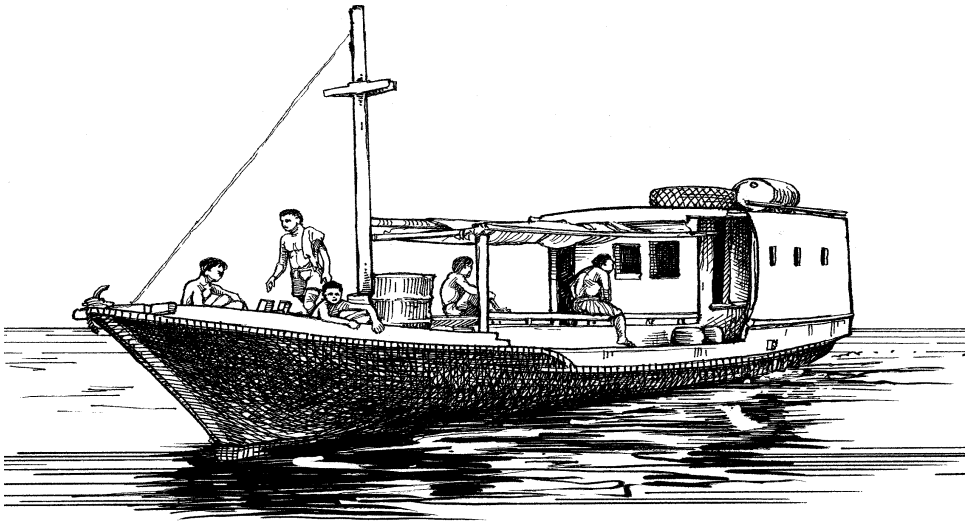
Although compressor activity is also reducing for Pulau Mesa, the compressor fishers from this community should be helped to change their practice. Compressor activity as a whole is increasing in the Park and this is extremely alarming. The activity is mostly by fishers from Sape and other outside communities and if this is not reversed immediately, local communities will no longer be willing to refrain from compressor fishing when they see outsiders getting away with it. unfortunately the enforcement system of the Park is still weak, especially against the high value, high earning, cyanide fishery for lobsters and live reef fish. Not a single successful prosecution was recorded out of a long record of arrests of cyanide fishermen. Cyanide fishermen cannot operate successfully without compressors, and nor can dynamite fishermen.

The main yield category from Komodo National Park is fish (almost 95%) and this fish is mostly caught by gillnets and by trolling and bottom hook and lines. Demersal trolling lines or 'kedo kedo' are wiping out the

coral trout stocks, bottom hook and lines take all predators and bottom longlines are decimating the sharks and large groupers. These gear types form considerable threats to the demersal and sedentary fish stocks in the Park, and gillnetting should be banned from the National Park as soon as possible. The situation is extremely serious in the light of the National Park's objectives.

The most important threats to the fish stocks of the Park are the gillnets and bottom longlines used by outsiders from South Flores and the heavy hook and line fishing by Sape communities. The pressure of the hook and line fishing is focussed around the spawning aggregation sites which aggravates the situation. Large amounts of spilled nylon fishing line were encountered at fish spawning aggregation sites and certain species like *Plectropomus areolatus* were decimated before actual spawning took place.

It is clear that the Park's fish resources will soon be depleted even if the spawning sites are closed for fishing. The fishing pressure on the reefs is very high and increasing and this needs to be reversed in order to achieve the objectives of the Park's management. These objectives can only be achieved when the total demersal fishing effort in the Park is greatly reduced. It seems obvious that this needs to be done by limiting the access to the resources by prohibiting outsiders from fishing in the Park and by establishment of exclusive use rights for local communities in selected multiple use zones. Spawning aggregation sites in the Park should be closed for all fishing activity.



7. ACKNOWLEDGEMENTS

Staff of Taman Nasional Komodo and the YPAN/TNC Komodo Field Office are greatly acknowledged for collecting the data described in this report. This type of data collection takes place under often very difficult circumstances.

8. REFERENCES

Abu Bakar, 1996. Resource utilization in and around Komodo National Park. Komodo Field Office data report.

Table 1. Starting dates of patrols in 1996, 1997 and 1998.

Week	Patrol 1996	Patrol 1997	Patrol 1998
1		No Patrol	No Patrol
2		08/01/97	No Patrol
3		No Patrol	12/01/98
4		No Patrol	23/01/98
5		No Patrol	03/02/98
6		No Patrol	05/02/98
7		12/02/97	09/02/98
8		No Patrol	20/02/98
9		No Patrol	27/02/98
10		06/03/97	04/03/98
11		No Patrol	10/03/98
12		No Patrol	20/03/98
13		25/03/97	24/03/98
14		03/04/97	03/04/98
15		No Patrol	No Patrol
16		14/04/97	16/04/98
17		25/04/97	21/04/98
18		No Patrol	29/04/98
19		05/05/97	06/05/98
20		14/05/97	No Patrol
21		No Patrol	18/05/98
22	28/05/96	No Patrol	26/05/98
23	No Patrol	05/06/97	01/06/98
24	No Patrol	No Patrol	09/06/98
25	17/06/96	No Patrol	17/06/98
26	25/06/96	23/06/97	24/06/98
27	03/07/96	No Patrol	29/06/98
28	10/07/96	08/07/97	07/07/98
29	16/07/96	No Patrol	16/07/98
30	25/07/96	No Patrol	22/07/98
31	01/08/96	No Patrol	29/07/98
32	No Patrol	07/08/97	No Patrol
33	12/08/96	16/08/97	10/08/98
34	20/08/96	No Patrol	19/08/98
35	31/08/96	No Patrol	23/08/98
36	No Patrol	No Patrol	03/09/98
37	09/09/96	10/09/97	12/09/98
38	21/09/96	No Patrol	17/09/98
39	26/09/96	No Patrol	25/09/98
40	03/10/96	02/10/97	No Patrol
41	09/10/96	No Patrol	06/10/98
42	16/10/96	No Patrol	No Patrol
43	23/10/96	20/10/97	22/10/98
44	No Patrol	No Patrol	No Patrol
45	05/11/96	No Patrol	03/11/98
46	No Patrol	No Patrol	10/11/98
47	No Patrol	No Patrol	No Patrol
48	26/11/96	No Patrol	No Patrol
49	No Patrol	No Patrol	No Patrol
50	No Patrol	08/12/97	07/12/98
51	No Patrol	No Patrol	17/12/98
52	No Patrol	No Patrol	No Patrol

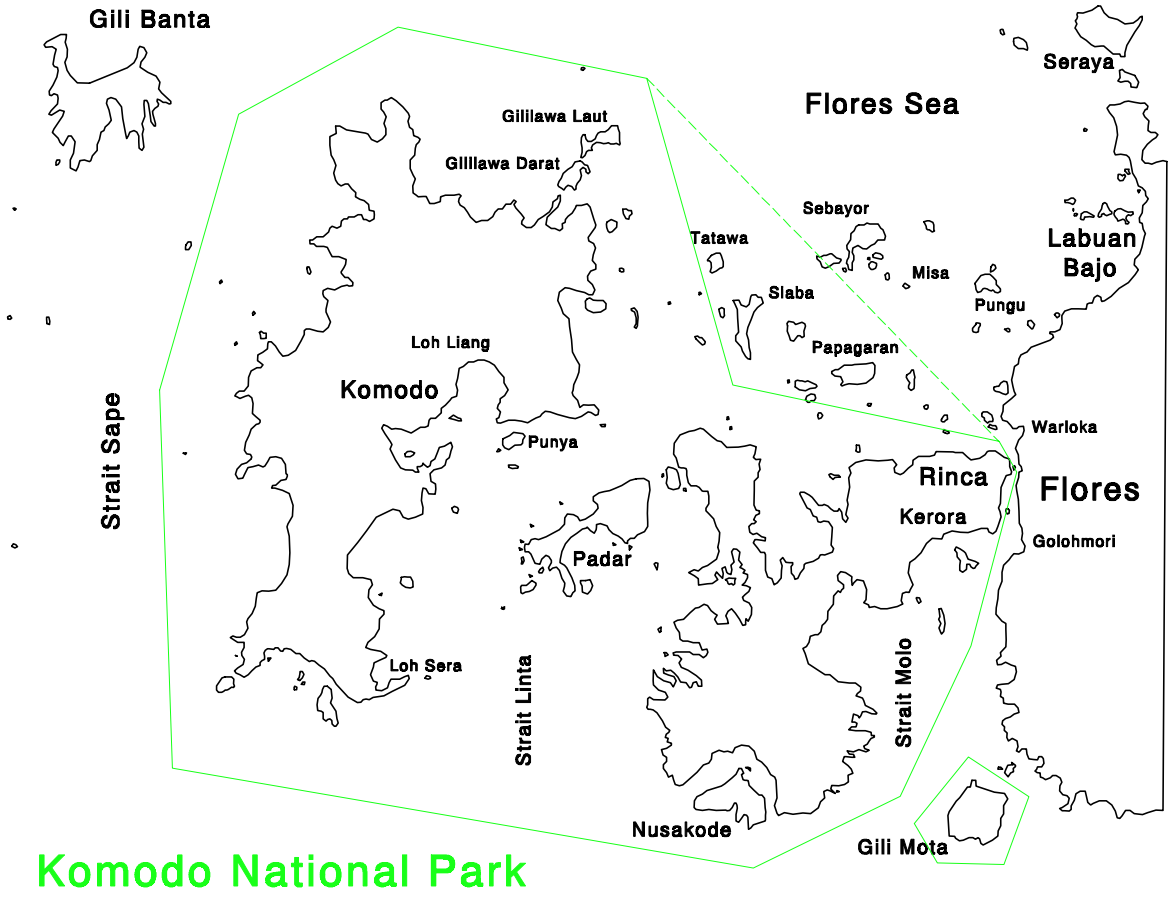

Gili Banta
Seraya
Flores Sea
Gililawa Laut
Gililawa Darat
Sebayor
Tatawa
Labuan
Bajo
Misa
Siaba
Pungu
Loh Liang
Papagaran
Komodo
Strait Sape
Warloka
Punya
Rinca
Flores
Kerora
Golohmori
Padar
Loh Sera
Strait Linta
Strait Molo
Nusakode
Gili Mota
Komodo National Park

Figure 1.

