Fisheries Centre

The University of British Columbia

Working Paper Series

Working Paper #2015 - 61

Marine Fisheries Catches of Western, Central and Eastern Indonesia, 1950-2010

Daniel Pauly and Vania Budimartono (editors)

Year: 2015

Email: d.pauly@fisheries.ubc.ca

MARINE FISHERIES CATCHES OF WESTERN, CENTRAL AND EASTERN INDONESIA, 1950-2010.

Daniel Pauly and Vania Budimartono (editors)

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.pauly@fisheries.ubc.ca; v.budimartono@fisheries.ubc.ca

Executive summary:

The two contributions in this Working Paper presents an attempt to combine official marine fisheries catch data from Western, Central and Eastern Indonesia with published and/or anecdotal knowledge on extensive foreign illegal and undocumented fishing (particularly in Eastern Indonesia) into coherent time series. These catch time series represent the reconstructed catch of Indonesia as a whole, and run from 1950, following Indonesian independence, and at a time when fisheries data collection was very sporadic, to 2010. Indonesia experienced decades of frenetic development subsidized by the national government and external entities (e.g., the Manila-based Asian Development Bank). Indonesia experienced illegal fishing, mainly by neighboring countries, particularly Thailand, Taiwan, China, Malaysia, and the Philippines, which we have considered in the present paper. Reconstructed catches have reached 5.1 million t·year^{-1} in the last decade. Overall, the reconstructed catch for all of Indonesia of 1950-2010 is 38% larger than reported by FAO on behalf of Indonesia. Domestic commercial fisheries (both reported and unreported components) made up about 78% of the total estimated catch, and their discards contributed and additional 20% to total estimated catch, mainly the result of shrimp trawler operations. The remaining amount of catch is from the subsistence fisheries, widely scattered throughout the Indonesian Archipelago; the catches of recreational fisheries are negligibly small. The catch is extremely diverse, with each family or other higher taxon in the reconstructed catch representing dozens of species, and each species representing hundreds and perhaps thousands of stocks scattered over 5,000 km of complex geography. Thus, a stock-by-stock, or even species-by-species study of these catch data will be largely in vain, except obviously for a few species of tuna, whose individuals may range over large swaths of South-East Asian seas.

A reconstruction of marine fisheries catches of Indonesia, with emphasis on Central and Eastern Indonesia, 1950 - 2010

Vania Budimartono[1], Muhammed Badrudin[2], Esther Divovich[1], Daniel Pauly[1]

[1] *Sea Around Us, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada*
[2] *Indonesia Marine and Climate Support (IMACS) Project, USAID, Indonesia*

Corresponding author: v.budimartono@fisheries.ubc.ca

ABSTRACT

This contribution presents an attempt to combine official catch data from the Java and southern South China Seas ('Central Indonesia') and from the eastern Indonesian provinces ('Eastern Indonesia) with anecdotal knowledge on extensive unreported fishing, particularly in Eastern Indonesia, into a coherent time series. These catch time series, when added to similar, previously estimated catch data from Western Indonesia, represent the reconstructed catch of Indonesia as a whole, and run from 1950, following Indonesian independence, and at a time when fisheries data collection was very sporadic, to 2010. Indonesia experienced decades of frenetic development subsidized by the national government and external entities (e.g., the Manila-based Asian Development Bank), and illegal fishing, mainly by neighboring countries, particularly Thailand, Taiwan, China, Malaysia, and the Philippines, which has been considered in the present paper. Reconstructed catches grew exponentially from 221,000 t in 1950 to 3,450,000 t in 1988, declined by 30%, and then continued growing to reach over 4 million t in 2010. Overall, the reconstructed catch for Central and Eastern Indonesia of 117 million t for 1950-2010 is 39% larger than the 84.2 million t reported by FAO on behalf of Indonesia. Industrial fisheries – both reported and unreported catch – made up 58.6% of the total estimated catch, along with an additional 18% of catch in the form of discards, mainly by shrimp trawlers. The remaining catch belongs to the artisanal sector (31% of catch), its discards (less than 1% of catch), subsistence fisheries (3% of catch), and recreational fisheries (less than 1% of reconstructed catch). The catch is extremely diverse, with each family or other higher taxon in the reconstructed catch representing dozens of species, and each species representing hundreds and perhaps thousands of stocks scattered over 5,000 km of complex geography. Thus, a stock-by-stock, or even species-by-species study of these catch data will be largely in vain, except obviously for a few species of tuna, whose individuals may range over large swaths of South-East Asian seas.

INTRODUCTION

Indonesia, as an archipelagic country, has a long tradition of fishing (Butcher 1996, 2004) and fish is an important component of the food of Indonesians (Pauly 1996a). However, the pressure on Indonesian marine fishery resources has increased strongly in recent decades (Priyono and Sumiono 1997; Wever *et al.* 2012), due to a multiplicity of factors, among them increased demand from a much increased population, particularly in the western half of the country (Pauly 1989), and the development of industrial fisheries, especially trawling, which started in the early 1960s and grew rapidly, leading to a series of conflicts with the hundred thousand of small-scale fishers (Sudjastani 1982). These conflicts, which intensified through the mid-1970s, caused the Government of Indonesia to ban trawl fishing around Java and Sumatra in 1980 (Sarjono 1980; Buchary 1999). In 1981, this ban was extended to Kalimantan and Sulawesi, and in 1983 to the rest of the country, except for shrimp fisheries in its far eastern reaches (Butcher 2004).

This trawl ban and other measures taken to reduce overt conflicts between industrial and small-scale fisheries were the results of open-entry policies, which allowed for fishing effort, notably by trawlers, to grow without control (Bailey *et al.* 1987). Re-establishing control over Indonesian fisheries, and subjecting them to some form of pre-emptive management requires that basic information be available in reliable form, including catch data which, given the country's size and complexity, are difficult to collect.

Indeed, Indonesia has one of the most diverse fish fauna of the world (see Froese *et al.* (1996); updates in FishBase, www.fishbase.org), and even scientific resource surveys, notably trawl surveys have been traditionally plagued by taxonomic problems (Pauly 1986) Moreover, even after these problems were overcome – as they were, due in large part to the FAO publishing excellent identification guides[1] – the fact remains that the catch composition of survey vessels, and by extension also in commercial catches, is extremely diverse. This may be illustrated by the contribution of Pauly and Martosubroto (1980), who studied the growth, mortality and yield-per-recruit of the red filament threadfin bream *Nemipterus marginatus,* based on catch per effort and length-frequency data collected during a trawl survey conducted in 1975 in the southern tip of the South China Sea.

During that survey, the Nemipteridae, or threadfin breams, with about 12 species then believed to occur in the area surveyed (Fischer and Whitehead 1974), were the most abundant taxon in the catch, contributing about 20%. Of this, *Nemipterus marginatus* was the most abundant threadfin bream, with about 6% of the family contribution; this, however, represented only 1.2% of the total catch. Thus, population dynamics studies aimed at identifying optimal mesh sizes and appropriate levels of fishing mortality for single species - e.g., the study of Pauly and Martosubroto (1980) – were essentially useless, as was the compilation of fish and shrimp growth and related parameters by Dwiponggo *et al.* (1986). Rather, it is now understood that the assessment of multispecies fish stocks such as occur in Indonesia should be focused on changes in catch levels and composition, with rapid changes of these indicators being strong evidence of lack of sustainability (Pauly 1979; Pauly *et al.* 1998; Kleisner *et al.* 2012).

Tracking catch levels and compositions, however, requires accurate catch data, including all fisheries, i.e., included catches from illegal fisheries, and discards, which are usually not included in catch statistics. This report is a small contribution toward this aim, i.e., an attempt to estimate the actual catches and thus correct - to the extent possible - various deficiencies in the official Indonesian statistics.

As implied by its title, the reconstruction presented here does not treat Indonesia as a single entity. Rather, because of its enormous longitudinal extent and different environmental (Longhurst and Pauly 1987) and socio-economic conditions in the West and East of the country, we decided to split Indonesia into three zones (Fig. 1):

1. Western Zone (I): largely overlapping with Indian Ocean waters (FAO Area 57), and with the eastern part of the Bay of Bengal (Budimartono *et al.* in press) and hence with the area covered by the Bay of Bengal Large Marine Ecosystem Project (BOBPLME; Harper *et al.* (2011); Kleisner and Pauly (2011));
2. Central Zone (II): consisting of the Java Sea and the southern top of the South China Sea; and
3. Eastern Zone (III): consisting of the waters of all Indonesian provinces east of the Java Sea (including Bali) and the corresponding EEZ. This Zone, which includes in its southwest some of the Indian Ocean not covered in Zone I, corresponds to the Indonesian part of the "Coral Triangle" as defined by Fidelman *et al.* (2012) and Veron *et al.* (2009) in Figure 1.

[1] Fischer and Whitehead (1974) and Carpenter and Niem (1998b, 1998a, 1999a, 1999b, 2001a, 2001b)

Because this contribution, which emphasizes Zone II and III, was assembled after that of Budimartono *et al.* (in press), covering Zone I, the descriptions of methods is adapted, sometimes literally, from this previous work, as were parts of this introduction.

METHODS

Data pre-processing

Figure 1 defines the areas emphasized here, which includes most of the Indonesian provinces listed in Table 1. Note that a few of these provinces have only one coast included within FAO area 71 (Western Central Pacific), with the other included in FAO Area 57 (Eastern Indian Ocean). For such cases, we have estimated the approximate fraction of their waters in each FAO Area (Table 1), and have allocated their reported catch proportionately. The next step consisted of first-order processing of the nominal (official) catch time series at the province level (obtained from Ministry of Marine Affairs and Fisheries).

This consisted of:

1) Transposing the available data, by province, from PDF format to Microsoft Excel format and correcting obvious errors detectable at this stage (notably, order-of-magnitude jumps in catches due to misplaced dots or zeroes);
2) Interpolating the catches, by province, for a few missing years on the assumption that fisheries do not disappear from one year to the next, and then re-appear a year later;
3) Translating the Indonesian common names used in provincial (and national statistics) into their nearest scientific equivalent using resources such as the book by Schuster and Djajadiredja (1952), Directorate General of Fisheries (1975) and FishBase (www.fishbase.org);
4) Applying the average proportion by provinces of each taxon from 1973 to 1975 backward into the total FAO catch (Area 57 and 71); and
5) Applying, once (1) to (4) were completed, a between-year taxonomic harmonization such as to avoid a higher taxonomic category, e.g., 'tuna' abruptly disintegrating into its component species, or vice-versa.

Steps (1) to (5) generated time series of nominal catch by Zone, accounting for the fact that the catch of a few provinces straddling FAO areas 57 and 71 had to be divided up between the Indian Ocean and Central Zones (see Table 1).

Table 1. Special Regions and Provinces of Indonesia, with % of their coastal areas in FAO Area 57 and/or 71.

Province	Zone 1 – Indian Ocean	Zone 2 – Central Indonesia	Zone 3 – Eastern Indonesia
Special Region of Yogyakarta	100	0	0
Aceh	100	0	0
North Sumatra	100	0	0
West Sumatra	100	0	0
Bengkulu	100	0	0
Riau	80	20	0
Lampung	30	70	0
Banten	50	50	0
West Java	60	40	0
Central Java	40	60	0
East Java	40	60	0
Bali	50	50	0
West Nusa Tenggara	0	0	100
East Nusa Tenggara	0	0	100
Jambi	0	100	0
Riau Islands	0	100	0
South Sumatra	0	100	0
Bangka-Belitung	0	100	0
Special Capital Region of Jakarta	0	100	0
West Kalimantan	0	100	0
Central Kalimantan	0	100	0
East Kalimantan	0	0	100
South Kalimantan	0	0	100
North Sulawesi	0	0	100
Gorontalo	0	0	100
Central Sulawesi	0	0	100
West Sulawesi	0	0	100
South Sulawesi	0	0	100
Southeast Sulawesi	0	0	100
North Maluku	0	0	100
Maluku	0	0	100
Papua	0	0	100
West Papua	0	0	100

Small-scale fisheries (artisanal, subsistence, and recreational)

In Indonesia, small-scale fisheries are defined by their use of vessels relying on sail or outboard engine for propulsion, as well as fishers operating gear without a boat, irrespective the size of their gear (Priyono and Sumiono 1997; Chuenpagdee *et al.* 2006). Thus, the relatively large '*bagans*' or fixed lift net (Pauly 1977) are considered artisanal, although they are likely to require a large capital investment to build.

To allocate the catches obtained in Step 5 to either industrial and artisanal fisheries, we created a list of species (or higher taxa) by province (or part thereof) and assigned to each the likely percentage of their catch presumed to be taken in 1970-2010 by industrial vessels (mainly purse seiners in the case of pelagic fishes and trawlers in the case of demersal fishes) (Appendix 1). These percentages (the mean of independent estimates by the three co-authors) were then used to compute the catch by species groups of industrial fisheries, and province, and by subtraction, the corresponding small-scale fisheries catch. For the years before 1970, a phase-in period of 5 years was assumed, starting in 1966 in Central Indonesia and 1975 in Eastern Indonesia, and thus reflecting the earlier industrialization of fisheries in Central Indonesia (Bailey *et al.* 1987; Butcher 2004; Morgan and Staples 2006).

Unreported catches in the artisanal sector were mostly in the region of Eastern Indonesia, yet were caught by artisanal migratory fishers from Western or Central Indonesia, who moved east due to declining catch

rates in their own respective regions (Bailey *et al.* 2007). Wagey *et al.* (2009) details the level of unreported catch by these migratory fishers, which we utilized in the present analysis.