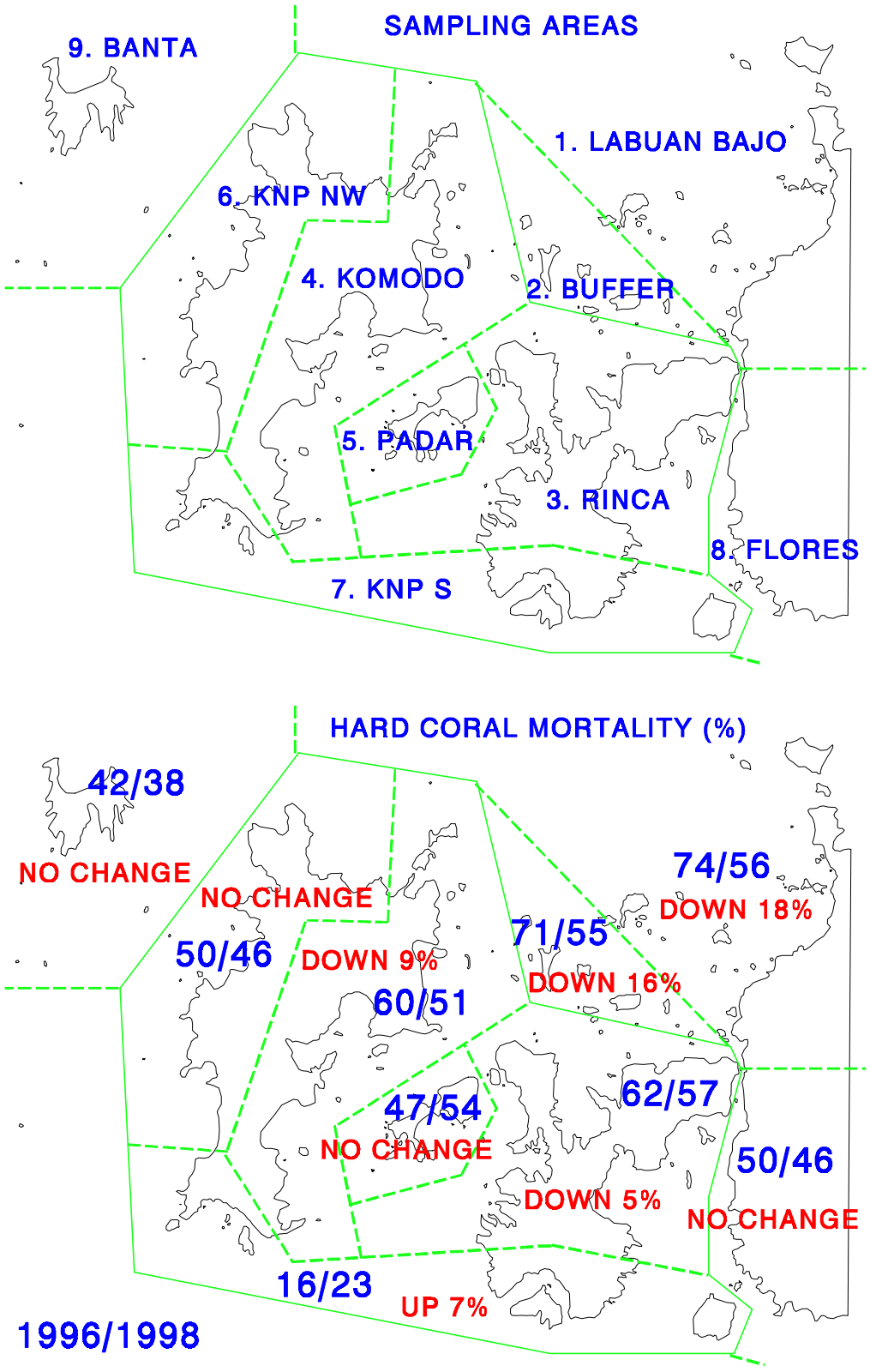

SAMPLING AREAS
9. BANTA
1. LABUAN BAJO
6. KNP NW
4. KOMODO
2. BUFFER
5. PADAR
3. RINCA
8. FLORES
7. KNP S
HARD CORAL MORTALITY (%)
42/38
NO CHANGE
NO CHANGE
74/56
DOWN 18%
71/55
50/46
DOWN 9%
DOWN 16%
60/51
62/57
47/54
NO CHANGE
50/46
DOWN 5%
NO CHANGE
16/23
UP 7%
1996/1998

Figure 2.

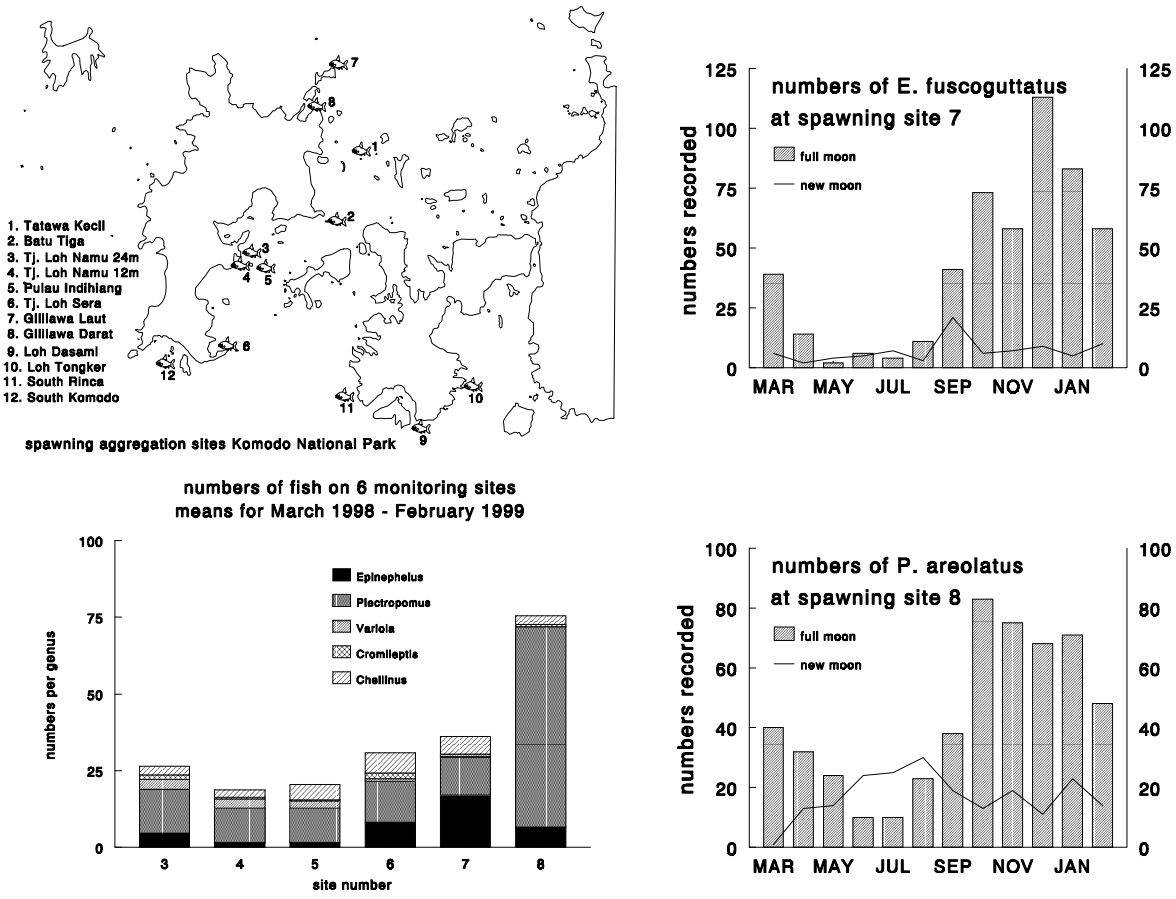


Figure 3.

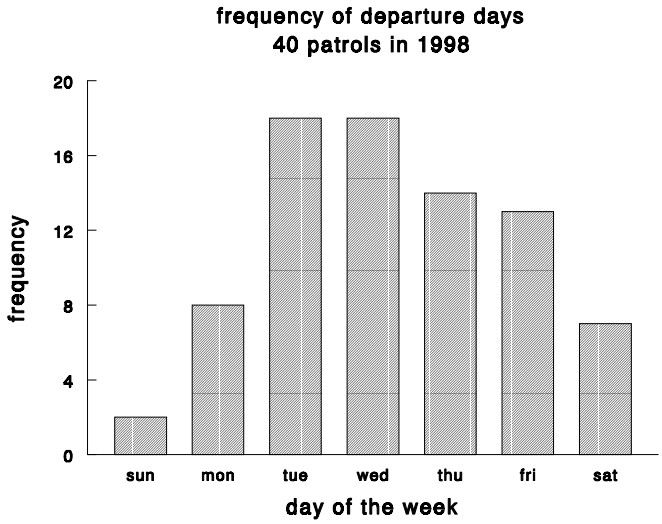
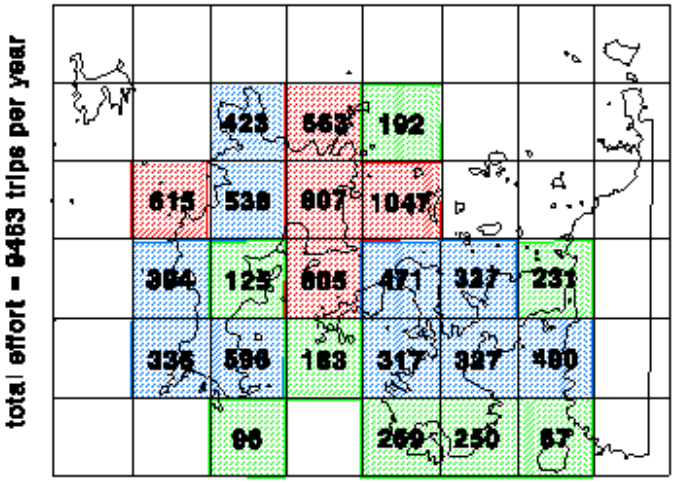


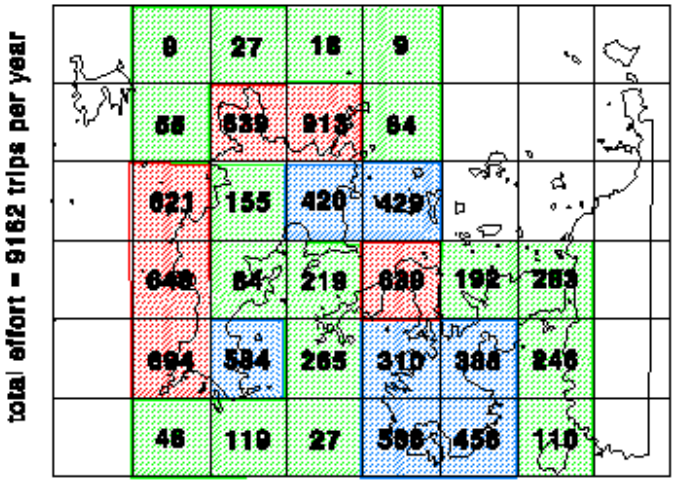
Figure 4.

resource utilization monitoring 1997 - 1998

distribution of total non-bagan effort in KNP 1997



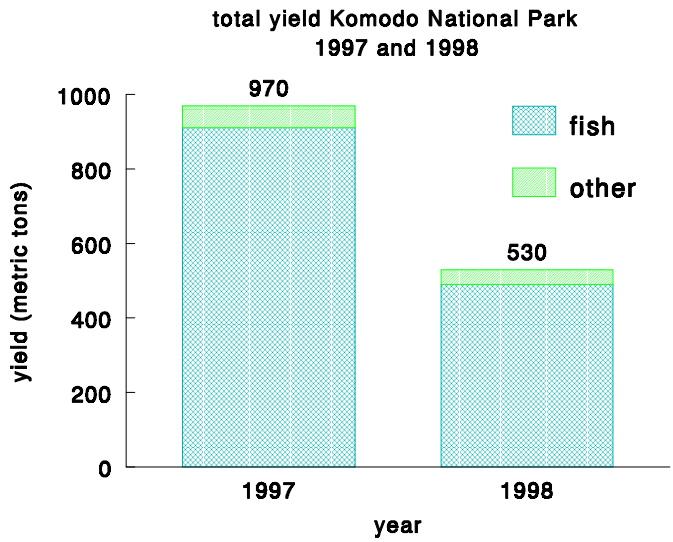
distribution of total non-bagan effort in KNP 1998