To estimate the contribution of subsistence fisheries (wherein fishers keep fish for their own consumption and that of their families and friends), the total number of fishers from 1976 to 2010 in 10 years intervals (with interpolations for the intervening years) and total number of fishers as a fraction of the total Indonesian population (1950 to 1975) were used, jointly with figures of 0.2 $kg \cdot fisher^{-1} \cdot day^{-1}$ for catches generated in Central Indonesia, and 0.4 $kg \cdot fisher^{-1} \cdot day^{-1}$ for catches generated in Eastern Indonesia, to estimate the take of subsistence fisheries (Willoughby *et al.* 1999). As we treated both full time fishers and part time fishers as equivalent (in the context of subsistence), and thus used their total number, we assumed that the frequency of fishing for each fisher would be 4 days per week and 40 weeks a year.

Marine recreational fishing was reported to generate a catch of 5,000 to 10,000 $t \cdot year^{-1}$ in the mid-1990s (unpublished update to Willoughby *et al.* 1999). Given that recreational fishing, in Indonesia, appears to be an urban-based phenomenon, we derived, from the relative population of the 10 largest cities in Indonesia, a key to allocate the midrange (7,500 t) of fish caught recreationally to the three parts of Indonesia identified above, i.e., Central Indonesia (80%; high because of the cumulative populations of Jakarta, Semarang, Bekasi, Tangerang, Depok, Palembang, and Surabaya), Western Indonesia (15%; e.g., Bandung and Medan), and Eastern Indonesia (5%; Makassar). The year 1994 catch of 7,500 t was decreased for previous years and increased to 2010 by making it proportional to the size of the Indonesian population.

Sudirman *et al.* (2006) suggest that the average discard rate for lift nets in Makassar Strait is about 2.2%, and that most of the discarded species have low values and/or are small sized. The artisanal fisheries in Indonesia have low discard rate; hence this rate will be used to estimate artisanal discards for both Central and Eastern Indonesia.

Industrial fisheries (legal and illegal) and their discards

The industrial reported catch was adjusted only lightly to account for the effect of the 1980 trawl ban. The ban was effective, in the short run and in some areas such as along the coast of Java, in reducing the *visibility* of trawlers to artisanal fishers, but they largely continued to operate further offshore, out of their sight (D. Pauly, 1983; pers. obs. on Javanese trawlers with recently used – and hence shiny – drums on their main winches), or were converted to purse seiners (Butcher 2004), another industrial gear. (The latter can be assumed to have led to an increase of the relative contribution of small pelagic fishes in the reported catch, and is thus accounted for). To account for the effects of the trawl ban, we shall assume that the catch of trawlers (and the corresponding discards) in Central Indonesia became, in 1980, only 30% of what it would have been had there been no ban, this fraction declining to 20% in 1981, and 10% in 1982 (after which we return to business as usual), with the artisanal fisheries and the industrial pelagic fisheries being attributed this additional (formerly trawl) catch.

Central Indonesian trawlers, and contrary to a widespread perception of the opposite, do engage in discarding their by-catch of less valuable fish, and keep mainly the shrimp and valuable fish (D. Pauly, pers. obs. July 1976 in the northern Java Sea, off Kalimantan), while discarding by trawlers in Eastern Indonesia is well documented (Wagey *et al.* 2009). Therefore, we have added an assumed discarded by-catch to the nominal industrial catch of demersal taxa, i.e., from 20% in 1965 to 1989, then declining linearly to 2% in 2000 (M. Badrudin, unpublished data). We consider this estimate conservative, as it is much less than the discarding rate estimated for the North Sumatra trawler fleet where it is suggested that "two thirds of the catch by the trawler fleet operating in North Sumatra is discarded over the side, lost to the marine ecosystem and the local fishermen" (JALA 2009).

There is, in all parts of Indonesia, a substantial amount of unreported industrial catch by both domestic fleets (unregulated catch) and foreign fleets (illegal catch), with an increasing gradient from West to East, although this seems to have abated in recent years (Ganapathiraju *et al.* 2008). Since Eastern Indonesia is very far from Indonesia's population centers and from the center of political power, both on Java Island and the West, the east is also where most foreign illegal fishing occurs, either as brazen incursions into the Indonesian EEZ by Thai, Taiwanese, Chinese or Philippine vessels, or based on agreements whose terms are not respected (Ganapathiraju *et al.* 2008). For the purposes of the present reconstruction, it was estimated that the most common countries to illegally fish in Indonesian waters were Thailand, Taiwan, China, Malaysia, and the Philippines.

For Eastern Indonesia, unregulated and illegal activities by industrial trawlers are documented by Wagey *et al.* (2009), and his estimates were used in the present analysis. We assumed that 10% of the unreported catch he cited was taken by domestic, Indonesian trawlers, and the remaining 90% of catch was illegal and was divided equally among the five countries listed above.

For Central Indonesia, we conservatively assumed unreported industrial fishing by trawlers (both foreign and domestic) corresponded, in the 1980s and 1990s, to 30% of the domestic reported catch that we assigned to industrial fisheries. For the period preceding this, we assume that this rate grew linearly from zero in 1961 to 30% in 1980. Also, we assumed, given the decline in illegal fishing alluded to above, that the rate of non-reporting declined from 30% to 10% in the period from 1995 to 2005, then remained stable at 10%. Due to lack of data on the likely proportion of catch taken by domestic and foreign trawlers (except the knowledge that there was more illegal catch in the east than in the west), we assumed an equal proportion of catch taken by trawlers from Indonesia, Thailand, Taiwan, China, Malaysia, and the Philippines.

In addition to unreported catch by trawlers, we assumed that unreported catch by purse-seiners (both domestic and foreign) was half of the unreported trawler catch in both Central and Eastern Indonesia (in tonnage). Furthermore, Kelleher (2005) suggests that the discard rate for purse seine in Java Sea is around 1%, while Bailey *et al.* (1996) suggest that the tuna discard rate for Eastern Indonesia is around 0.39%. Their discards consist of target catches, as well as other small pelagics (Nurhakim *et al.* 1998).

The discards of unreported catch were assumed to be the same as for the reported trawl and purse-seine fishery (see above). For inferences of unregulated and illegal fishing and discarding, we use the sources in Table 2.

Table 2. Sources used to infer the extent of illegal, unreported fishing, and discarding in Central and Eastern Indonesia

Zone (IUU and/or discards)	Source	Remarks
Eastern (discards)	Sudirman *et al.* (2006)	2.18% for artisanal by using bagan bambo (liftnet)
Eastern (discards)	Bailey *et al.* (1996)	0.39%; only for targeted catch (purse-seine)
Eastern (discards)	Clucas and Teutscher (1998)	88.4% In Arafura Sea
Eastern (discards)	Gillett (2008)	>80% in Arafura Sea
Eastern (IUU)	Varkey *et al.* (2009)	IUU in Raja Ampat Regency
Eastern (IUU)	Badrudin *et al.* (2008)	Unreported catch in Arafura Sea
Eastern (IUU)	Bailey *et al.* (2007)	Unreported catch in Kabui Bay, Raja Ampat
Eastern (IUU and discards)	Wagey *et al.* (2009)	IUU and discard rates for shrimp trawler catch (Table 2)
Central (discards)	JALA (2009)	2/3 of the total catch in North Sumatra is discarded
Central (discards)	M. Badrudin (unpubl. data)	2% around northern Java
Central and Eastern (discards)	Kelleher (2005)	>80% in Arafura Sea; 8% for the rest of Indonesia
Central and Eastern (IUU and discards)	Willoughby *et al.* (1999)	Unreported catch in Indonesia
Central and Eastern (IUU and discards)	Ganapathiraju *et al.* (2008)	IUU and discards in Indonesia
Central and Eastern (IUU and discards)	Funge-Smith *et al.* (2005)	"Discards in Indonesia are considered insignificant […] except for Arafura Sea shrimp fishery"

RESULTS AND DISCUSSION

The catch reconstructions and related information that were obtained here are presented separately for Central and Eastern Indonesia and, jointly with data from Budimartono *et al.* (in press) on Western Indonesia, for Indonesia as a whole.

Issues related to the nominal catch statistics

Our partitioning of provincial catch statistics within FAO Area 71 resulted in slight discrepancies with the catches submitted by Indonesia to FAO and disseminated through the FishStat database (Figure 2). These discrepancies were evidential almost throughout the time series, and they were presumably due to inadequate data transfer from Indonesia to FAO (see also Yamamoto 1980). FAO's data usually remain markedly above national data, suggesting that the data transfer between the Indonesian statistical service and FAO could still be improved (Zeller *et al.* 2007). Note that in more recent years, there was a decrease in the discrepancies, i.e., our partitioning of provincial catch statistics closely resembled FAO's data, which might indicate an improvement in data transfer.

Moreover, in the mid-1970s, there was a significant decrease in the reported catch for FAO Area 71, and this was thought to be an anomaly in the data, possibly due to changes FAO made to the boundaries between the FAO Areas 57 and 71. The anomaly was reduced by applying backward the average proportion by provinces of each taxon into the total reported FAO catch (Area 57 and 71) assigned to each taxon (see Material & Methods section).

Central Indonesia

This Zone consists exclusively of the southern tip of the South China Sea and the Java Sea, and covers an area of 1.8 million km^2, i.e., the shallow waters of the Sunda Shelf, where trawl fisheries were initiated in the 1960s, aided by loans from the Asian Development Bank (Mannan 1997). These fisheries rapidly grew and were soon involved in widespread (and often violent conflicts) with the hundreds thousands of artisanal fishers operating along the coast of Java (Buzeta *et al.* 1979; Bailey *et al.* 1987). This led, in 1980, to a trawl ban (see above) whose effect was strongest along the coast of Java. One of these effects was the explosive development of an industrial fishery for small pelagics (predominantly scads, *Decapterus* spp.; Figure 3), which were mostly caught by large and medium purse-seine vessels (Widodo 1995; Nurhakim *et al.* 1998) The *Decapterus* spp. catch from the northern part of Java shows high fluctuations, with a number of peaks - notably in 1985 - and an overall upward trend in the early time period (Nurhakim *et al.* 1998). The development of purse-seines first started around northwestern Java, then since 1982, it spread to the entire Java Sea, the southern part of the South China Sea, and the southern part of the Makassar Strait (Nurhakim *et al.* 1987; Potier and Petit 1995). Illegal fishing by foreign fleets occurs, in Central Indonesia, mainly in the southern tip of the South China Seas, in the vast space between the West Coast of Kalimantan, Singapore and the Southeast coast of Sumatra (see Figure 1). Detailed reviews of the demersal and pelagic fisheries resources and their biology in Central Indonesia are included in Pauly and Martosubroto (1996).

The reconstructed total catch for Central Indonesian marine fisheries from 1950 to 2010 was estimated to be 40.3 million t (Figure 4), and increased from around 145,000 t·year^{-1} in the 1950s to around 1.34 million t·year^{-1} in the 2000s. The total catches are estimated to be around 14.4% higher than the catch reported by FAO and Indonesia (adjusted to Central Indonesia). Industrial domestic fisheries – both reported and unreported - made up 55.6% of the total estimated catch. Discards from both artisanal and industrial fisheries were estimated to be 8% (from artisanal catch, shrimp trawlers catch, and purse-seiners catch) of total catches, while artisanal (34%), subsistence (2%), and recreational fisheries (<1%) made up the rest.

Discarding rates are widely assumed to be insignificant in Central Indonesia, as fishers are thought to retain by-catch for sale or family consumption (Funge-Smith *et al.* 2005; Ganapathiraju *et al.* 2008). Following the introduction of industrial gears, discard rates were relatively high. However, in recent years, discard rates are thought to have declined as only the least valuable part of the catch is discarded ('trash' fishes, damaged, and/or small sized fishes; M. Badrudin, unpublished data).

Major contributing taxa in the reconstructed catch were Carangidae (jacks and pompanos), Scombridae (mackerels, tunas, and bonitos), Clupeidae (herrings, shads, and sardines), Engraulidae (anchovies), Ariidae (sea catfishes), Penaeidae (penaeid shrimps), Leiognathidae (slipmouths, or ponyfishes), and Polynemidae (threadfins; Figure 5). As might be seen, the fish catch consisted of a wide variety of families – notably percoids – almost all of which are consumed, even small fishes such as the abundant pony fishes, of Leiognathidae (Pauly 1977; Pauly and Wade-Pauly 1981).

Eastern Indonesia

Contrary to Central Indonesia, which consists of massive islands separated by shallow shelf waters, Eastern Indonesia is characterized by scattered, smaller islands (except for Eastern Papua, of course), separated by deep basins (Dalzell and Pauly 1989). Successive eustatic changes of sea levels have repeatedly isolated then reunited these basins, thus causing an extraordinary rate of speciation (Froese and Pauly 2013). This is the reason why Eastern Indonesia is part of the global center of marine diversity (Hoeksema 2007), and hence part of the Coral Triangle (Veron *et al.* 2009; Fidelman *et al.* 2012).

The total reconstructed catch for Eastern Indonesian marine fisheries and increased from around 147,000 $t \cdot year^{-1}$ in the 1950s to around 2.42 million $t \cdot year^{-1}$ in the 2000s (Figure 6). The total catches of 76.8 million t from 1950 – 2010 are estimated to be around 57% higher than the catch reported by FAO and Indonesia (adjusted to Eastern Indonesia). Industrial and artisanal fisheries catch – both reported and unreported amounts – contributed 43% and 29%, respectively, to total estimated catch. Discards from both artisanal and industrial fisheries were estimated to be 25% (from artisanal catch, shrimp trawlers catch, and purse-seiners catch) of total catches, while subsistence (3%) and recreational fisheries (<1%) made up the rest.