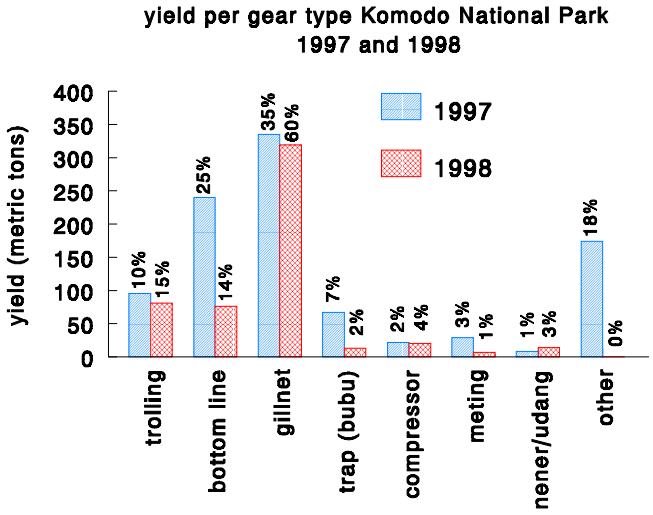


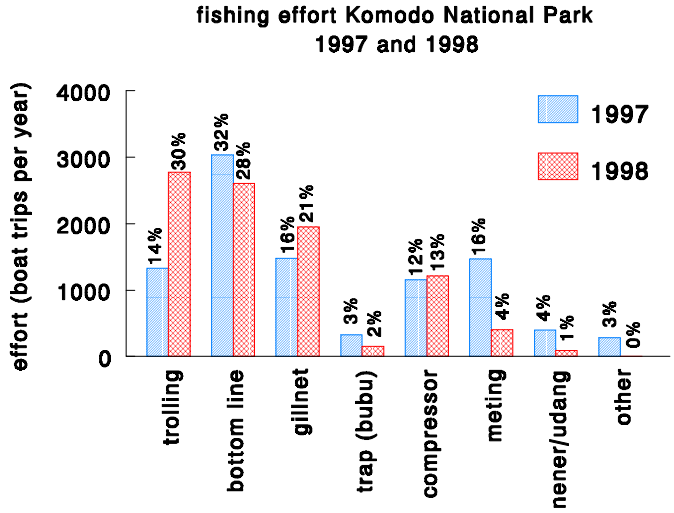
more than 600 boat trips per year

300 to 600 boat trips per year

less than 300 boat trips per year


total yield Komodo National Park
1997 and 1998
yield (metric tons)
1000
800
600
400
200
0
970
530
fish
other
1997
1998
year


yield per gear type Komodo National Park
1997 and 1998
yield (metric tons)
400
350
300
250
200
150
100
50
0
1997
1998
10%
15%
25%
14%
35%
60%
7%
2%
2%
4%
3%
1%
1%
3%
18%
0%
trolling
bottom line
gillnet
trap (bubu)
compressor
meting
nener/udang
other


fishing effort Komodo National Park
1997 and 1998
effort (boat trips per year)
4000
3000
2000
1000
0
1997
1998
14%
30%
32%
28%
16%
21%
3%
2%
12%
13%
16%
4%
4%
1%
3%
0%
trolling
bottom line
gillnet
trap (bubu)
compressor
meting
nener/udang
other

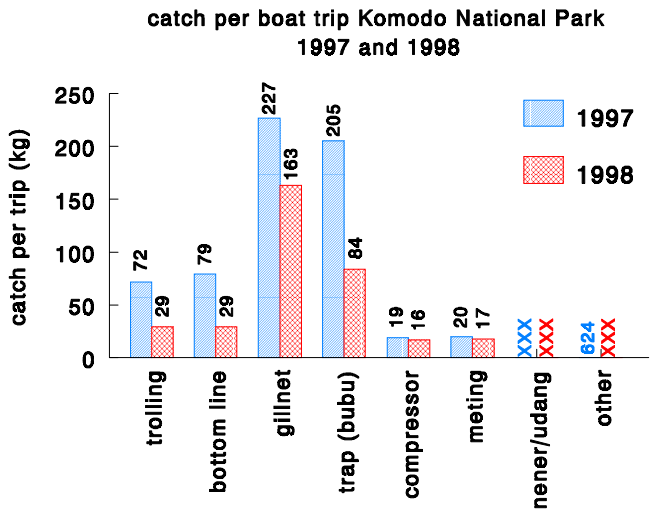
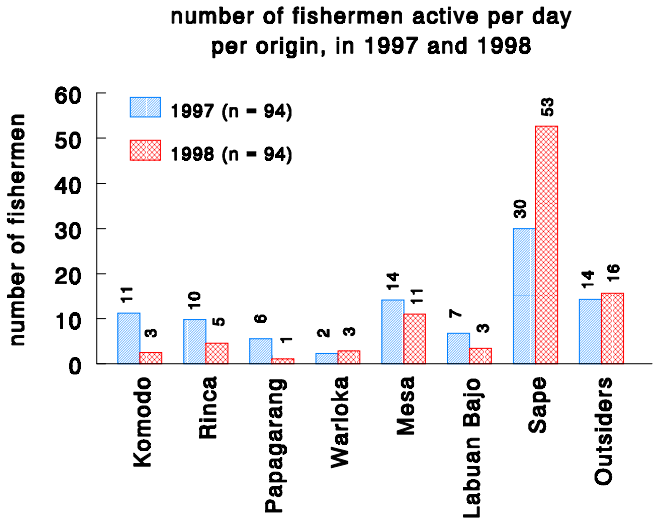
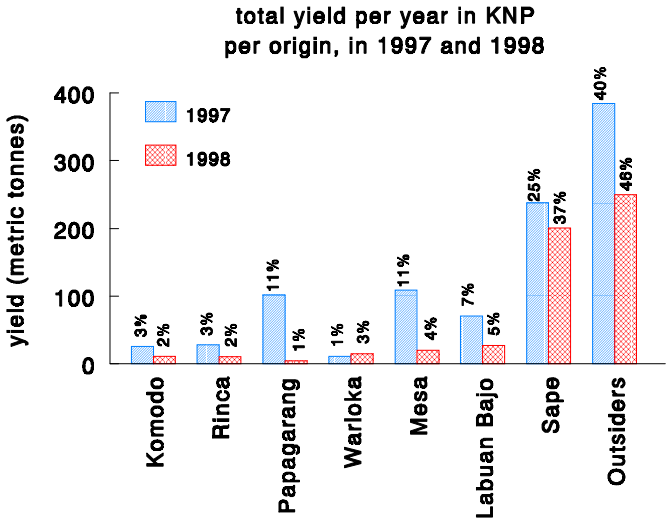
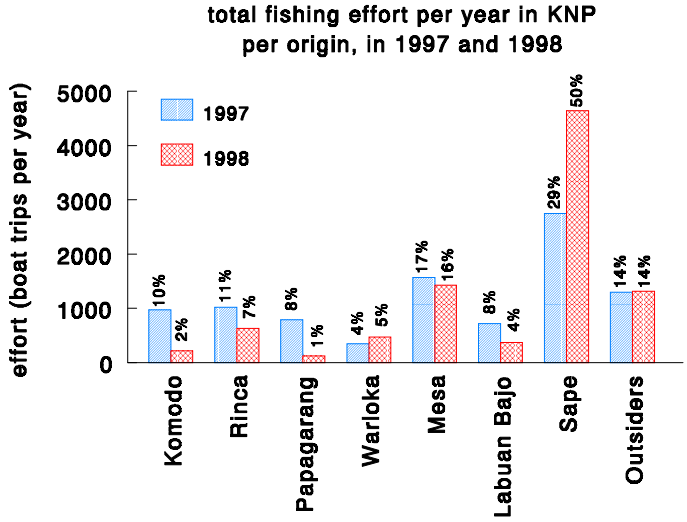

catch per boat trip Komodo National Park
1997 and 1998
catch per trip (kg)
250
200
150
100
50
0
1997
1998
72
29
79
29
227
163
205
84
19
16
20
17
XXX
XXX
624
XXX
trolling
bottom line
gillnet
trap (bubu)
compressor
meting
nener/udang
other

Figure 6.


number of fishermen active per day
per origin, in 1997 and 1998
number of fishermen
1997 (n = 94)
1998 (n = 94)
0
10
20
30
40
50
60
11
3
10
5
6
1
2
3
14
11
7
3
30
53
14
16
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders


total yield per year in KNP
per origin, in 1997 and 1998
yield (metric tonnes)
1997
1998
0
100
200
300
400
3%
2%
3%
2%
11%
1%
1%
3%
11%
4%
7%
5%
25%
37%
40%
48%
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders


total fishing effort per year in KNP
per origin, in 1997 and 1998
effort (boat trips per year)
1997
1998
0
1000
2000
3000
4000
5000
10%
2%
11%
7%
8%
1%
4%
5%
17%
16%
8%
4%
29%
50%
14%
14%
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders

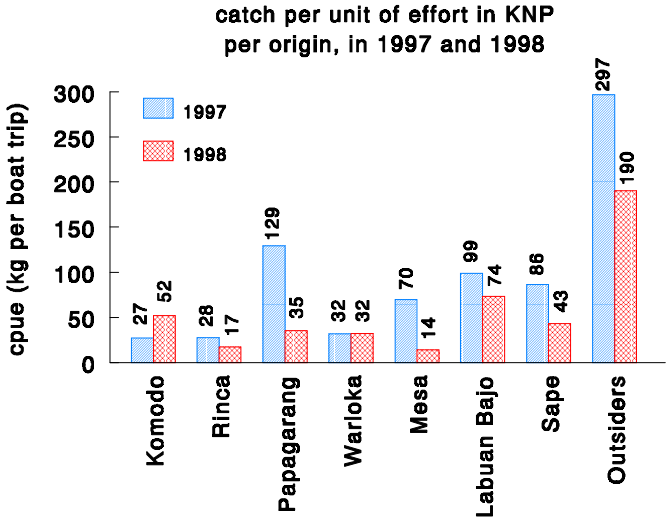

catch per unit of effort in KNP
per origin, in 1997 and 1998
cpue (kg per boat trip)
1997
1998
0
50
100
150
200
250
300
27
52
28
17
129
35
32
32
70
14
99
74
86
43
297
190
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders

Figure 7.