Due to the its exemption from the 1980 trawl ban and remote geographical location, Eastern Indonesia is known to have the highest industrial discard rates in the region (Kelleher 2005; Gillett 2008). The trend is apparent in the early 1980s to mid-1990s, where discard rates were highest, and the fishery expanded its capacity and fishing grounds (Wagey *et al.* 2009). In recent years, the discard rates and amounts varied, with a general downward trend (Ganapathiraju *et al.* 2008; Wagey *et al.* 2009). A similar trend can also be seen with the illegal and misreported components of industrial fishery in the region. As there are numerous remote and small landing sites around the region, a large proportion of the catch are not included in the official statistics (Varkey *et al.* 2009). Moreover, misreporting could also be contributed to artisanal migratory fishers who fish in Eastern Indonesia yet do not report their catch (Bailey *et al.* 2007). The decline in discard, misreported, and illegal components of industrial fishery in Eastern Indonesia presumably impacts on the increase of reported industrial catch, itself due to improvements in the surveillance and enforcement in the region (Wagey *et al.* 2009).

Figure 7 presents the taxonomic composition of the catch from Eastern Indonesia, highlighting the importance of large pelagic fishes, notably tuna, in this part of the world. Major contributing taxa in the reconstructed catch were Carangidae (jacks and pompanos), Scombridae (mackerels, tunas, and bonitos), Clupeidae (herrings, shads, and sardines), Hemiramphidae (halfbeaks), Engraulidae (anchovies), Leiognathidae (slipmouths, or ponyfishes), Latidae (lates perches), and Ariidae (sea catfishes). We believe that the estimates presented in these two figures still underestimate catches, but the scarcity of comprehensive datasets on the extent of unregulated and illegal fishing forced us to be conservative.

Indonesia – Central and Eastern

Figure 8 shows a time series of total reconstructed marine catch from 1950 to 2010 for Central and Eastern Indonesia, by fishery sectors and compares it with the catch that the FAO reports on behalf of Indonesia. Overall, reconstructed catch, of 117 million t is 1.39 times larger than the FAO reported catch. The ratio of reconstructed to reported catch peaks in the 1980s, where the reconstructed catch is around 1.72 times the FAO reported catch, although this has improved to around 1.09 times since 2000. Industrial fisheries – both reported and unreported catch - made up 48% of the total estimated catch, along with an additional 18% of catch in the form of discards, mainly by shrimp trawlers. The remaining catch belongs to the artisanal sector (31% of catch), its discards (less than 1% of catch), subsistence fisheries (3% of catch), and recreational fisheries (less than 1% of reconstructed catch).

The estimated discarded industrial catch peaked in the early 1980s to early 1990s, due to rapid development of industrial fisheries in most of Indonesia (Figure 8). With low enforcement and surveillance levels, illegal fishing activities, as well as misreporting in Indonesia were high, especially in Eastern Indonesia (Buchary *et al.* 2006; Wagey *et al.* 2009).

Small-scale activities in Indonesia are considered to be stable, with low tonnage generated by recreational and subsistence fisheries (Figure 8), and a low discarding rate for artisanal fisheries. Figure 9 presents the taxonomic composition of the reconstructed catch, Major contributing taxa in the reconstructed catch were Carangidae (jacks and pompanos), Scombridae (mackerels, tunas, and bonitos), Clupeidae (herrings, shads, and sardines), Engraulidae (anchovies), Leiognathidae (slipmouths, or ponyfishes), Ariidae (sea catfishes), Hemiramphidae (halfbeaks), and Penaeidae (peneid shrimps). It must be realized, however, that this figure was derived through inter- and extrapolations, and in any case, can give only a rough approximation of an extremely diverse catch of Indonesian fishes. Notably, each family or other higher taxon in this figure represent dozens of species, and each species may represent hundreds of stocks scattered over 5,000 km of complex geography. Thus, a stock-by-stock, or even species-by-species study of these catch data will be largely in vain, except obviously for a few species of tuna, whose individuals may range over large swaths of South-East Asian seas.

ACKNOWLEDGEMENTS

This is a contribution of the *Sea Around Us*, which is funded by The Pew Charitable Trusts and the Paul G. Allen Family Foundation. We also thank Mr. Peter Mous of Indonesia's Marine and Climate Support (IMACS) Project (USAID) for having facilitated our collaboration.

REFERENCES

Badrudin, Nurhakim S and Prisantoso BI (2008) Estimated unrecorded catch relate to the number of licensed fishing vessel in the Arafura Sea. Indonesian Fisheries Research Journal 14 (2): 43-49.

Bailey C, Dwiponggo A and Marahudin F (1987) Indonesian marine capture fisheries. International Center for Living Aquatic Resources Management (ICLARM), Makati, Metro Manila, Philippines.

Bailey K, WIlliams PG and Itano D (1996) By-catch and discards in Western Pacific tuna fisheries: A review of SPC data holdings and literature. Oceanic fisheries programme technical report South Pacific Commission, Noumea, New Caledonia.

Bailey M, Rotinsulu C and Sumaila R (2007) The migrant anchovy fishey in Kabui Bay, Raja Ampat, Indonesia: Catch, profitability, and income distribution. Marine Policy 32: 483-488.

Buchary EA (1999) Evaluating the effect of the 1980 trawl ban in the Java Sea, Indonesia: An ecosystem-based approach. MSc thesis, University of University of British Columbia, Vancouver. 143 p.

Buchary EA, Pitcher TJ and Ganapathiraju P (2006) An Estimation of Compliance of the Fisheries of Indonesia with Article 7 (Fisheries Management) of the FAO (UN) Code of Conduct for Responsible Fishing. p. 36 *In* Pitcher TJ, Kalikoski D and Pramod G (eds.), Evaluations of Compliance with the FAO (UN) Code of Conduct for Responsible Fisheries. University of British Columbia, Vancouver, Canada.

Budimartono V, Badrudin M and Pauly D (in press) Indonesian marine fisheries catches in the Western Indonesia (FAO Area 57) and in the Bay of Bengal Project (BOBP) area: a tentative reconstruction, 1950-2010. Fisheries Centre Research Report.

Butcher JG (1996) The marine fisheries of the Westen Archipelago: Toward an economic history, 1850 to the 1960s. pp. 24-39 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. International Center for Living Aquatic Resources and Management (ICLARM), Makati City, Philippines.

Butcher JG (2002) Getting into trouble: the diaspora of Thai trawlers, 1965–2002. International Journal of Maritime History 14(2): 85–121.

Butcher JG (2004) The closing of the frontier - A history of the marine fisheries of Southeast Asia c. 1850-2000. Institute of Southeast Asian Studies, Singapore.

Buzeta RB, Dwiponggo A and Sujastani T (1979) Report of the workshop on demersal and pelagic resources of the Java Sea. South China Sea Fisheries Development and Coordinating Programme, Manila, Phillipines.

Carpenter KE and Niem VH, editors (1998a) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 709 p.

Carpenter KE and Niem VH, editors (1998b) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 686 p.

Carpenter KE and Niem VH, editors (1999a) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 671 p.

Carpenter KE and Niem VH, editors (1999b) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 721 p.

Carpenter KE and Niem VH, editors (2001a) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 589 p.

Carpenter KE and Niem VH, editors (2001b) FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific. FAO, Rome. 837 p.

Chuenpagdee R, Liguori L, Palomares MD and Pauly D (2006) Bottom-Up, Global Estimates of Small-Scale Marine Fisheries Catches. University of British Columbia, Vancouver, Canada.

Clucas I and Teutscher F, editors (1998) Report and proceedings of FAO/DFID expert consultation on by catch utilization in tropical fisheries - Beijing, China, September 1998 Chatham, United Kingdom.

Dalzell P and Pauly D (1989) Assessment of the fish resources of Southeast Asia, with emphasis on the Banda and Arafura Seas. Netherlands Journals of Sea Research 24(4): 641-650.

Directorate General of Fisheries DoA (1975) Ketentuan kerja pengumpulan, pengolahan, dan penyajian data statistik perikanan: Standard statistik perikanan [Provision of work collecting, processing, and presentation of statistical data fishery: Standard fishery statistics]. Directorate General of Fisheries, Department of Agriculture. iv + 207 p.

Dwiponggo A, Hariati T, Banon S, Palomares ML and Pauly D (1986) Growth, mortality and recruitment of commercially important fishes and penaeid shrimps in Indonesian waters. International Center for Living Aquatic Resources Management (ICLARM) Technical Reports 17, International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines. 91 p.

Fidelman P, Evans L, Fabinyi M, Foale S, Cinner J and Rosen F (2012) Governing large-scale marine commons: Contextual challenges in the Coral Triangle. Marine Policy 36: 42-53.

Fischer W and Whitehead PJP, editors (1974) FAO species identification sheets for fishery purposes: Eastern Indian Ocean (fishing area 57) and Western Central Pacific (fishing area 71). Food and Agriculture Organization of the United Nations (FAO), Rome.

Froese R, Luna SM and Capuli EC (1996) Checklist of marine fishes of Indonesia, compiled from published literature. pp. 217-275 *In* Pauly D and Martosubroto P (eds.), Baseline studies of diversity: The fish resources of western Indonesia. Philippines, Makati City.

Froese R and Pauly D (2013) Fish Stocks. Vol. 3. pp. 477-487 *In* Levin S (ed.) Encyclopedia of Biodiversity 2nd Edition. Academic Press/Elsevier, Waltham M.A.

Funge-Smith S, Lindebo E and Staples D (2005) Asian fisheries today: The production and use of low value/trash fish from marine fisheries in the Asia-Pacific region. Food and Agriculture of the United Nations, Bangkok, Thailand.

Ganapathiraju P, Pitcher TJ, Pearce J and Agnew D (2008) Sources of information supporting estimates of unreported fishery catches (IUU) for 59 countries and the High Seas. University of British Columbia, Vancouver, Canada. 242 p.

Gillett R (2008) Global study of shrimp fisheries. Food and Agriculture Organization of the United Nations, Rome.

Harper S, O'Meara D, Booth S, Zeller D and Pauly D (2011) Fisheries catches from the Bay of Bengal Large Marine Ecosystem since 1950. Report to the Bay of Bengal Large Marine Ecosystem Project 16, Bay of Bengal Large Marine Ecosystem (BOBLME). 97 p.

Hoeksema BW (2007) Delineation of the Indo-Malayan centre of maximum marine biodiversity: the Coral Triangle - Biogeography, time, and place: distributions, barriers, and islands. Springer Netherlands: 117-178.

JALA (2009) When fishing turns deadly: The environmental and social impacts of illegal trawling in North Sumatra. JALA - the Advocacy Network for North Sumatra Fisherfolk, Medan Johor, Indonesia. 6 p.

Kelleher K (2005) Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper 470, FAO, Rome.

Kleisner K, Froese R, Zeller D and Pauly D (2012) Using global catch data for inferences on the world's marine fisheries. Fish and Fisheries 14(3): 293-311.

Kleisner K and Pauly D (2011) Performance in managing marine resources in the Bay of Bengal. Report to the Bay of Bengal Large Marine Ecosystem Project 17, Bay of Bengal Large Marine Ecosystem (BOBLME). 146 p.

Longhurst A and Pauly D (1987) Ecology of tropical oceans. Academic Press, San Diego. 407 p.

Mannan MA (1997) Foreword. p. v *In* Silvestre G and Pauly D (eds.), Status and management of tropical coastal fisheries in Asia. Asian Development Bank (ADB) and International Centre for Living Aquatic Resources Management (ICLARM), Manila, Philippines.

Morgan GR and Staples DJ (2006) The history of industrial marine fisheries in Southeast Asia. Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific (FAO-RAP), Bangkok. i + 28 p.

Nurhakim S, Banon S, Potier M and Boely T (1987) Study on the big purse seiners fishery in the Java Sea. Jurnal Pen. Perikanan Laut 40: 65-76.

Pauly D (1977) The Leiognathidae (Teleostei): Their species, stocks and fisheries in Indonesia, with notes on the biology of Leiognathus splendens (Cuvier). Marine Research in Indonesia (19): 73-93.

Pauly D (1979) Theory and Management of Tropical Multispecies Stocks: a Review, with Emphasis on the Southeast Asian Demersal Fisheries. 35 p.

Pauly D (1986) On identifying fish species rather than assessing fish stocks: a review of two books on the taxonomy of the neritic fishes of the Western Indian Ocean. Naga, the International Center for Living Aquatic Resources Management (ICLARM) Quarterly 9(3): 21.

Pauly D (1996a) Fleet-operational, economic and cultural determinants of by-catch uses in Southeast Asia. Solving By-Catch: Considerations for Today and Tomorrow 96, University of Alaska, Sea Grant College Program, Fairbanks. 285-288 p.