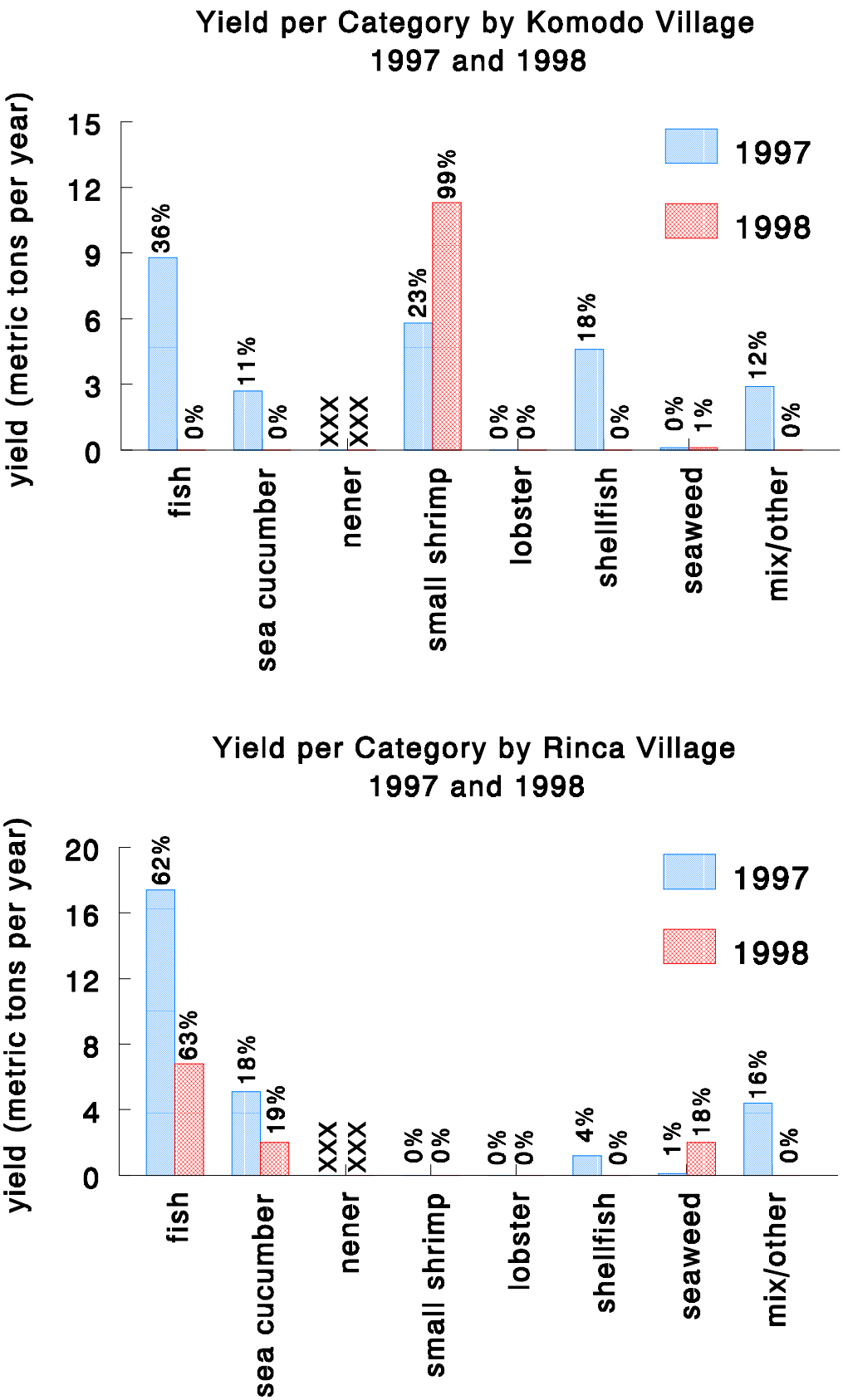
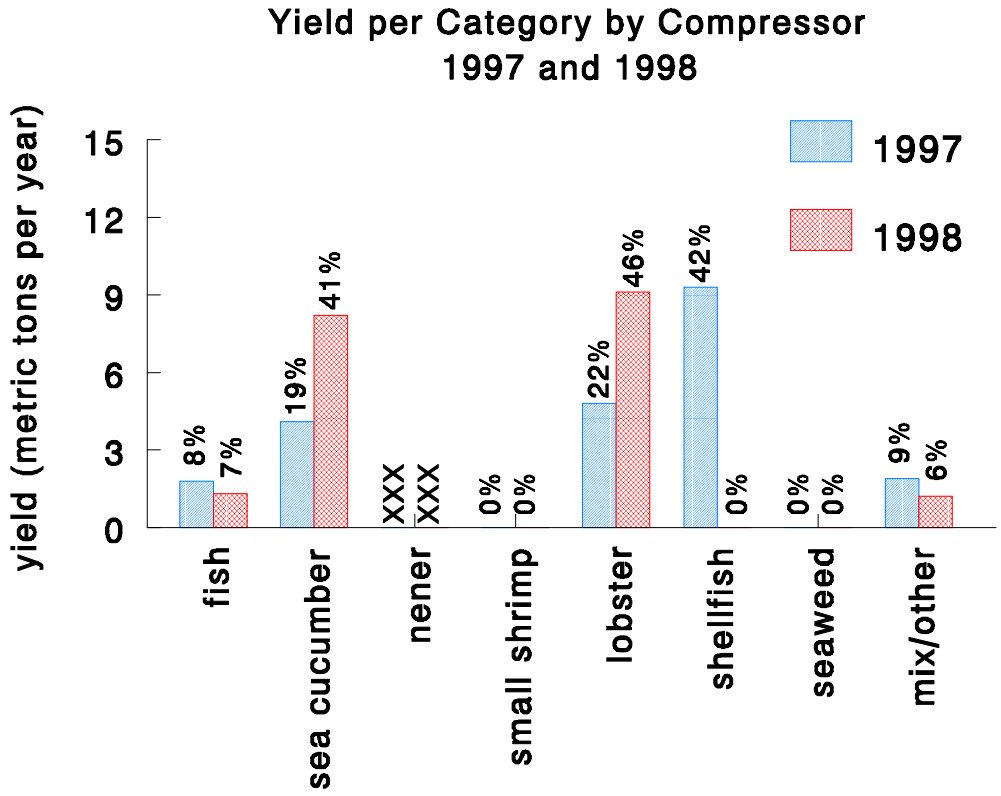

Yield per Category by Komodo Village
1997 and 1998
yield (metric tons per year)
15
12
9
6
3
0
1997
1998
36%
0%
11%
0%
XXX
XXX
23%
99%
0%
0%
18%
0%
0%
1%
12%
0%
fish
sea cucumber
nener
small shrimp
lobster
shellfish
seaweed
mix/other
Yield per Category by Rinca Village
1997 and 1998
yield (metric tons per year)
20
16
12
8
4
0
1997
1998
62%
63%
18%
19%
XXX
XXX
0%
0%
0%
0%
4%
0%
1%
18%
16%
0%
fish
sea cucumber
nener
small shrimp
lobster
shellfish
seaweed
mix/other

Figure 8.


Yield per Category by Compressor
1997 and 1998
yield (metric tons per year)
15
12
9
6
3
0
1997
1998
8%
7%
19%
41%
XXX
XXX
0%
0%
22%
46%
42%
0%
0%
0%
9%
6%
fish
sea cucumber
nener
small shrimp
lobster
shellfish
seaweed
mix/other

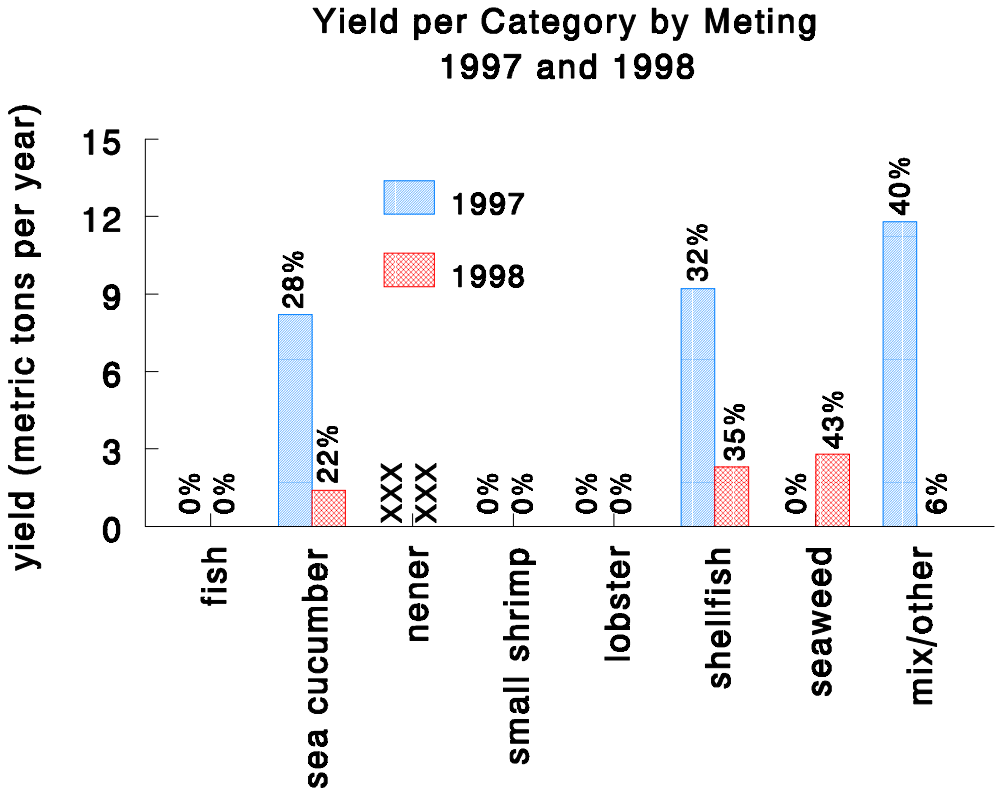

Yield per Category by Meting
1997 and 1998
yield (metric tons per year)
15
12
9
6
3
0
1997
1998
0%
0%
28%
22%
XXX
XXX
0%
0%
0%
0%
32%
35%
0%
43%
40%
6%
fish
sea cucumber
nener
small shrimp
lobster
shellfish
seaweed
mix/other

Figure 9.

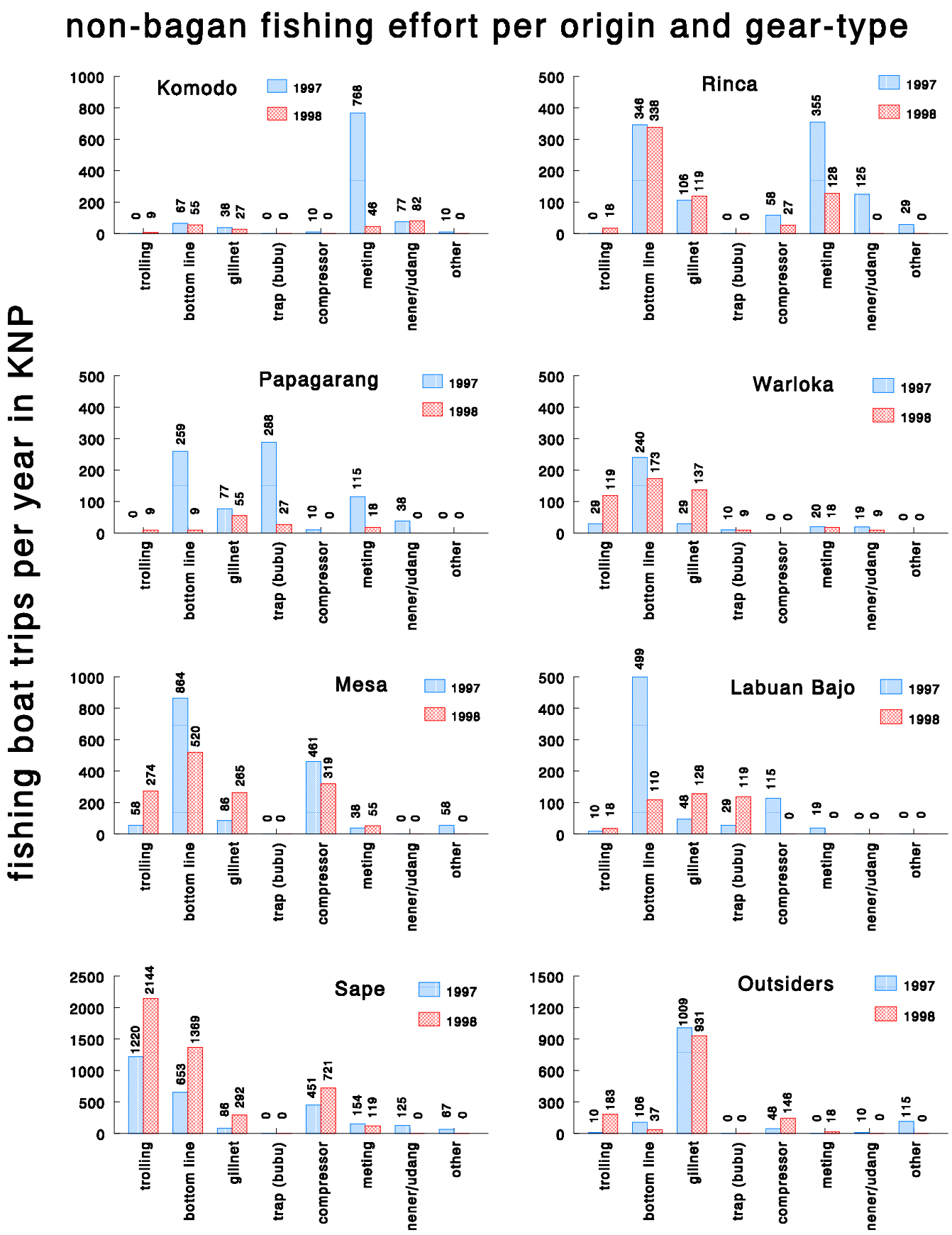

non-bagan fishing effort per origin and gear-type
fishing boat trips per year in KNP
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders
1997
1998
trolling
bottom line
gillnet
trap (bubu)
compressor
meting
nener/udang
other