Pauly D, Christensen V, Dalsgaard J, Froese R and Torres FC (1998) Fishing down marine food webs. Science 279: 860-863.
Pauly D and Martosubroto P (1980) The population dynamics of *Nemipterus marginatus* (Cuv. & Val.) off Western Kalimantan, South China Sea. Journal of Fish Biology 17: 263-273.
Pauly D and Martosubroto P, editors (1996) Baseline studies in biodiversity: The fish resources of western Indonesia. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines. 390 p.
Pauly D and Wade-Pauly S (1981) An annotated bibliography of slipmouths (Pisces: Leiognathidae). 62 p.
Potier M and Petit D (1995) Fishing strategies and tactics in the Javanese seiners fisheries. *In* Potier M and Nurhakim S (eds.), Biology, dunamics, exploitation of the small pelagic fishes in the Java Sea. BIODYNEX - Pelfish, Indonesia.
Priyono BE and Sumiono B (1997) The marine fisheries of Indonesia, with emphasis on the coastal demersal stock of the Sunda shelf. pp. 38-46 *In* Silvestre G and Pauly D (eds.), Status and Management of tropical coastal fisheries in Asia. International Center for Living Aquatic Resources Management (ICLARM).
Sarjono I (1980) Trawlers banned in Indonesia. INternational Center for Living Aquatic Resources Management (ICLARM) Newsletter 3(4): 3.
Schuster WH and Djajadiredja R (1952) Local common names of Indonesian fishes. W.V. Hoeve, Bandung, Indonesia.
Sudjastani T (1982) The marine fishery resources of the Cilacap region. *In* Bird ECF, Soegiarto A and Soegiarto KA (eds.), Proceedings of the workshop on coastal resources management in the Cilacap region. The Indonesian Institution of Sciences and the United Nations University, Jakarta, Indonesia.
Varkey DA, Ainsworth CH, Pitcher TJ, Goram Y and Sumaila R (2009) Illegal, unreported, and unregulated fisheries catch in Raja Ampat Regency, Eastern Indonesia. Marine Policy 34: 228-236.
Veron JEN, Devantier LM, Turak E, Green AL, Kininmonth S, Stafford-Smith M and Peterson N (2009) Delineating the coral triangle. Galaxea, Journal of Coral Reef Studies 11(2): 91-100.
Wagey GA, Nurhakim S, Nikijuluw VPH, Badrudin and Pitcher TJ (2009) A study of illegal, unreported, and unregulated (IUU) fishing in the Arafura Sea, Indonesia. Ministry of Marine Affairs and Fisheries, Jakarta, Indonesia.
Wever L, Glaser M, Gorris P and Ferrol-Schulte D (2012) Decentralization and participation in integrated coastal management: Policy lessons from Brazil and Indonesia. Ocean & Coastal Management 66: 63–72.
Widodo J (1995) Population dynamics of ikan layang, scads (*Decapterus* spp.). *In* Potier M and Nurhakim S (eds.), Biology, dynamics, exploitation of the small pelagic fishes in the Java Sea. BIODYNEX - Pelfish, Indonesia.
Yamamoto T (1980) A standard statistical system for current fishery statistics in Indonesia. A report prepared for the Fisheries Development and Management Project, Indonesia. Food and Agriculture Organization of the United Nations (FAO), Rome. 79 p.
Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. Fishery Bulletin 105(2): 266-277.

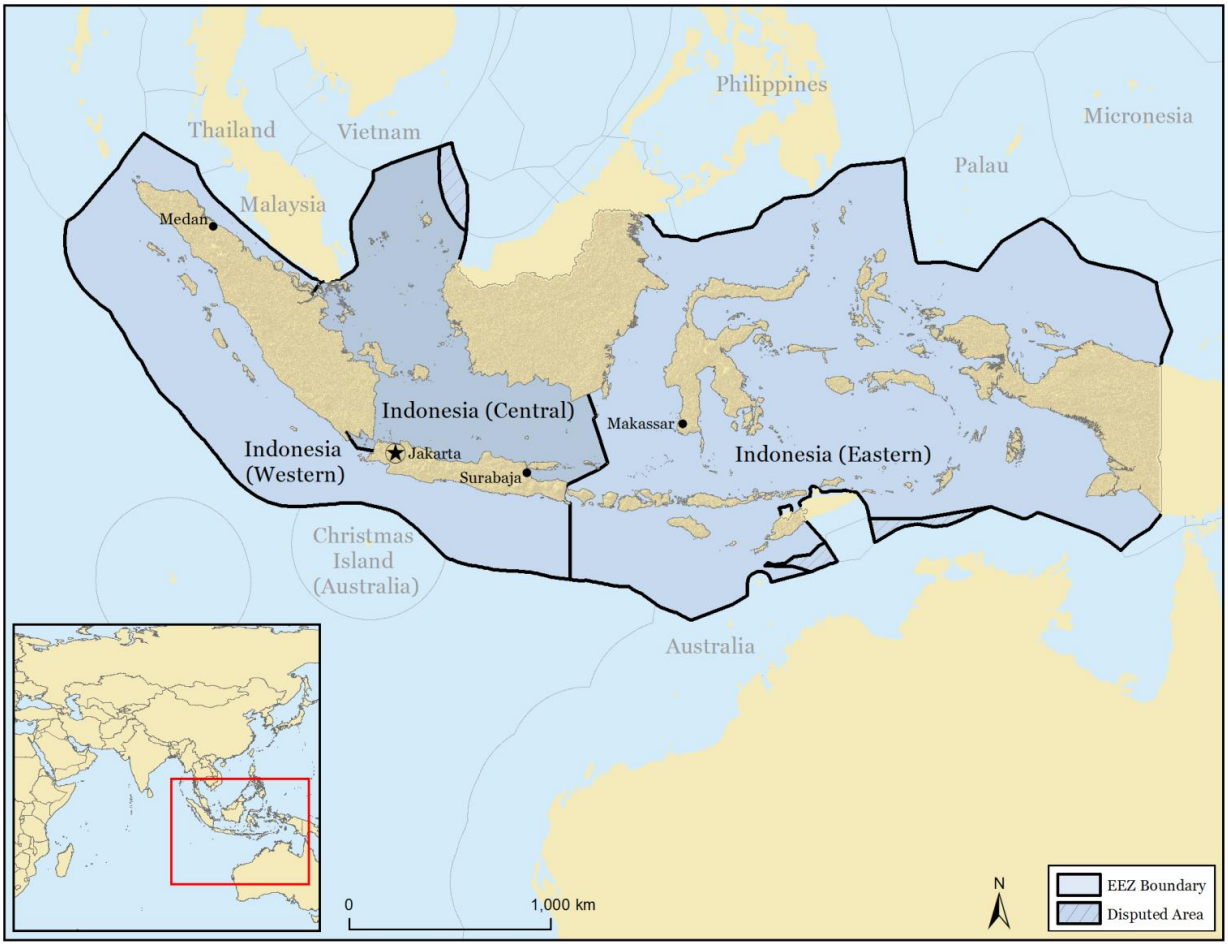

Figure 1. The EEZ of Indonesia, showing the extent of the three zones into which we have split this huge country. Note that the westernmost part, the "Western Zone", was covered in Budimartono *et al.* (in press) and that its north-western part corresponds to Indonesia's part of the Bay of Bengal (Harper *et al.* 2011; Kleisner and Pauly 2011). The Eastern Zone represents Indonesia's part of the Coral Triangle (Veron *et al.* 2009). Please note that there are a few disputed areas within the Indonesian EEZ claims; with China in the southern tip of South China Sea, and with Australia around the Timor Sea. Moreover, a part of the Timor Sea belongs to East Timor.

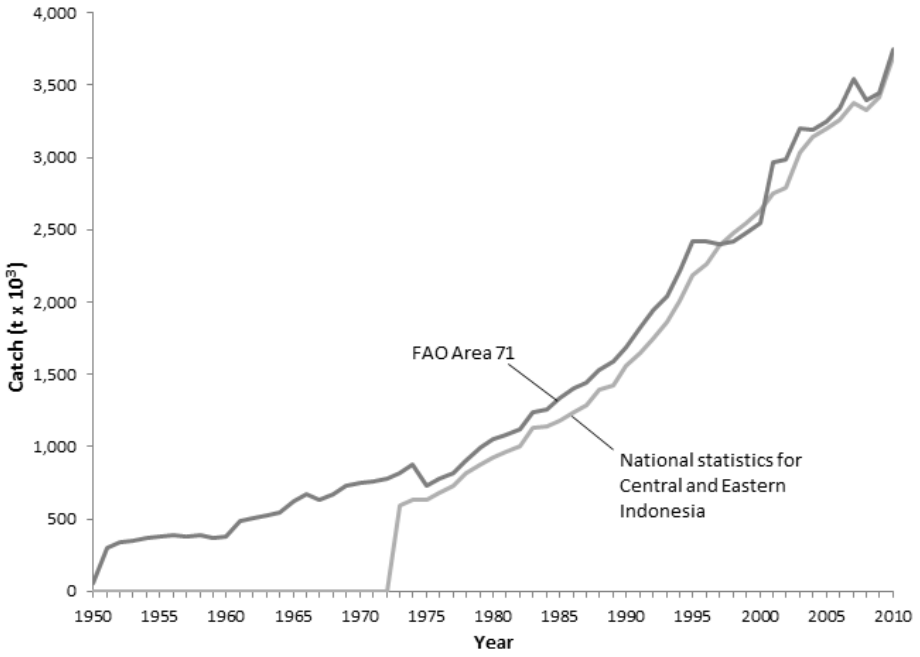

Figure 2. Nominal catch statistics available from the Ministry of Marine Affairs and Fisheries for what we define as Central and Eastern Indonesia compared with data from FAO Area 71. See text for discrepancies between these two lines.

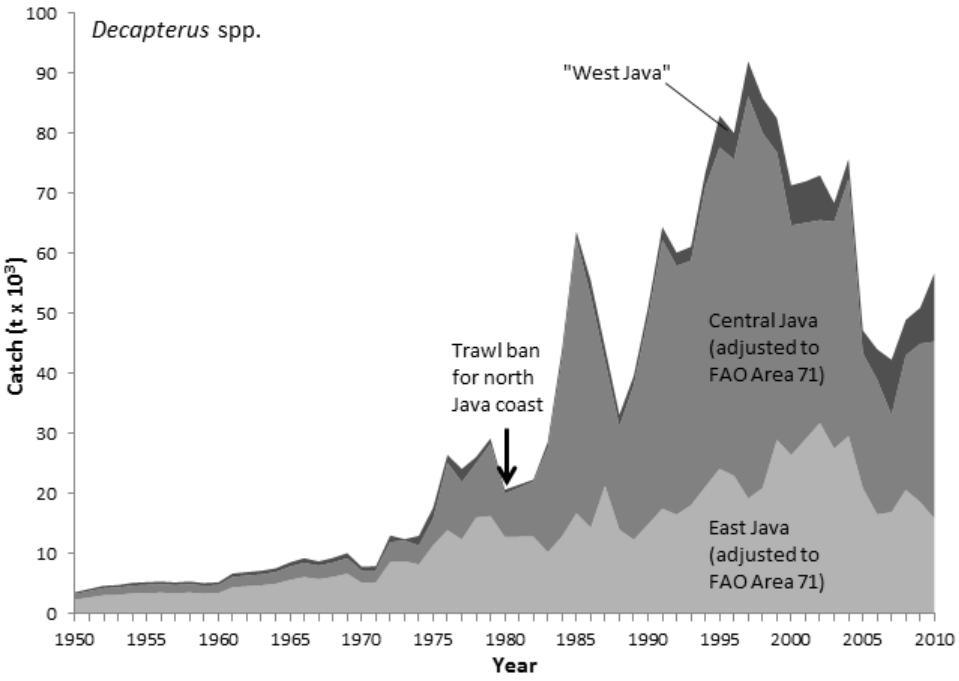

Figure 3. Nominal fisheries catch of scads (*Decapterus* spp.), 1950-2010, for "West Java" (catches from West Java [adjusted to FAO Area 71], Jakarta, and Banten), Central Java, and East Java Provinces (both adjusted to FAO Area 71), exhibiting the effect of trawl ban on the development of purse-seine fishery in northern Java (see text).

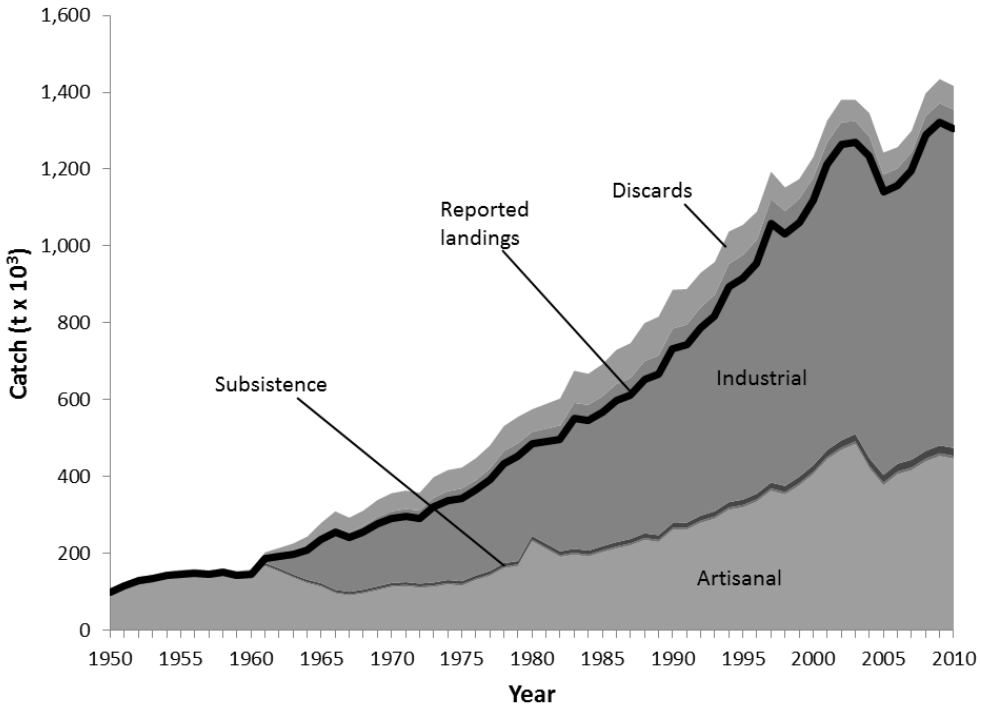

Figure 4. Reconstructed total catches for Central Indonesia (as defined in Figure 1), by sectors, 1950-2010 (See Appendix A3 for the corresponding tabular data). The catch of recreational fisheries is too small to be shown on this graph.

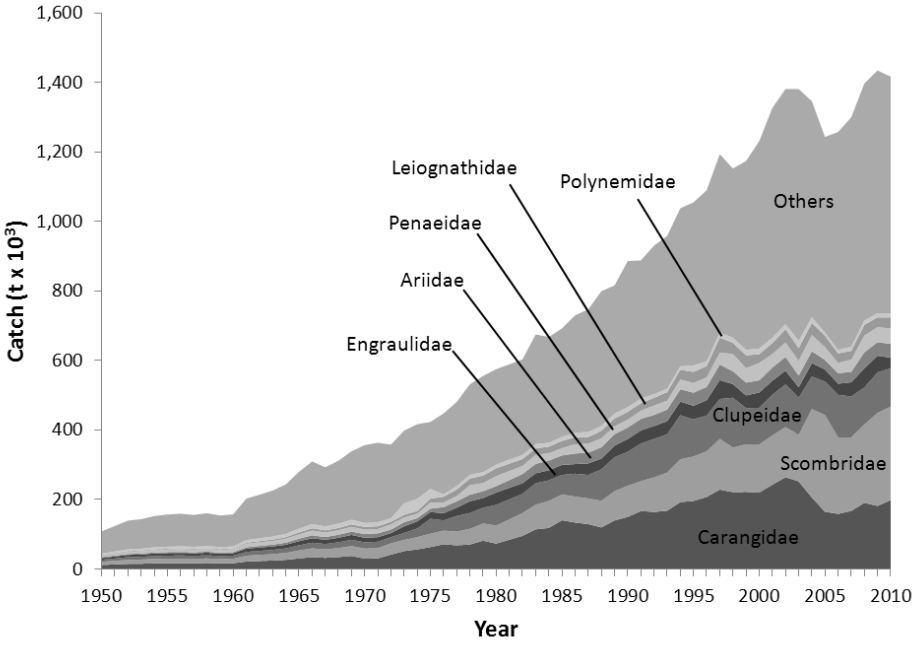

Figure 5. Reconstructed total catches for Central Indonesia (as defined in Figure 1), by major taxa, 1950-2010. All other taxa (n=26) were grouped into 'Others' (see Appendix A4 for the corresponding tabular data).

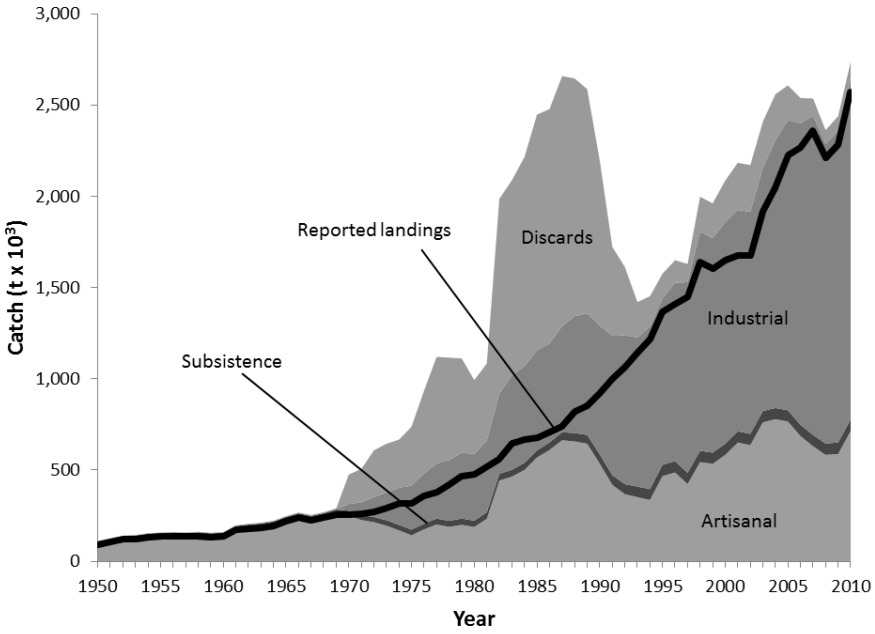

Figure 6. Reconstructed total catches for Eastern Indonesia (as defined in Figure 1), by sectors, 1950-2010 (See Appendix A5 for the corresponding tabular data). The catch of recreational fisheries is too small to be shown on this graph.

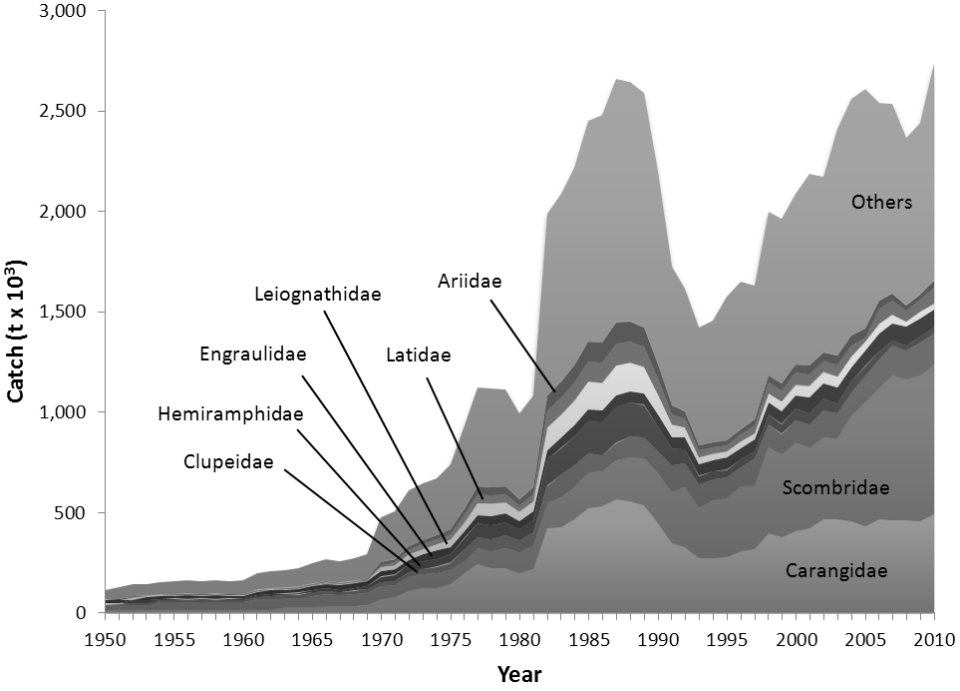

Figure 7. Reconstructed total catches for Eastern Indonesia (as defined in Figure 1), by major taxa, 1950-2010. All other taxa (n=26) were grouped into 'Others' (see Appendix A6 for the corresponding tabular data).

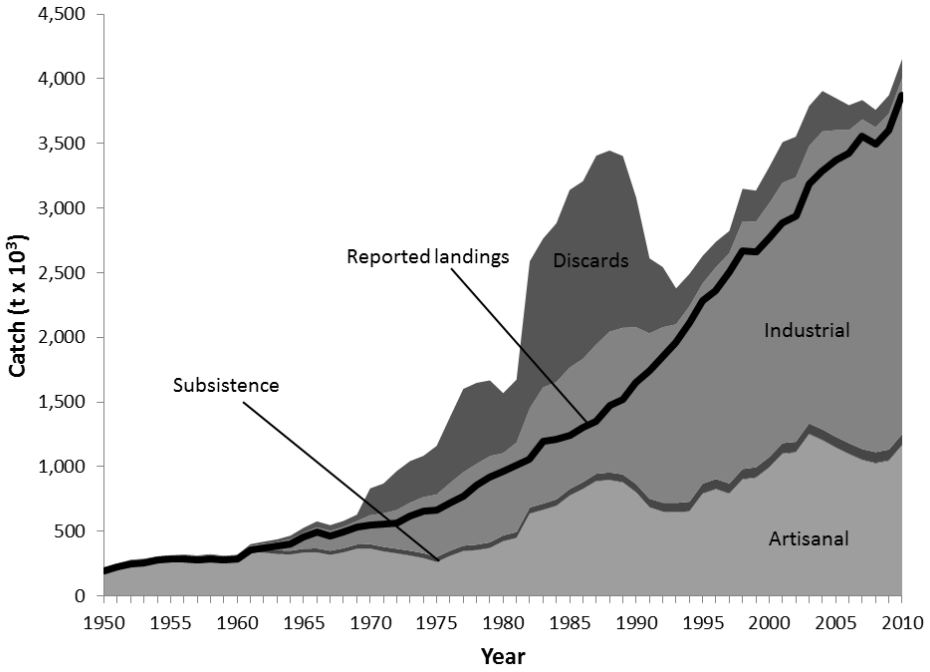

Figure 8. Reconstructed total catches for Indonesia (Central and Eastern), by sectors, 1950-2010 (See Appendix A7 for the corresponding tabular data). The catch of recreational fisheries is too small to be shown on this graph.

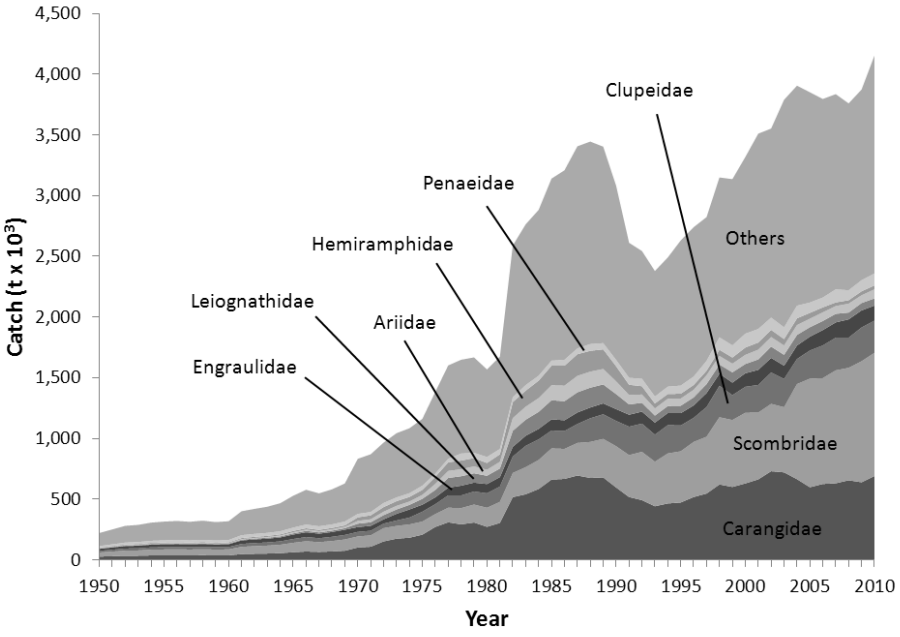

Figure 9. Reconstructed total catches for Indonesia (Central and Eastern), by major taxa, 1950-2010. All other taxa (n=32) were grouped into 'Others' (see Appendix A8 for the corresponding tabular data).

Appendix Table A1. Percentage (in 2000-2010) of the catch of taxa or other groups (in Indonesian statistics) that are caught by industrial gears (trawlers for demersal taxa, seiners or longliners for pelagic taxa), with the rest being caught being small-scale fisheries. The % values are the mean of estimates by the 3 authors, based on the characteristics of each taxon or group. Area A = Central Indonesia; Area B = Eastern Indonesia. Names and maximum lengths are from FishBase (www. fishbase.org), SeaLifeBase (www.sealifebase.org), and the Sea Around Us database (www.seaaroundus.org).

Common name Bahasa Indonesia (English)	**Scientific name**	**Maximum length**	**Area A**	**Area B**
Invertebrates				
Cephalopods				
Cumi-cumi (Common squids)	*Loligo* spp.	25	70	70
Crustaceans				
Udang putih/Jerbung (Shrimps/prawns)	*Fenneropenaeus* spp.	17	60	80
Udang dogol (Metapenaeus shrimps)	*Metapenaeus* spp.	17	60	80
Binatang berkulit keras lainnya (Miscellaneous crustaceans)	Miscellaneous crustaceans	-	40	40
Udang lainnya (Miscellaneous shrimps)	Miscellaneous shrimps	-	60	80
Udang windu (Penaeus shrimps)	*Penaeus* spp.	34	60	80
Udang rebon (Akiami paste shrimp)	*Acetes* spp.	3	0	0
Molluscs				
Kerang darah (Granular ark)	*Tegillarca granosa*	4	0	0
Binatang lunak lainnya (Miscellaneous molluscs)	Miscellaneous molluscs	-	0	0
Jellyfishes				
Ubur-ubur (Jellyfishes)	*Rhopilema* spp.	31	0	0
Sea cucumbers				
Teripang (Sea cucumber)	*Stichopus* spp.	40	80	80
Teleostei (Bony fishes)				
Manyung (Giant catfish)	*Netuma thalassina*	145	75	75
Tongkol krai (Frigate tuna)	*Auxis thazard thazard*	54	75	75
Ekor kuning/Pisang-pisang (Redbelly yellowtail fusilier)	*Caesio cuning*	54	75	75
Kuwe (Jacks)	*Caranx* spp.	102	75	75
Selar (Scads)	*Selaroides* spp.	10	75	75
Golok-golok/Parang-parang (Dorab wolf-herring)	*Chirocentrus dorab*	100	75	75
Ikan terbang (Flyingfishes)	*Cypselurus* spp.	18	60	40
Ikan laying (Scads)	*Decapterus* spp.	37	60	60
Japuh (Rainbow sardines)	*Dussumieria acuta*	20	80	80
Tongkol (Kawakawa)	*Euthynnus affinis*	93	80	80
Julung-julung (Halfbeaks)	*Hemiramphus* spp.	45	80	80
Cakalang (Skipjack tuna)	*Katsuwonus pelamis*	108	30	100
Kakap putih (Barramundi)	*Lates calcarifer*	162	90	50
Peperek (Slipmouths or ponyfishes)	Leiognathidae	12	80	80
Lencam (Emperors)	*Lethrinus* spp.	70	80	80
Kakap merah/Bambangan (Snappers)	*Lutjanus* spp.	98	80	80
Tetengkek (Torpedo scad)	*Megalaspis cordyla*	69	80	80
Ikan lainnya (Miscellaneous fishes)	Miscellaneous fishes	-	50	50
Belanak (Mullets)	Mugilidae	120	75	80
Kurisi (Ornate threadfin bream)	*Nemipterus hexodon*	21	75	80
Bawal putih (Silver pomfret)	*Pampus argenteus*	60	80	80
Bawal hitam (Black pomfret)	*Parastromateus niger*	62	80	80
Kuro/Senangin (Threadfins)	*Polynemus* spp.	20	90	80
Kembung (Short mackerel)	*Rastrelliger brachysoma*	32	95	95
Lemuru (Bali sardinella)	*Sardinella lemuru*	23	80	90
Tembang (Sardinella)	*Sardinella* spp. *(*Not *Sardinella lemuru)*	21	60	60
Gulamah/Tigawaja (Yellow drum)	*Nibea albiflora*	44	60	60
Tenggiri (Narrow-barred Spanish mackerel)	*Scomberomorus commerson*	205	80	80
Tenggiri papan (Indo-pacific king mackerel)	*Scomberomorus guttatus*	71	80	80
Kerapu karang (Chocolate hind)	*Cephalopholis boenak*	21	60	80
Ikan beronang (Goldlined spinefoot)	*Siganus guttatus*	38	60	80
Teri (Anchovies)	*Stolephorus* spp.	10	60	70
Albakora (Albacore)	*Thunnus alalunga*	136	100	95
Madidihang (Yellowfin tuna)	*Thunnus albacares*	231	95	95
Tuna mata besar (Bigeye tuna)	*Thunnus obesus*	219	95	95
Tongkol abu-abu (Longtail tuna)	*Thunnus tonggol*	126	95	95
Layur (Hairtails)	*Trichiurus* spp.	150	80	80
Elasmobranchii (Sharks and rays)				
Pari kembang/Pari macan (Stingrays)	*Dasyatis* spp.	150	75	80
Cucut lanyam (Sharks)	*Carcharhinus* spp.	241	80	70

Appendix Table 2. Organisms usually discarded, irrespective of their size and age, and included in the 'miscellaneous fishes group'. Names are from FishBase (www.fishbase.org).