Figure 10

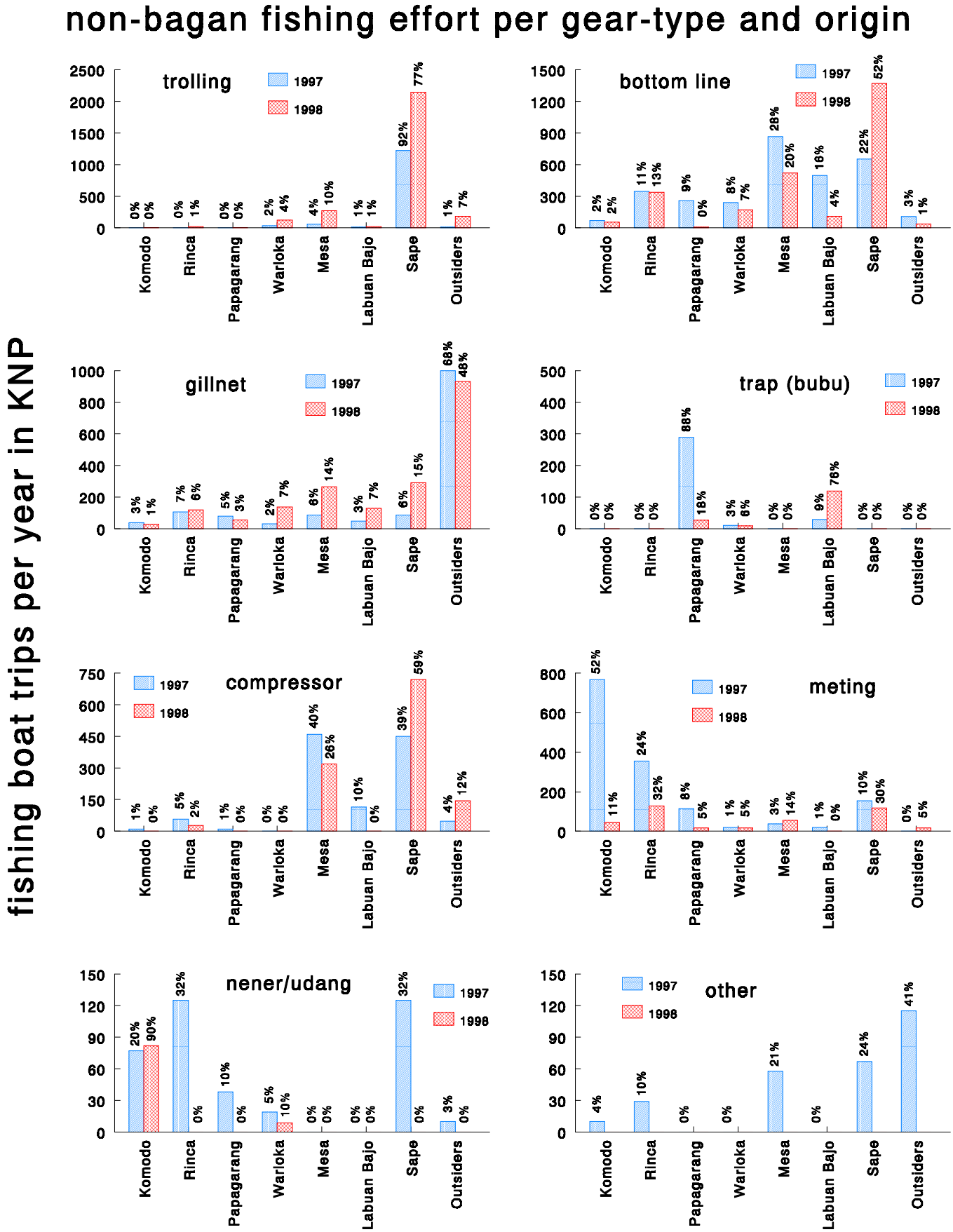

non-bagan fishing effort per gear-type and origin
fishing boat trips per year in KNP
trolling
1997
1998
2500
2000
1500
1000
500
0
0% 0%
0% 1%
0% 0%
2% 4%
4% 10%
1% 1%
92% 77%
1% 7%
Komodo
Rinca
Papagarang
Warloka
Mesa
Labuan Bajo
Sape
Outsiders
bottom line
1997
1998
1500
1200
900
600
300
0
2% 2%
11% 13%
9% 0%
8% 7%
28% 20%
16% 4%
22% 52%
3% 1%
gillnet
1997
1998
1000
800
600
400
200
0
3% 1%
7% 8%
5% 3%
2% 7%
6% 14%
3% 7%
6% 15%
68% 48%
trap (bubu)
1997
1998
500
400
300
200
100
0
0% 0%
0% 0%
88% 18%
3% 8%
0% 0%
9% 76%
0% 0%
0% 0%
compressor
1997
1998
750
600
450
300
150
0
1% 0%
5% 2%
1% 0%
0% 0%
40% 26%
10% 0%
39% 59%
4% 12%
meting
1997
1998
800
600
400
200
0
52% 11%
24% 32%
8% 5%
1% 5%
3% 14%
1% 0%
10% 30%
0% 5%
nener/udang
1997
1998
150
120
90
60
30
0
20% 90%
32% 0%
10% 0%
5% 10%
0% 0%
0% 0%
32% 0%
3% 0%
other
1997
1998
150
120
90
60
30
0
4%
10%
0%
0%
21%
0%
24%
41%

Figure 11.

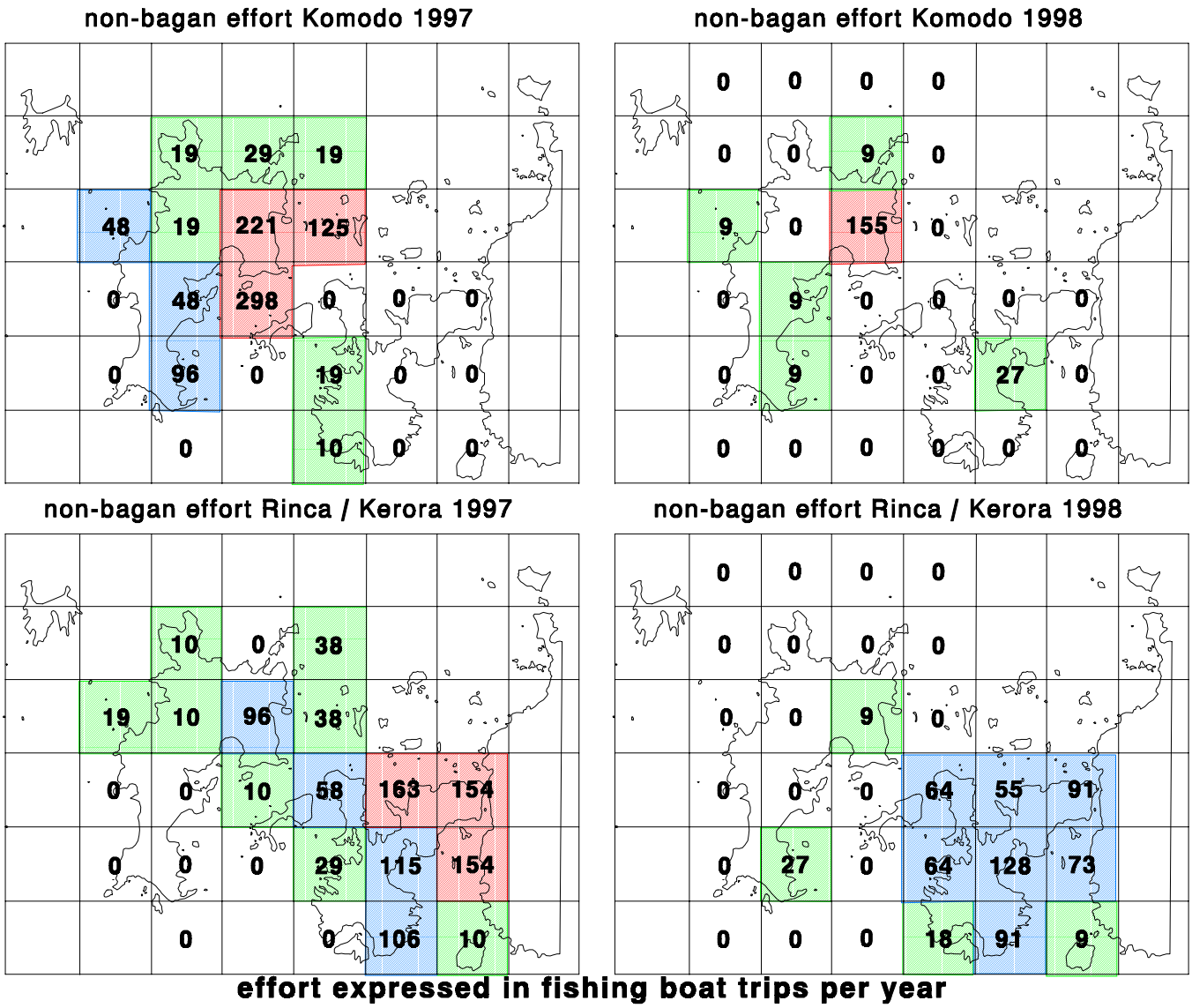

non-bagan effort Komodo 1997
19 29 19
48 19 221 125
0 48 298 0 0 0
0 96 0 19 0 0
0 10 0 0
non-bagan effort Komodo 1998
0 0 0 0
0 0 9 0
9 0 155 0
0 9 0 0 0 0
0 9 0 0 27 0
0 0 0 0 0 0
non-bagan effort Rinca / Kerora 1997
10 0 38
19 10 96 38
0 0 10 58 163 154
0 0 0 29 115 154
0 0 106 10
non-bagan effort Rinca / Kerora 1998
0 0 0 0
0 0 0 0
0 0 9 0
0 0 0 64 55 91
0 27 0 64 128 73
0 0 0 18 91 9
effort expressed in fishing boat trips per year

Figure 12.