Family name	Common name (English)
Anacanthidae	Leatherjackets
Antennaridae	Frogfishes
Apogonidae	Cardinalfishes
Balistidae	Triggerfishes (except for *Abalistes stellaris)*
Blenniidae	Combtooth blennies
Callionymidae	Dragonets
Centriscidae	Snipefishes and shrimpfishes
Chaetodontidae	Butterflyfishes
Dactylopteridae	Flying gurnards
Diodontidae	Porcupinefishes (burrfishes)
Echeneidae	Remoras
Fistulariidae	Cornetfishes
Gobiidae	Gobies
Labridae	Wrasses (except for *Napoleon wrasse*)
Monocanthidae	Filefishes
Ostraciidae	Boxfishes
Parapercidae	Grub fish
Platycephalidae	Flatheads
Pomacanthidae	Angelfishes
Pomacentridae	Damselfishes
Scaridae	Parrotfishes (<25 g)
Scorpaeonidae	Scorpionfishes
Syngnathidae	Pipefishes
Tetraodontidae	Puffers
Triacanthidae	Triplespines
Triglidae	Searobins
Uranoscopidae	Stargazers

Appendix Table A3. FAO landings vs reconstructed total catch (in tonnes), and catch by sector with discards shown separately for Central Indonesia, 1950-2010.

Year	FAO landings	Reconstructed total catch	Artisanal	Recreational	Subsistence	Industrial	Discards
1950	99,600	108,000	99,600	2,370	4,280	0	2,220
1951	115,000	124,000	115,000	2,410	4,360	0	2,550
1952	130,000	139,000	130,000	2,450	4,430	0	2,890
1953	133,000	143,000	133,000	2,500	4,520	0	2,970
1954	142,000	152,000	142,000	2,580	4,660	0	3,160
1955	146,000	157,000	146,000	2,600	4,700	0	3,260
1956	148,000	159,000	148,000	2,660	4,800	0	3,310
1957	145,000	156,000	145,000	2,710	4,910	0	3,230
1958	149,000	161,000	149,000	2,780	5,020	0	3,330
1959	143,000	154,000	143,000	2,840	5,140	0	3,180
1960	146,000	157,000	146,000	2,780	5,260	0	3,250
1961	186,000	203,000	167,000	2,850	5,390	19,400	8,350
1962	192,000	214,000	152,000	2,920	5,530	40,300	13,000
1963	198,000	226,000	136,000	3,000	5,670	62,700	17,900
1964	210,000	243,000	122,000	3,070	5,810	88,600	23,700
1965	236,000	279,000	113,000	3,150	5,970	125,000	32,100
1966	255,000	309,000	95,600	3,230	6,120	164,000	40,600
1967	241,000	293,000	90,000	3,320	6,280	155,000	38,300
1968	256,000	311,000	95,500	3,400	6,440	165,000	40,700
1969	278,000	339,000	104,000	3,490	6,610	180,000	44,300
1970	291,000	356,000	112,000	3,580	6,780	187,000	46,700
1971	296,000	363,000	114,000	3,670	6,960	191,000	47,500
1972	292,000	358,000	110,000	3,770	7,130	191,000	46,200
1973	322,000	398,000	113,000	3,860	7,310	221,000	53,500
1974	337,000	417,000	119,000	3,960	7,490	231,000	55,100
1975	344,000	423,000	116,000	4,060	7,680	241,000	54,400
1976	364,000	448,000	130,000	4,160	7,860	249,000	56,800
1977	392,000	481,000	141,000	4,260	8,170	267,000	60,000
1978	435,000	531,000	161,000	4,360	8,480	292,000	65,300
1979	452,000	555,000	167,000	4,460	8,790	306,000	68,900
1980	486,000	575,000	231,000	4,570	9,100	271,000	58,800
1981	491,000	589,000	211,000	4,670	9,420	300,000	64,600
1982	497,000	603,000	191,000	4,780	9,730	327,000	70,400
1983	551,000	675,000	197,000	4,890	10,000	380,000	83,200
1984	546,000	668,000	192,000	5,000	10,300	379,000	81,300
1985	567,000	692,000	203,000	5,100	10,700	390,000	83,600
1986	597,000	730,000	213,000	5,210	11,000	412,000	89,200
1987	611,000	747,000	221,000	5,310	11,300	418,000	91,200
1988	652,000	799,000	235,000	5,410	11,600	448,000	98,900
1989	666,000	816,000	230,000	5,510	12,000	468,000	101,000
1990	733,000	886,000	261,000	5,610	12,300	506,000	101,000
1991	743,000	888,000	262,000	5,710	12,600	515,000	93,000
1992	786,000	930,000	279,000	5,810	13,000	542,000	89,900
1993	818,000	959,000	290,000	5,900	13,300	564,000	85,100
1994	895,000	1,040,000	313,000	6,000	13,600	620,000	84,500
1995	915,000	1,060,000	320,000	6,100	14,000	637,000	78,400
1996	955,000	1,090,000	335,000	6,190	14,600	661,000	72,800
1997	1,060,000	1,190,000	363,000	6,280	15,200	738,000	71,800
1998	1,030,000	1,150,000	353,000	6,370	15,800	716,000	61,100
1999	1,060,000	1,170,000	376,000	6,470	16,400	723,000	51,500
2000	1,120,000	1,230,000	406,000	6,560	17,000	749,000	53,400
2001	1,210,000	1,330,000	445,000	6,660	17,600	801,000	56,400
2002	1,260,000	1,380,000	469,000	6,750	18,200	828,000	58,800
2003	1,270,000	1,380,000	485,000	6,850	18,900	814,000	56,200
2004	1,240,000	1,350,000	421,000	6,950	19,500	838,000	61,200
2005	1,140,000	1,240,000	377,000	7,050	20,100	781,000	57,500
2006	1,160,000	1,260,000	406,000	7,150	20,100	769,000	55,000
2007	1,200,000	1,300,000	416,000	7,250	20,100	801,000	55,800
2008	1,290,000	1,400,000	439,000	7,360	20,100	871,000	59,400
2009	1,320,000	1,430,000	453,000	7,460	20,100	891,000	62,400
2010	1,310,000	1,420,000	446,000	7,560	20,100	881,000	61,400

Appendix Table A4. Reconstructed total catch (in tonnes) by major taxa for Central Indonesia, 1950-2010. 'Others' contain 26 additional taxa.

Year	Carangidae	Scombridae	Clupeidae	Engraulidae	Ariidae	Penaeidae	Leiognathidae	Polynemidae	Others
1950	11,600	9,210	5,980	5,100	2,000	5,380	1,360	4,000	63,800
1951	13,200	10,500	6,840	5,820	2,260	6,110	1,520	4,610	73,100
1952	14,700	11,700	7,700	6,530	2,520	6,850	1,690	5,210	82,400
1953	15,100	12,100	7,880	6,730	2,630	7,160	1,720	5,330	84,700
1954	16,200	12,900	8,440	7,150	2,730	7,570	1,860	5,700	89,700
1955	16,600	13,200	8,650	7,340	2,840	7,880	1,920	5,820	92,500
1956	16,900	13,500	8,760	7,480	2,890	8,240	1,960	5,940	93,500
1957	16,400	13,100	8,560	7,270	2,790	8,210	1,890	5,770	91,600
1958	17,000	13,600	8,870	7,520	2,950	8,070	1,960	5,950	94,700
1959	16,200	13,000	8,460	7,170	2,740	8,310	1,860	5,720	90,500
1960	16,600	13,200	8,610	7,340	2,850	8,440	1,930	5,840	92,500
1961	21,600	16,800	11,000	9,260	4,010	12,400	2,800	7,610	119,200
1962	22,900	17,800	11,600	9,580	4,580	12,400	3,270	8,130	125,000
1963	24,300	18,600	12,100	9,880	5,230	12,400	3,800	8,680	132,000
1964	26,400	20,100	12,900	10,400	6,010	12,400	4,430	9,460	142,000
1965	30,500	23,000	14,800	11,800	7,290	12,400	5,460	11,000	163,000
1966	34,000	25,600	16,300	12,700	8,540	13,600	6,450	12,300	180,000
1967	32,200	24,400	15,500	12,100	8,080	13,000	6,070	11,600	170,000
1968	34,300	26,100	16,500	12,900	8,560	13,100	6,490	12,400	181,000
1969	37,500	28,600	18,100	14,000	9,300	13,900	7,040	13,500	197,000
1970	30,000	29,000	17,900	13,000	10,800	12,700	7,810	11,300	224,000
1971	30,600	29,800	18,300	13,100	10,900	12,400	7,950	11,400	229,000
1972	41,400	32,500	17,900	11,500	10,200	15,300	7,280	10,200	212,000
1973	51,600	32,100	20,300	18,800	11,800	13,500	7,880	33,500	209,000
1974	56,600	35,300	24,900	20,400	9,110	13,100	7,850	35,000	214,000
1975	63,100	38,400	43,000	19,400	9,620	17,400	11,500	28,000	193,000
1976	71,100	39,300	29,600	20,600	17,600	13,300	16,500	7,170	232,000
1977	68,100	39,600	44,800	23,900	18,500	15,200	18,800	10,000	242,000
1978	70,400	45,200	45,400	33,700	19,100	27,400	19,000	10,800	260,000
1979	81,500	49,500	45,300	28,200	19,200	23,600	21,600	9,900	277,000
1980	73,200	52,100	59,400	35,400	18,600	29,000	22,200	10,800	274,000
1981	84,300	58,700	57,500	33,000	22,400	26,100	21,200	11,600	274,000
1982	95,600	65,300	55,500	30,700	26,200	23,100	20,100	12,300	274,000
1983	114,000	70,900	62,100	28,300	27,100	26,000	18,300	12,400	316,000
1984	118,000	78,000	59,000	28,900	28,100	20,900	19,200	11,200	304,000
1985	140,000	74,100	56,300	28,900	27,100	21,300	20,300	12,000	312,000
1986	134,000	74,600	65,800	27,700	30,300	26,500	20,500	12,800	338,000
1987	129,000	74,100	67,400	33,300	31,000	25,700	18,800	14,900	353,000
1988	120,000	76,600	90,300	31,000	32,300	26,300	21,500	13,800	388,000
1989	140,000	84,600	97,700	33,100	33,000	23,000	22,200	14,000	369,000
1990	150,000	89,900	97,400	36,900	32,900	22,400	22,700	13,600	420,000
1991	167,000	85,800	108,000	37,900	33,200	23,700	21,500	13,100	398,000
1992	164,000	99,300	111,000	36,900	31,900	27,200	21,900	10,700	427,000
1993	168,000	110,000	110,000	38,200	33,000	25,500	24,900	10,200	439,000
1994	193,000	123,000	127,000	39,200	35,600	28,000	28,200	10,200	454,000
1995	196,000	128,000	107,000	39,100	37,600	28,200	31,600	18,400	470,000
1996	207,000	131,000	103,000	44,200	38,300	27,600	32,200	14,100	492,000
1997	229,000	146,000	115,000	54,400	44,800	34,200	43,000	14,800	513,000
1998	221,000	128,000	143,000	39,300	37,000	49,800	32,100	14,700	487,000
1999	222,000	137,000	104,000	36,400	36,900	41,700	37,100	15,300	543,000
2000	220,000	139,000	106,000	43,700	34,900	50,300	24,800	16,500	597,000
2001	243,000	142,000	117,000	40,600	38,100	38,700	31,400	15,800	661,000
2002	264,000	144,000	123,000	39,600	39,500	41,400	38,200	14,800	676,000
2003	252,000	134,000	107,000	29,800	33,800	43,000	36,100	21,000	724,000
2004	206,000	254,000	93,800	38,400	34,300	46,800	34,700	16,500	621,000
2005	165,000	278,000	96,100	35,100	27,300	36,900	33,000	8,490	563,000
2006	159,000	220,000	122,000	32,100	30,200	29,500	27,600	10,200	627,000
2007	167,000	212,000	118,000	40,900	30,000	35,500	24,900	11,900	660,000
2008	191,000	225,000	106,000	55,200	46,200	48,500	30,600	12,200	682,000
2009	181,000	268,000	117,000	47,800	38,900	43,400	28,100	11,900	698,000
2010	198,000	269,000	110,000	30,600	39,800	44,500	31,200	11,700	681,000

Appendix Table A5. FAO landings vs reconstructed total catch (in tonnes), and catch by sector with discards shown separately for Eastern Indonesia, 1950-2010.