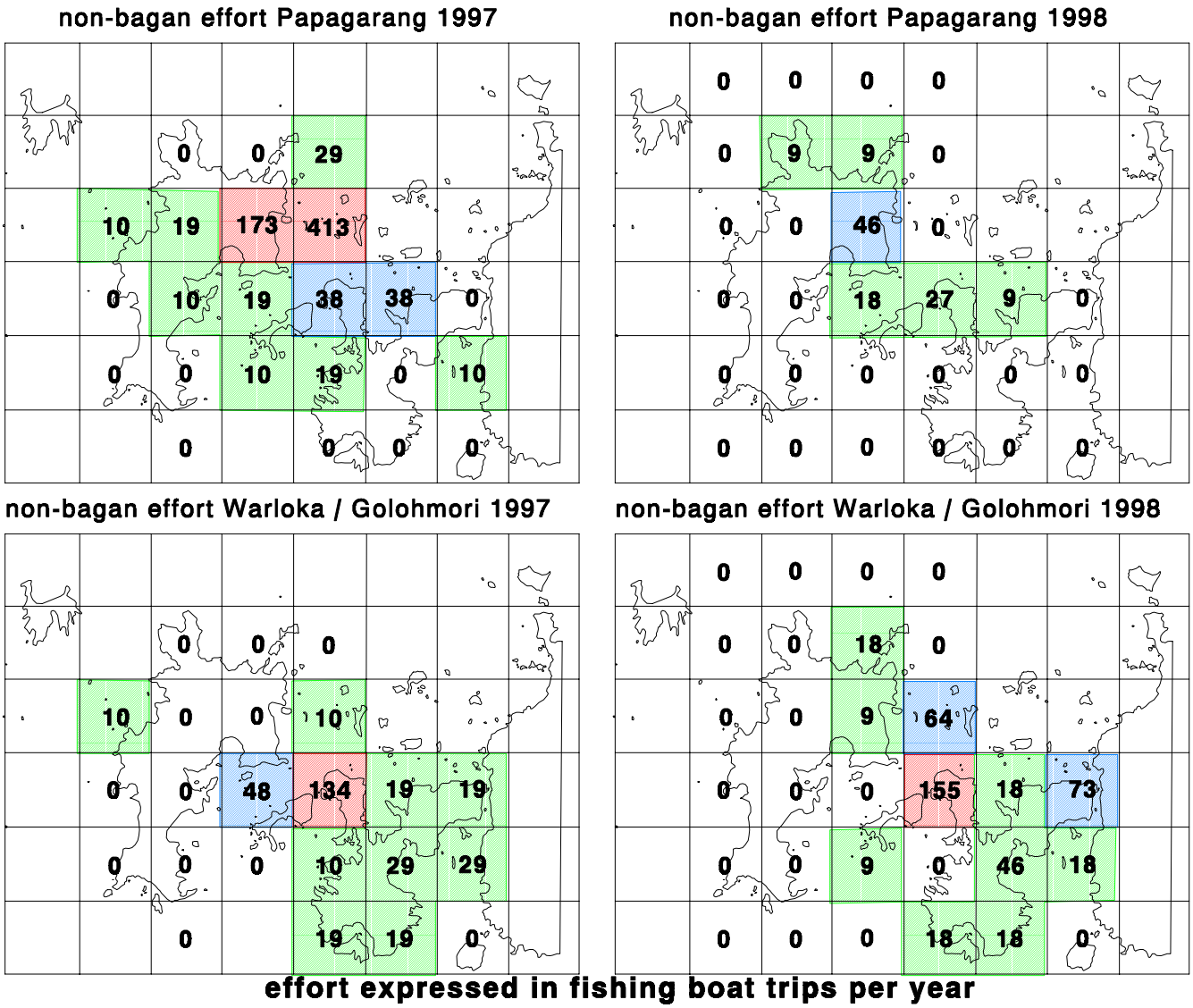

non-bagan effort Papagarang 1997
0 0 29
10 19 173 413
0 10 19 38 38 0
0 0 10 19 0 10
0 0 0 0
non-bagan effort Papagarang 1998
0 0 0 0
0 9 9 0
0 0 46 0
0 0 18 27 9 0
0 0 0 0 0 0
0 0 0 0 0 0
non-bagan effort Warloka / Golohmori 1997
0 0 0
10 0 0 10
0 0 48 134 19 19
0 0 0 10 29 29
0 19 19 0
non-bagan effort Warloka / Golohmori 1998
0 0 0 0
0 0 18 0
0 0 9 64
0 0 0 155 18 73
0 0 9 0 46 18
0 0 0 18 18 0
effort expressed in fishing boat trips per year

Figure 13.

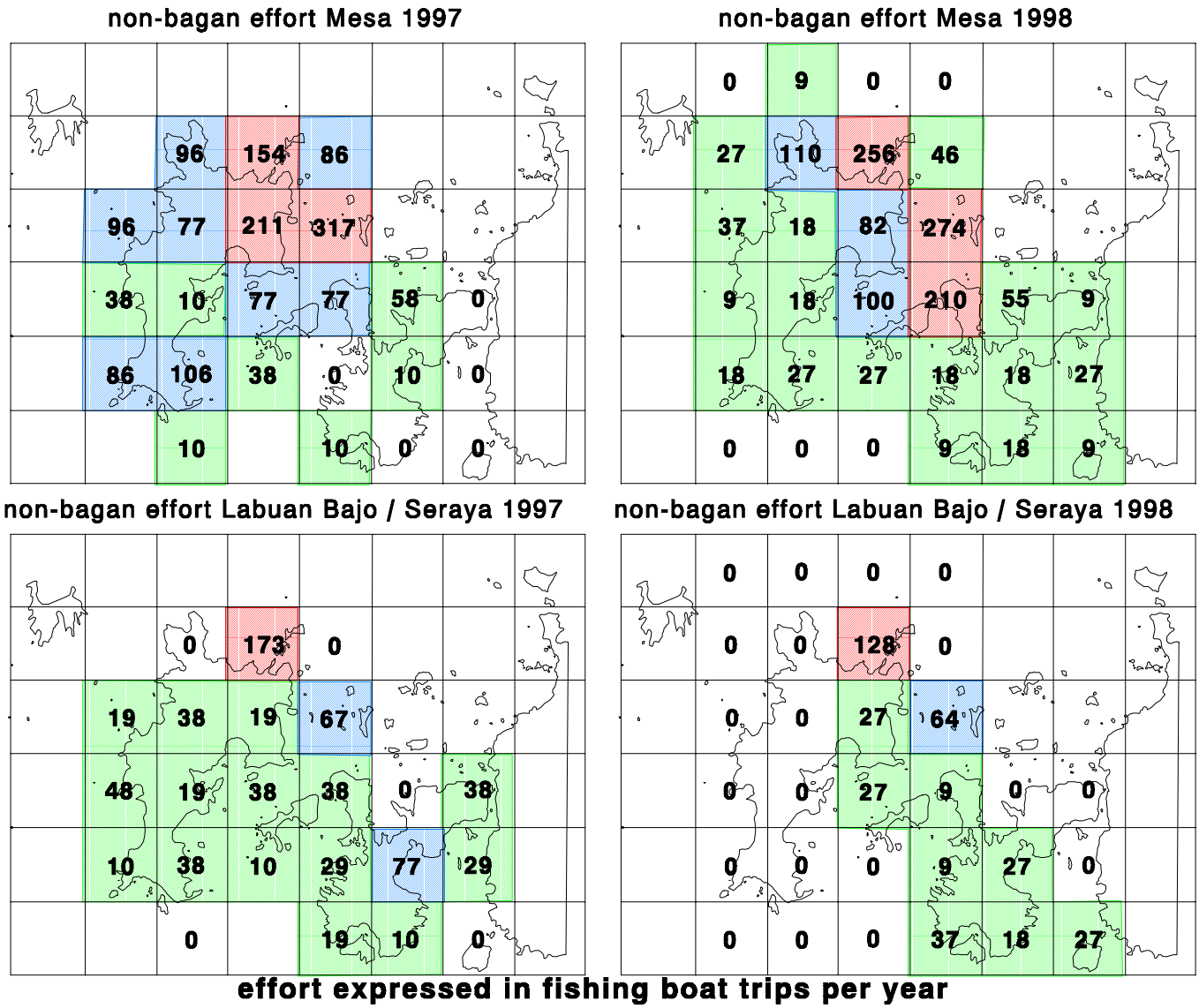

non-bagan effort Mesa 1997
96 154 86
96 77 211 317
38 10 77 77 58 0
86 106 38 0 10 0
10 10 0 0
non-bagan effort Mesa 1998
0 9 0 0
27 110 256 46
37 18 82 274
9 18 100 210 55 9
18 27 27 18 18 27
0 0 0 9 18 9
non-bagan effort Labuan Bajo / Seraya 1997
0 173 0
19 38 19 67
48 19 38 38 0 38
10 38 10 29 77 29
0 19 10 0
non-bagan effort Labuan Bajo / Seraya 1998
0 0 0 0
0 0 128 0
0 0 27 64
0 0 27 9 0 0
0 0 0 9 27 0
0 0 0 37 18 27
effort expressed in fishing boat trips per year

Figure 14.

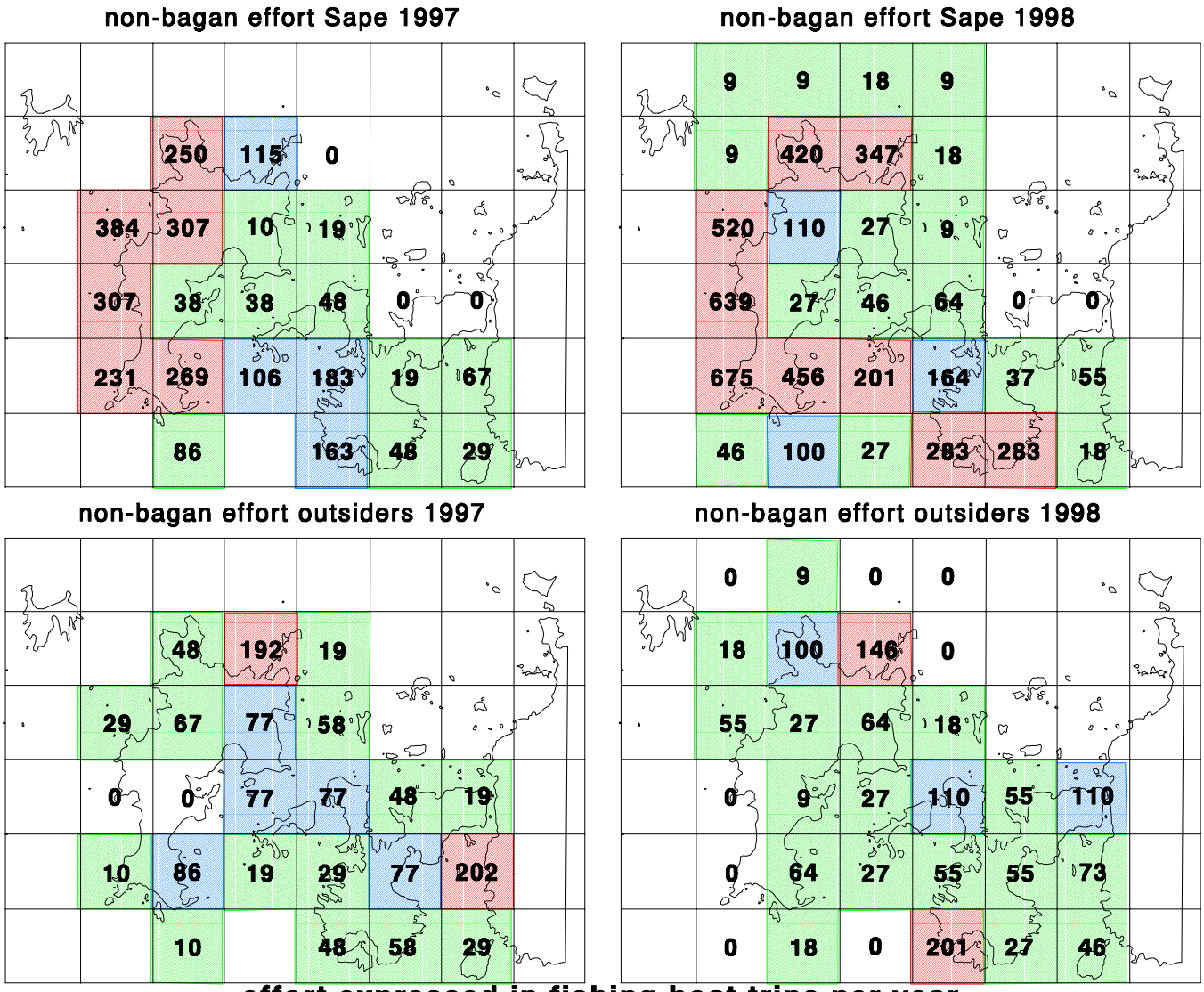

non-bagan effort Sape 1997
250 115 0
384 307 10 19
307 38 38 48 0 0
231 269 106 183 19 67
86 163 48 29
non-bagan effort Sape 1998
9 9 18 9
9 420 347 18
520 110 27 9
639 27 46 64 0 0
675 456 201 164 37 55
46 100 27 283 283 18
non-bagan effort outsiders 1997
48 192 19
29 67 77 58
0 0 77 77 48 19
10 86 19 29 77 202
10 48 58 29
non-bagan effort outsiders 1998
0 9 0 0
18 100 146 0
55 27 64 18
0 9 27 110 55 110
0 64 27 55 55 73
0 18 0 201 27 46
effort expressed in fishing boat trips per year

Figure 15.

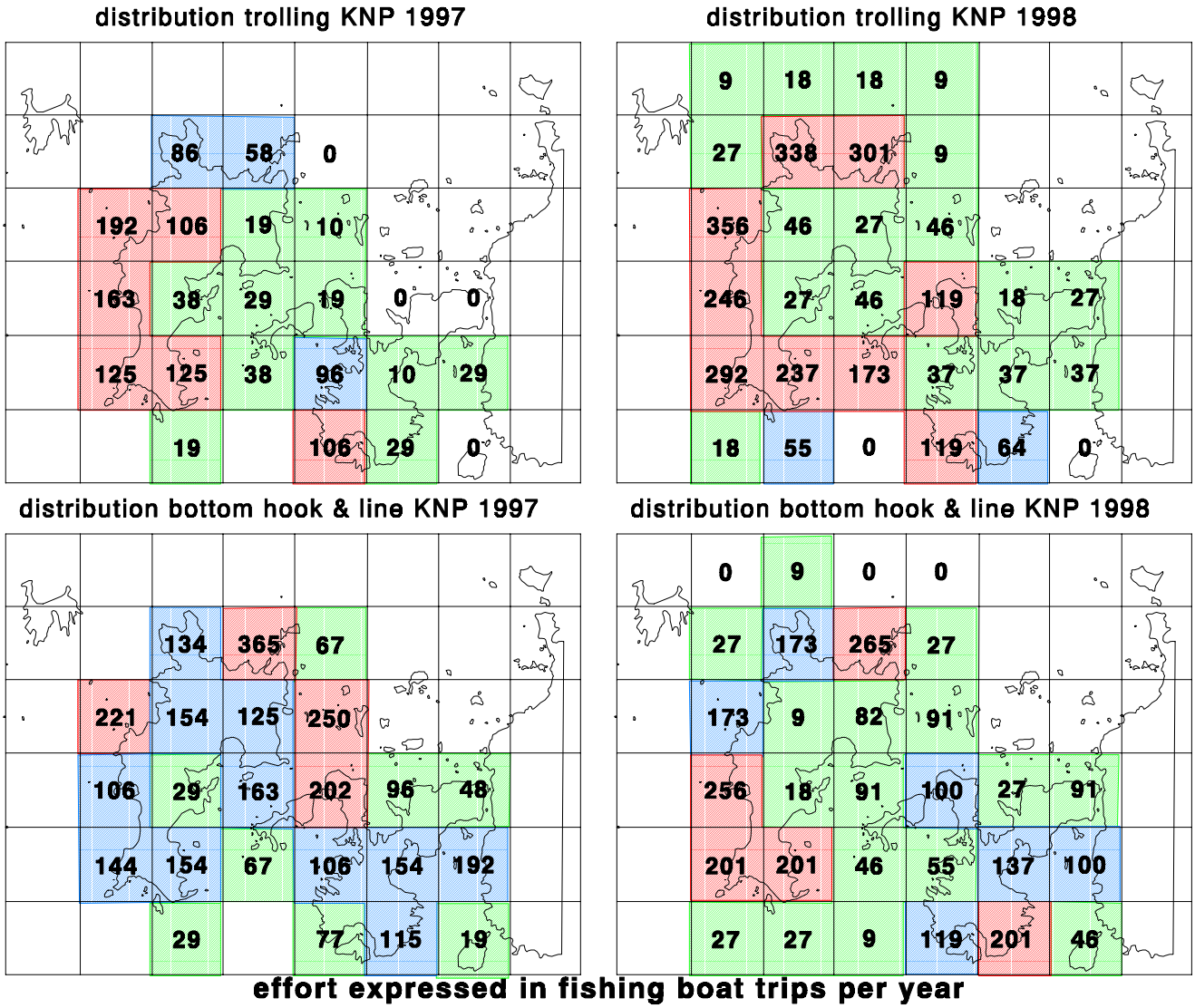

distribution trolling KNP 1997
86 58 0
192 106 19 10
163 38 29 19 0 0
125 125 38 96 10 29
19 106 29 0
distribution trolling KNP 1998
9 18 18 9
27 338 301 9
356 46 27 46
246 27 46 119 18 27
292 237 173 37 37 37
18 55 0 119 64 0
distribution bottom hook & line KNP 1997
134 365 67
221 154 125 250
106 29 163 202 96 48
144 154 67 106 154 192
29 77 115 19
distribution bottom hook & line KNP 1998
0 9 0 0
27 173 265 27
173 9 82 91
256 18 91 100 27 91
201 201 46 55 137 100
27 27 9 119 201 46
effort expressed in fishing boat trips per year

Figure 16.

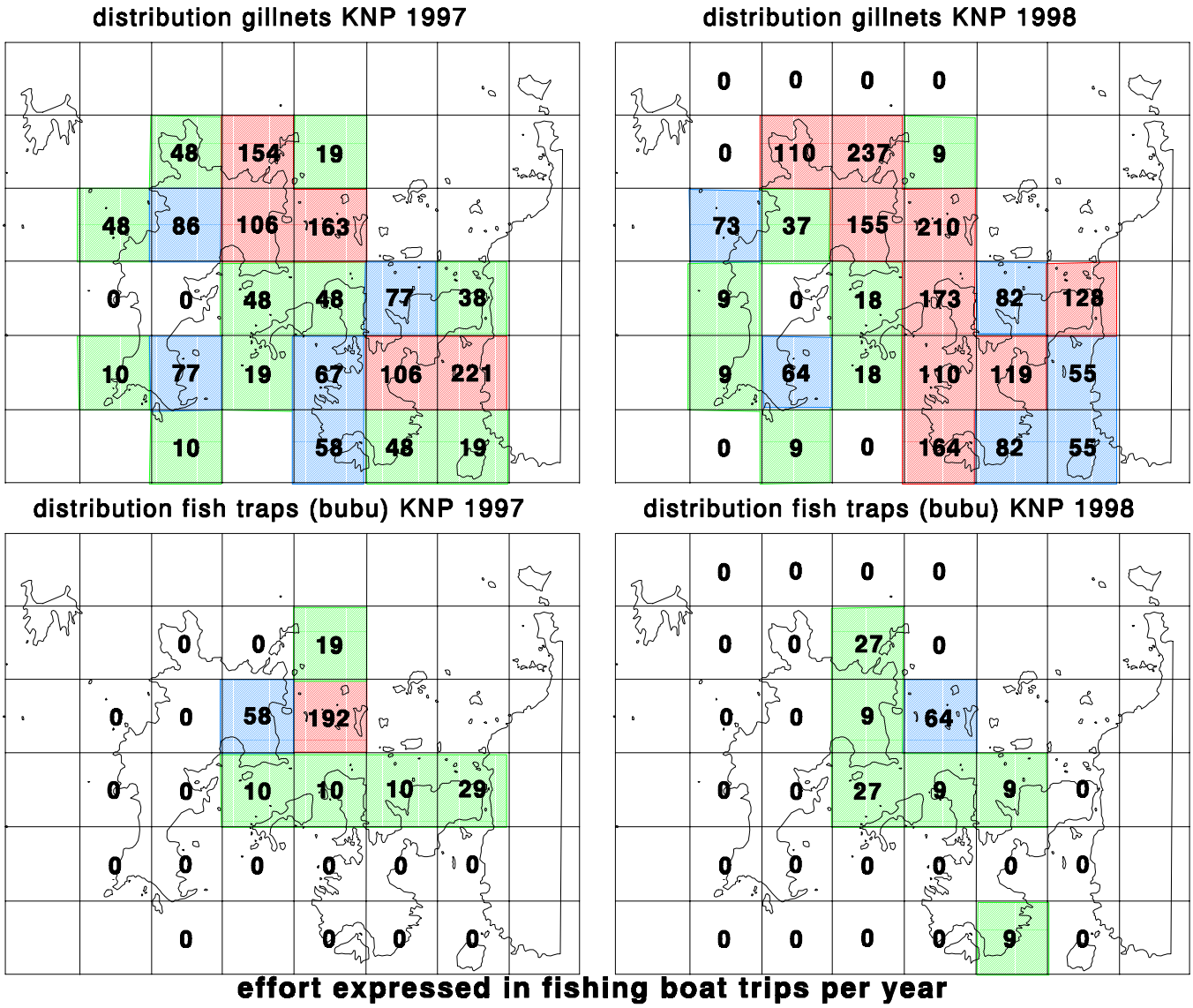

distribution gillnets KNP 1997
48 154 19
48 86 106 163
0 0 48 48 77 38
10 77 19 67 106 221
10 58 48 19
distribution gillnets KNP 1998
0 0 0 0
0 110 237 9
73 37 155 210
9 0 18 173 82 128
9 64 18 110 119 55
0 9 0 164 82 55
distribution fish traps (bubu) KNP 1997
0 0 19
0 0 58 192
0 0 10 10 10 29
0 0 0 0 0 0
0 0 0 0
distribution fish traps (bubu) KNP 1998
0 0 0 0
0 0 27 0
0 0 9 64
0 0 27 9 9 0
0 0 0 0 0 0
0 0 0 0 9 0
effort expressed in fishing boat trips per year

Figure 17.