Year	FAO landings	Reconstructed total catch	Artisanal	Recreational	Subsistence	Industrial	Discards
1950	92,700	112,000	93,000	148	17,200	0	2,060
1951	106,000	126,000	106,000	151	17,500	0	2,370
1952	120,000	140,000	120,000	153	17,800	0	2,670
1953	123,000	144,000	123,000	156	18,200	0	2,750
1954	132,000	154,000	132,000	161	18,700	0	2,940
1955	136,000	158,000	136,000	162	18,900	0	3,020
1956	138,000	161,000	138,000	166	19,300	0	3,080
1957	134,000	157,000	134,000	170	19,700	0	3,000
1958	139,000	162,000	139,000	174	20,200	0	3,090
1959	133,000	157,000	133,000	178	20,700	0	2,960
1960	136,000	160,000	136,000	174	21,200	0	3,030
1961	172,000	197,000	172,000	178	21,700	0	3,820
1962	179,000	205,000	179,000	183	22,200	0	3,990
1963	184,000	211,000	184,000	187	22,800	0	4,110
1964	194,000	222,000	194,000	192	23,400	0	4,330
1965	219,000	248,000	219,000	197	24,000	0	4,870
1966	237,000	267,000	237,000	202	24,600	0	5,290
1967	224,000	254,000	224,000	207	25,200	0	4,990
1968	237,000	269,000	237,000	213	25,900	0	5,290
1969	257,000	290,000	257,000	218	26,600	0	5,730
1970	255,000	475,000	250,000	224	27,300	37,200	161,000
1971	258,000	506,000	226,000	230	28,000	68,800	183,000
1972	272,000	608,000	214,000	235	28,700	109,000	255,000
1973	292,000	644,000	195,000	241	29,400	151,000	268,000
1974	319,000	667,000	170,000	247	30,100	203,000	264,000
1975	318,000	737,000	142,000	254	30,900	242,000	322,000
1976	357,000	935,000	175,000	260	31,600	275,000	453,000
1977	379,000	1,120,000	201,000	266	32,500	302,000	584,000
1978	422,000	1,120,000	188,000	273	33,400	333,000	562,000
1979	466,000	1,110,000	200,000	279	34,300	361,000	516,000
1980	477,000	993,000	187,000	286	35,200	365,000	405,000
1981	517,000	1,080,000	233,000	292	36,100	392,000	422,000
1982	557,000	1,990,000	442,000	299	37,000	439,000	1,070,000
1983	647,000	2,090,000	464,000	306	37,900	519,000	1,070,000
1984	670,000	2,210,000	501,000	312	38,800	529,000	1,150,000
1985	680,000	2,450,000	568,000	319	39,700	549,000	1,290,000
1986	710,000	2,480,000	610,000	325	41,900	541,000	1,290,000
1987	740,000	2,660,000	663,000	332	44,100	582,000	1,370,000
1988	820,000	2,650,000	656,000	338	46,400	640,000	1,300,000
1989	850,000	2,590,000	644,000	344	48,600	666,000	1,230,000
1990	920,000	2,190,000	535,000	351	50,800	706,000	903,000
1991	1,000,000	1,720,000	419,000	357	53,100	763,000	488,000
1992	1,060,000	1,610,000	367,000	363	55,300	815,000	375,000
1993	1,140,000	1,420,000	352,000	369	57,500	818,000	193,000
1994	1,220,000	1,450,000	336,000	375	59,700	891,000	166,000
1995	1,370,000	1,580,000	467,000	381	62,000	912,000	135,000
1996	1,410,000	1,650,000	486,000	387	61,900	978,000	124,000
1997	1,450,000	1,630,000	423,000	393	61,900	1,040,000	100,000
1998	1,640,000	2,000,000	544,000	398	61,800	1,200,000	191,000
1999	1,600,000	1,960,000	534,000	404	61,800	1,180,000	190,000
2000	1,650,000	2,090,000	583,000	410	61,700	1,210,000	228,000
2001	1,670,000	2,180,000	650,000	416	61,700	1,210,000	258,000
2002	1,670,000	2,170,000	636,000	422	61,600	1,220,000	256,000
2003	1,920,000	2,410,000	761,000	428	61,600	1,330,000	253,000
2004	2,050,000	2,560,000	778,000	434	61,500	1,470,000	252,000
2005	2,230,000	2,610,000	765,000	441	61,500	1,590,000	191,000
2006	2,270,000	2,540,000	686,000	447	61,800	1,650,000	139,000
2007	2,360,000	2,540,000	630,000	453	62,100	1,750,000	93,700
2008	2,210,000	2,360,000	583,000	460	62,400	1,640,000	75,300
2009	2,280,000	2,440,000	588,000	466	62,800	1,710,000	79,500
2010	2,570,000	2,740,000	715,000	472	63,100	1,870,000	88,400

Appendix Table A6. Reconstructed total catch (in tonnes) by major taxa for Eastern Indonesia, 1950-2010. 'Others' contain 26 additional taxa.

Year	Carangidae	Scombridae	Clupeidae	Hemiramphidae	Engraulidae	Leiognathidae	Latidae	Ariidae	Others
1950	14,500	25,000	7,540	4,140	11,100	2,140	1,610	733	45,300
1951	16,200	27,900	8,520	4,780	12,500	2,360	1,780	818	51,200
1952	17,900	30,900	9,500	5,410	13,900	2,590	1,960	904	57,200
1953	18,400	31,600	9,710	5,610	14,300	2,640	2,040	940	59,000
1954	19,600	34,500	10,400	5,980	15,200	2,830	2,150	975	62,200
1955	20,000	35,100	10,600	6,070	15,600	2,930	2,220	1,010	64,100
1956	20,300	36,100	10,700	6,170	15,900	2,980	2,260	1,030	65,200
1957	19,900	35,100	10,500	6,000	15,500	2,890	2,240	998	64,200
1958	20,500	36,000	10,900	6,300	16,000	2,990	2,270	1,050	65,900
1959	19,800	35,000	10,500	6,050	15,400	2,860	2,170	987	64,000
1960	20,200	35,500	10,700	6,150	15,700	2,970	2,250	1,030	65,600
1961	25,200	42,800	13,300	7,570	19,500	3,660	2,790	1,260	81,200
1962	26,100	45,700	13,800	7,850	20,200	3,750	2,900	1,300	83,900
1963	26,800	47,000	14,200	8,140	20,800	3,900	2,980	1,360	86,200
1964	28,300	49,200	14,900	8,510	22,000	4,090	3,130	1,430	90,900
1965	31,600	54,700	16,700	9,490	24,500	4,550	3,480	1,580	101,000
1966	34,000	59,500	18,000	10,200	26,400	4,930	3,740	1,720	109,000
1967	32,400	56,400	17,000	9,720	25,100	4,670	3,570	1,640	104,000
1968	34,300	59,800	18,100	10,400	26,600	5,000	3,790	1,730	109,000
1969	37,200	64,000	19,600	11,200	28,800	5,370	4,120	1,870	118,000
1970	70,900	62,500	19,500	28,300	26,900	19,800	13,600	12,200	222,000
1971	77,200	63,500	19,900	30,600	27,200	21,800	15,100	13,700	237,000
1972	110,000	76,800	19,300	36,400	23,800	27,400	20,400	18,100	275,000
1973	122,000	73,100	24,900	37,000	35,900	27,900	23,100	18,000	282,000
1974	125,000	74,400	31,400	36,600	46,400	30,100	23,500	18,300	281,000
1975	144,000	69,700	38,200	40,100	38,700	36,400	26,200	23,200	321,000
1976	199,000	67,300	51,400	56,900	35,600	44,700	36,200	32,000	412,000
1977	241,000	80,800	57,000	69,500	38,900	61,400	43,800	39,700	488,000
1978	222,000	88,000	58,800	70,400	47,300	58,600	42,000	38,800	491,000
1979	225,000	98,900	62,000	67,500	44,700	56,000	39,100	37,400	481,000
1980	198,000	105,000	60,000	55,000	40,800	46,100	32,600	30,400	425,000
1981	219,000	115,000	69,000	59,600	44,600	49,800	35,600	33,000	459,000
1982	420,000	134,000	80,000	130,000	49,400	112,000	82,900	78,200	899,000
1983	426,000	153,000	114,000	131,000	54,100	115,000	84,100	80,100	933,000
1984	465,000	161,000	110,000	142,000	58,200	121,000	89,700	85,600	982,000
1985	520,000	183,000	91,500	160,000	63,000	137,000	100,000	96,600	1,097,000
1986	532,000	173,000	81,200	163,000	61,300	137,000	102,000	97,400	1,132,000
1987	565,000	194,000	89,000	177,000	61,500	147,000	110,000	104,000	1,210,000
1988	555,000	220,000	104,000	170,000	58,000	142,000	105,000	99,700	1,192,000
1989	539,000	233,000	105,000	160,000	56,900	134,000	102,000	94,600	1,164,000
1990	446,000	250,000	111,000	123,000	60,600	101,000	77,000	71,900	955,000
1991	350,000	259,000	126,000	83,100	60,500	63,200	47,700	44,200	689,000
1992	327,000	298,000	122,000	66,200	61,600	51,200	42,400	36,300	608,000
1993	273,000	257,000	113,000	39,800	60,700	32,900	31,900	26,000	586,000
1994	271,000	289,000	107,000	37,000	60,000	29,400	31,300	24,300	603,000
1995	276,000	294,000	105,000	37,600	62,500	30,000	32,200	21,400	716,000
1996	309,000	323,000	95,300	37,100	58,200	33,800	35,000	24,100	734,000
1997	317,000	323,000	130,000	34,600	60,800	31,300	40,200	27,900	665,000
1998	399,000	426,000	116,000	48,900	60,300	43,800	56,200	32,800	815,000
1999	378,000	414,000	101,000	48,400	66,700	47,700	53,800	34,300	817,000
2000	409,000	443,000	108,000	56,500	67,900	51,700	60,800	40,200	849,000
2001	420,000	409,000	111,000	54,400	83,400	55,200	57,500	41,900	952,000
2002	466,000	411,000	136,000	55,500	80,400	54,400	58,900	39,800	870,000
2003	468,000	403,000	127,000	48,300	79,100	53,700	62,600	42,900	1,130,000
2004	458,000	530,000	113,000	52,700	72,700	52,600	56,600	47,200	1,180,000
2005	433,000	616,000	136,000	45,400	79,100	44,700	20,300	42,700	1,190,000
2006	466,000	652,000	147,000	37,500	94,300	47,500	71,900	41,200	982,000
2007	463,000	719,000	152,000	25,400	85,300	45,200	68,300	34,200	944,000
2008	464,000	701,000	142,000	24,000	95,600	25,500	53,700	26,900	830,000
2009	457,000	729,000	162,000	29,100	92,900	32,600	61,400	25,000	850,000
2010	492,000	746,000	155,000	29,200	93,400	27,600	78,200	35,100	1,080,000

Appendix Table A7. FAO landings vs reconstructed total catch (in tonnes), and catch by sector with discards shown separately for Indonesia, 1950-2010.