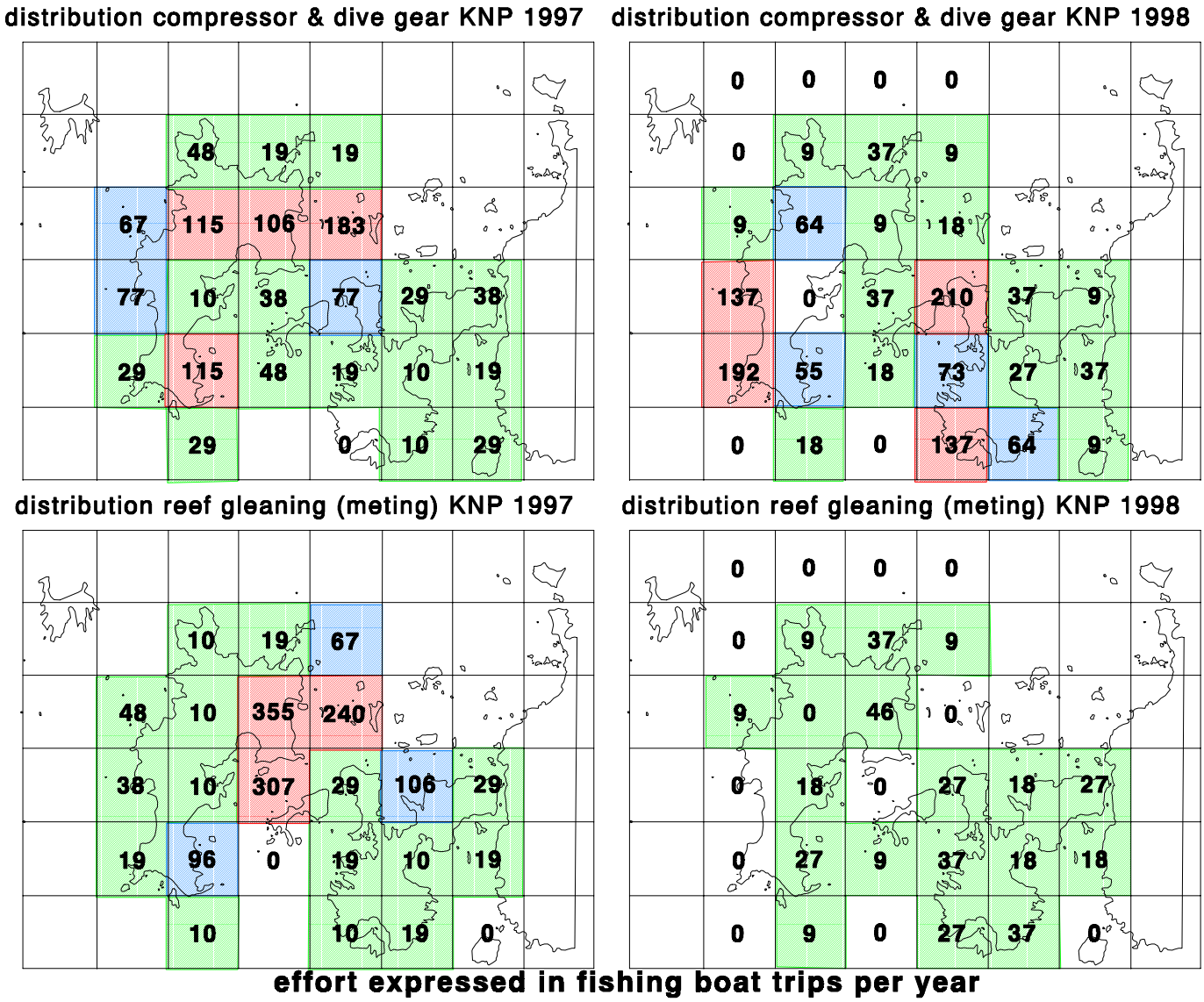

distribution compressor & dive gear KNP 1997
48 19 19
67 115 106 183
77 10 38 77 29 38
29 115 48 19 10 19
29 0 10 29
distribution compressor & dive gear KNP 1998
0 0 0 0
0 9 37 9
9 64 9 18
137 0 37 210 37 9
192 55 18 73 27 37
0 18 0 137 64 9
distribution reef gleaning (meting) KNP 1997
10 19 67
48 10 355 240
38 10 307 29 106 29
19 96 0 19 10 19
10 10 19 0
distribution reef gleaning (meting) KNP 1998
0 0 0 0
0 9 37 9
9 0 46 0
0 18 0 27 18 27
0 27 9 37 18 18
0 9 0 27 37 0
effort expressed in fishing boat trips per year

Figure 18.

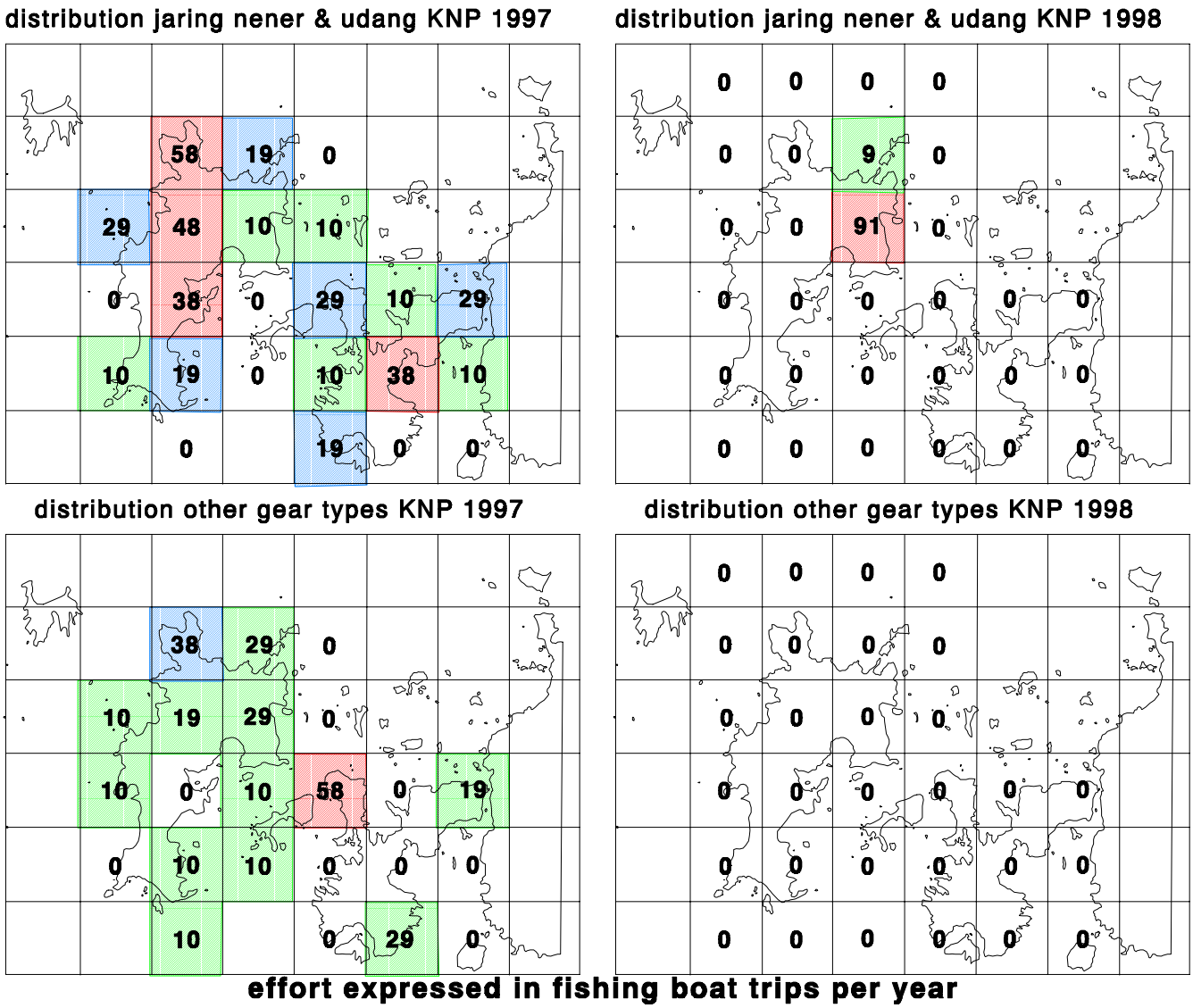

distribution jaring nener & udang KNP 1997
58 19 0
29 48 10 10
0 38 0 29 10 29
10 19 0 10 38 10
0 19 0 0
distribution jaring nener & udang KNP 1998
0 0 0 0
0 0 9 0
0 0 91 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
distribution other gear types KNP 1997
38 29 0
10 19 29 0
10 0 10 58 0 19
0 10 10 0 0 0
10 0 29 0
distribution other gear types KNP 1998
0 0 0 0
0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
effort expressed in fishing boat trips per year

Figure 19.

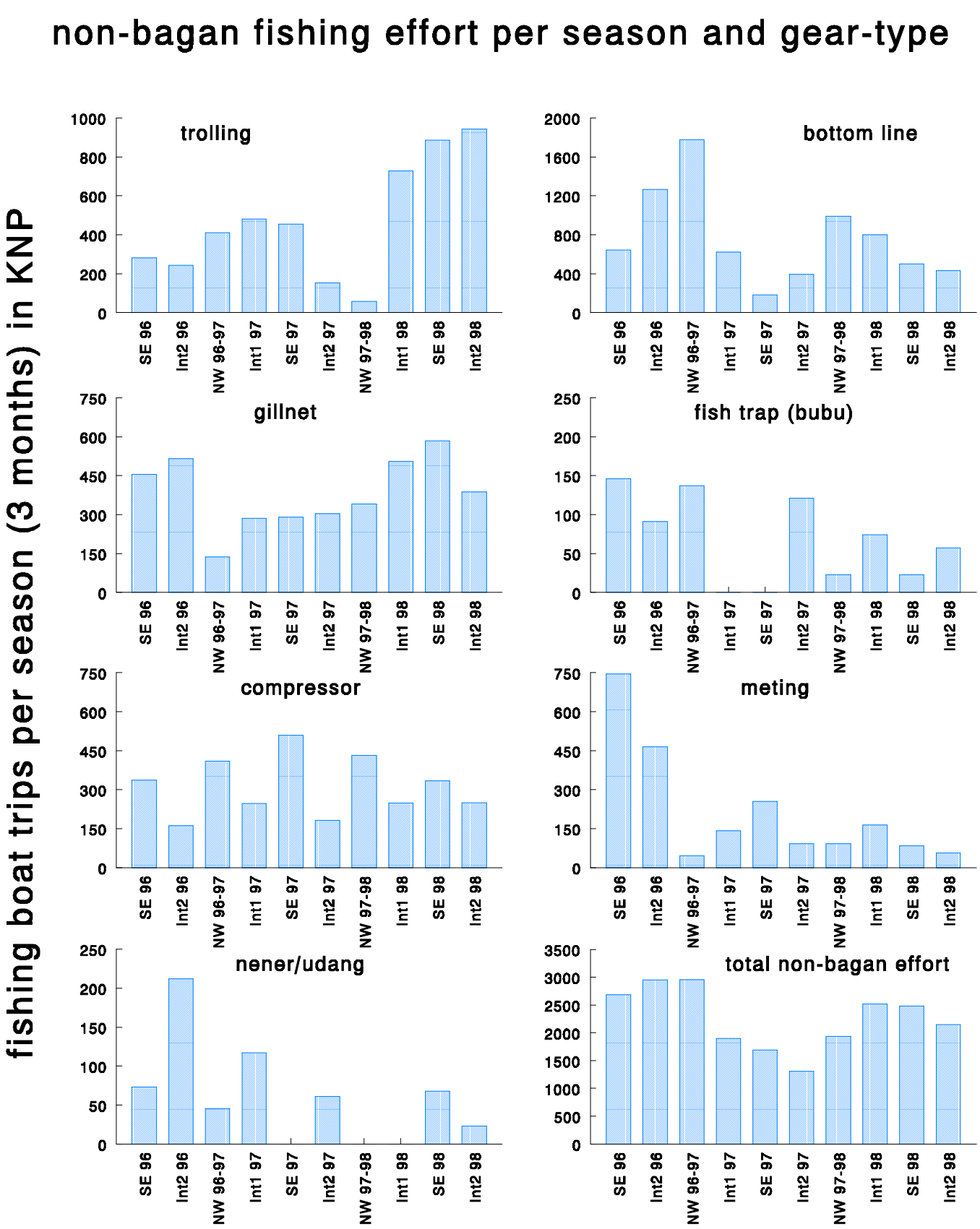

non-bagan fishing effort per season and gear-type
fishing boat trips per season (3 months) in KNP
trolling
bottom line
gillnet
fish trap (bubu)
compressor
meting
nener/udang
total non-bagan effort
SE 96
Int2 96
NW 96-97
Int1 97
SE 97
Int2 97
NW 97-98
Int1 98
SE 98
Int2 98

Figure 20.