Year	FAO landings	Reconstructed total catch	Artisanal	Recreational	Subsistence	Industrial	Discards
1950	192,000	221,000	192,000	2,520	21,500	0	4,280
1951	221,000	250,000	221,000	2,560	21,900	0	4,920
1952	249,000	280,000	249,000	2,600	22,200	0	5,550
1953	257,000	288,000	257,000	2,650	22,700	0	5,720
1954	274,000	306,000	274,000	2,740	23,400	0	6,100
1955	282,000	314,000	282,000	2,760	23,600	0	6,280
1956	286,000	320,000	286,000	2,820	24,100	0	6,380
1957	279,000	313,000	279,000	2,880	24,600	0	6,220
1958	288,000	323,000	288,000	2,950	25,200	0	6,420
1959	276,000	311,000	276,000	3,020	25,800	0	6,140
1960	282,000	317,000	282,000	2,960	26,400	0	6,280
1961	358,000	400,000	338,000	3,030	27,100	19,400	12,200
1962	371,000	419,000	331,000	3,110	27,700	40,300	17,000
1963	383,000	437,000	321,000	3,180	28,500	62,700	22,000
1964	404,000	466,000	317,000	3,260	29,200	88,600	28,000
1965	454,000	527,000	331,000	3,350	29,900	125,000	37,000
1966	493,000	577,000	333,000	3,430	30,700	164,000	45,900
1967	464,000	547,000	314,000	3,520	31,500	155,000	43,300
1968	493,000	580,000	333,000	3,620	32,300	165,000	46,000
1969	535,000	628,000	361,000	3,710	33,200	180,000	50,100
1970	546,000	832,000	362,000	3,810	34,000	224,000	208,000
1971	554,000	869,000	340,000	3,900	34,900	260,000	230,000
1972	563,000	966,000	325,000	4,000	35,800	300,000	301,000
1973	613,000	1,040,000	308,000	4,100	36,700	372,000	322,000
1974	656,000	1,080,000	288,000	4,210	37,600	434,000	319,000
1975	662,000	1,160,000	258,000	4,310	38,500	483,000	377,000
1976	721,000	1,380,000	305,000	4,420	39,500	524,000	510,000
1977	771,000	1,600,000	343,000	4,520	40,700	569,000	644,000
1978	857,000	1,650,000	350,000	4,630	41,900	625,000	627,000
1979	920,000	1,670,000	366,000	4,740	43,100	668,000	585,000
1980	960,000	1,570,000	419,000	4,850	44,300	637,000	463,000
1981	1,010,000	1,670,000	444,000	4,970	45,500	692,000	487,000
1982	1,050,000	2,590,000	632,000	5,080	46,700	767,000	1,140,000
1983	1,200,000	2,760,000	661,000	5,190	47,900	899,000	1,150,000
1984	1,210,000	2,880,000	692,000	5,310	49,100	908,000	1,230,000
1985	1,240,000	3,140,000	771,000	5,420	50,300	939,000	1,370,000
1986	1,300,000	3,210,000	823,000	5,530	52,900	953,000	1,370,000
1987	1,350,000	3,410,000	884,000	5,640	55,500	1,000,000	1,460,000
1988	1,470,000	3,450,000	891,000	5,750	58,000	1,090,000	1,400,000
1989	1,520,000	3,400,000	874,000	5,850	60,600	1,130,000	1,330,000
1990	1,650,000	3,080,000	795,000	5,960	63,100	1,210,000	1,000,000
1991	1,740,000	2,610,000	680,000	6,060	65,700	1,280,000	581,000
1992	1,850,000	2,540,000	647,000	6,170	68,200	1,360,000	465,000
1993	1,960,000	2,380,000	642,000	6,270	70,800	1,380,000	278,000
1994	2,110,000	2,490,000	649,000	6,380	73,400	1,510,000	250,000
1995	2,280,000	2,630,000	786,000	6,480	75,900	1,550,000	213,000
1996	2,360,000	2,740,000	821,000	6,580	76,500	1,640,000	196,000
1997	2,510,000	2,820,000	786,000	6,670	77,000	1,780,000	172,000
1998	2,670,000	3,150,000	897,000	6,770	77,600	1,920,000	252,000
1999	2,660,000	3,140,000	910,000	6,870	78,200	1,900,000	242,000
2000	2,770,000	3,320,000	988,000	6,970	78,700	1,960,000	281,000
2001	2,880,000	3,510,000	1,100,000	7,070	79,300	2,010,000	314,000
2002	2,940,000	3,550,000	1,100,000	7,170	79,900	2,050,000	315,000
2003	3,190,000	3,790,000	1,250,000	7,280	80,400	2,150,000	309,000
2004	3,280,000	3,910,000	1,200,000	7,380	81,000	2,310,000	313,000
2005	3,370,000	3,850,000	1,140,000	7,490	81,500	2,370,000	248,000
2006	3,420,000	3,800,000	1,090,000	7,600	81,900	2,420,000	194,000
2007	3,560,000	3,840,000	1,050,000	7,710	82,200	2,550,000	150,000
2008	3,500,000	3,760,000	1,020,000	7,810	82,600	2,510,000	135,000
2009	3,600,000	3,870,000	1,040,000	7,920	82,900	2,600,000	142,000
2010	3,870,000	4,150,000	1,160,000	8,030	83,300	2,750,000	150,000

Appendix Table A6. Reconstructed total catch (in tonnes) by major taxa for Indonesia, 1950-2010. 'Others' contain 32 additional taxa.

Year	Carangidae	Scombridae	Clupeidae	Engraulidae	Leiognathidae	Ariidae	Hemiramphidae	Penaeidae	Others
1950	26,100	34,200	13,500	16,200	3,500	2,730	4,430	12,500	107,000
1951	29,400	38,400	15,400	18,400	3,890	3,080	5,120	14,100	122,000
1952	32,600	42,600	17,200	20,500	4,280	3,420	5,810	15,700	137,000
1953	33,500	43,700	17,600	21,100	4,360	3,570	6,010	16,500	141,000
1954	35,800	47,400	18,800	22,300	4,690	3,710	6,420	17,300	150,000
1955	36,600	48,400	19,200	22,900	4,850	3,850	6,510	18,000	154,000
1956	37,200	49,500	19,500	23,300	4,930	3,920	6,620	18,800	156,000
1957	36,300	48,200	19,100	22,700	4,790	3,790	6,440	18,800	153,000
1958	37,500	49,600	19,800	23,500	4,950	4,000	6,760	18,500	158,000
1959	36,000	47,900	18,900	22,500	4,730	3,730	6,490	19,100	151,000
1960	36,800	48,800	19,300	23,100	4,900	3,870	6,600	19,400	155,000
1961	46,700	59,600	24,300	28,800	6,450	5,270	8,160	23,400	197,000
1962	49,000	63,400	25,400	29,800	7,020	5,880	8,500	24,300	206,000
1963	51,200	65,700	26,300	30,700	7,700	6,590	8,860	24,600	216,000
1964	54,600	69,300	27,900	32,400	8,520	7,440	9,300	25,900	231,000
1965	62,100	77,700	31,500	36,300	10,000	8,870	10,430	28,100	262,000
1966	68,000	85,100	34,300	39,100	11,400	10,300	11,275	30,900	286,000
1967	64,500	80,800	32,500	37,200	10,700	9,720	10,718	29,700	271,000
1968	68,600	85,900	34,600	39,500	11,500	10,300	11,432	29,900	288,000
1969	74,600	92,600	37,700	42,900	12,400	11,200	12,337	31,600	313,000
1970	101,000	91,500	37,400	39,900	27,600	23,000	29,632	28,600	453,000
1971	108,000	93,300	38,200	40,400	29,800	24,600	32,009	27,800	475,000
1972	151,000	109,000	37,200	35,300	34,700	28,300	37,645	33,900	498,000
1973	174,000	105,000	45,200	54,700	35,800	29,800	38,401	31,000	529,000
1974	182,000	110,000	56,300	66,800	37,900	27,400	37,642	31,100	535,000
1975	207,000	108,000	81,200	58,100	47,900	32,800	41,343	34,300	550,000
1976	270,000	107,000	81,000	56,200	61,200	49,700	58,585	26,000	673,000
1977	309,000	120,000	102,000	62,800	80,200	58,200	70,588	29,200	769,000
1978	292,000	133,000	104,000	81,000	77,600	57,900	71,445	57,900	772,000
1979	307,000	148,000	107,000	72,800	77,600	56,600	68,560	43,800	785,000
1980	272,000	157,000	119,000	76,200	68,300	49,000	56,247	49,300	721,000
1981	303,000	173,000	127,000	77,700	70,900	55,400	61,376	44,300	760,000
1982	516,000	199,000	136,000	80,100	132,200	104,400	132,100	39,300	1,250,000
1983	540,000	224,000	176,000	82,500	133,000	107,100	131,900	45,700	1,320,000
1984	583,000	239,000	169,000	87,100	140,000	113,700	143,600	40,600	1,370,000
1985	661,000	257,000	148,000	91,900	157,200	123,700	160,900	41,500	1,500,000
1986	666,000	247,000	147,000	89,000	157,000	127,700	164,200	49,200	1,560,000
1987	694,000	268,000	156,000	94,800	166,000	135,300	178,900	47,800	1,660,000
1988	674,000	296,000	195,000	89,000	163,500	132,100	171,600	55,400	1,670,000
1989	678,000	317,000	203,000	90,000	155,900	127,600	161,600	51,300	1,620,000
1990	596,000	340,000	208,000	97,500	123,700	104,800	124,600	52,000	1,430,000
1991	517,000	345,000	234,000	98,400	84,700	77,400	84,800	57,400	1,110,000
1992	491,000	398,000	233,000	98,500	73,100	68,200	68,400	61,200	1,050,000
1993	441,000	367,000	223,000	98,900	57,800	59,000	41,500	57,400	1,030,000
1994	464,000	412,000	234,000	99,200	57,600	59,900	38,800	60,600	1,060,000
1995	472,000	422,000	212,000	102,000	61,700	59,000	40,000	66,900	1,200,000
1996	517,000	454,000	198,000	102,000	66,000	62,400	39,800	69,500	1,230,000
1997	545,000	468,000	244,000	115,000	74,300	72,700	37,500	80,800	1,180,000
1998	620,000	554,000	259,000	99,600	75,900	69,800	51,100	103,000	1,320,000
1999	600,000	551,000	205,000	103,000	84,800	71,200	50,800	100,000	1,370,000
2000	629,000	582,000	214,000	112,000	76,600	75,100	60,200	115,000	1,460,000
2001	662,000	550,000	228,000	124,000	86,600	80,000	59,000	112,000	1,610,000
2002	730,000	555,000	259,000	120,000	92,600	79,200	59,100	101,000	1,560,000
2003	720,000	537,000	233,000	109,000	89,800	76,700	52,600	97,000	1,870,000
2004	664,000	784,000	206,000	111,000	87,300	81,500	54,900	104,000	1,810,000
2005	597,000	895,000	232,000	114,000	77,700	70,000	48,000	85,300	1,730,000
2006	624,000	872,000	269,000	126,000	75,100	71,400	40,500	81,200	1,640,000
2007	630,000	931,000	269,000	126,000	70,100	64,200	30,200	107,000	1,610,000
2008	655,000	927,000	248,000	151,000	56,100	73,000	28,400	82,500	1,540,000
2009	638,000	997,000	278,000	141,000	60,600	63,900	33,000	91,200	1,570,000
2010	690,000	1,020,000	265,000	124,000	58,800	74,900	32,200	98,800	1,800,000

INDONESIAN MARINE FISHERIES CATCHES IN THE WESTERN INDONESIA (FAO AREA 57) AND IN THE BAY OF BENGAL LARGE MARINE ECOSYSTEM PROJECT (BOBLME) AREA: A TENTATIVE RECONSTRUCTION, 1950-2010

Vania Budimartono[1], M. Badrudin[2] and Daniel Pauly[1]

[1]*Sea Around* Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada
[2] Indonesia Marine and Climate Support (IMACS) Project, USAID, Indonesia

Corresponding author: v.budimartono@fisheries.ubc.ca

ABSTRACT

A detailed examination of the marine fisheries catches is presented for the westernmost area of Indonesia, from the province of Aceh down the Malacca Straits to Riau in the northwest, and down along the Indian Ocean coast to East Java in the southwest. This area, covering most of the Indonesian waters in the Indian Ocean (as defined by the limits of FAO area 57), also covers the Indonesian waters of the Bay of Bengal Project (BOBP). The catch statistics of the 11 provinces in that area (some of them in parts only) have deficiencies, which we here attempt to circumvent. The resulting 'reconstructed' catch is 45 million tonnes (t) from 1950 to 2010, notably with estimates averaging 131,500 t·year^{-1} in the 1950s and 1.4 million t·year^{-1} in the 2000s. This is over 37.3% higher than the reported landings of 32.6 million t over the same time period. In the 2000s, industrial fisheries (mainly trawling and trolling) made up 70% of the catch (including discards estimated at 13% of the shrimp trawler catch), while artisanal and subsistence fisheries made up the rest.

INTRODUCTION

Indonesia, as an archipelagic country has a long tradition of fishing (Butcher 1996, 2004) and fish is an important component of the food of Indonesians (Pauly 1996a; Jati *et al.* 2012).

The pressure on Indonesian marine fishery resources has increased strongly in recent decades (Priyono and Sumiono 1997; Wever *et al.* 2012), due to a multiplicity of factors, among them increased demand from a much increased population, and the development of industrial fisheries, especially trawling, which starting in the late 1960s, gradually intensified, and led to a series of conflicts with the hundred thousand of small-scale fishers. These conflicts, which intensified through the mid-1970s, caused the government of Indonesia to ban, in 1980, trawl fishing around Java and Sumatra (Sarjono 1980; Buchary 1999). In 1981, this ban was extended to Kalimantan and Sulawesi, and in 1983 to the rest of the country, except for shrimp fisheries in its far east (Butcher 2004).

This trawl ban and other measures taken to reduce overt conflicts between industrial and small-scale fisheries are the results of open-entry policies, which allowed for fishing effort, notably by trawlers, to grow without control. Re-establishing control over Indonesian fisheries, and subjecting them to some form of pre-emptive management requires that basic information on the fisheries be available in reliable form, including catch data which, given the country's size and complexity, are difficult to collect (Willoughby *et al.* 1999).

This report is a small contribution toward this aim, i.e., an attempt to estimate actual catches from the western part of Indonesia (Figure 1) and thus correct - to the extent possible, various deficiencies in the official statistics of that region. Because the northern half of western Indonesia is also a part of the area covered by the Bay of Bengal Large Marine Ecosystem project (BOBLME), this report also presents a

summary of Indonesian fisheries catches in the Bay of Bengal area, as required for a comprehensive review of the resources of the Bay of Bengal and their exploitation (Harper *et al.* 2011; Kleisner and Pauly 2011).

METHODS

Because of its huge longitudinal range, which reaches from 95° to 140° E, the *Sea Around Us* project has divided the Indonesian Exclusive Economic Zone (EEZ) into 'western', 'central' and 'eastern' parts. The western part, defined in Figure (1), is the only one covered here, while the central part, covering the Java Sea and the southern tip of the South China Sea, and the eastern part, covering the Arafura, Banda, Sula and Timor Seas, and fully congruent with the Indonesian part of the Coral Triangle (Veron *et al.* 2009) is dealt with in Budimartono et al. (2015). In terms of the large statistical areas to which the world catch is allocated by the United Nations Food and Agriculture Organization (FAO), Western Indonesia largely overlaps with FAO area 57 (Eastern Indian Ocean), Central Indonesia overlaps with FAO Area 71 in the north, and FAO Area 57 in the south, while Eastern Indonesia is entirely within FAO Area 71 (Western Central Pacific).

Table (1) lists the Indonesian provinces fully or partly included in the area covered here, and defined by Figure 1. Note that some of these provinces have only one coast (typically on the southeast) included within FAO area 57, with the other (northwest) included in FAO Area 71. For such cases, we have estimated the approximate fraction of their waters in each FAO Area (Table 1), and have allocated their reported catch, obtained from the Ministry of Marine Affairs and Fisheries, proportionately. The next step consisted of first-order processing of the nominal (official) catch time series at the province level, which consisted of:

1) Transposing the available data from PDF format to Microsoft Excel format and correcting obvious errors detectable at this stage (notably, order-of-magnitude jumps in catches due to misplaced dots or zeroes);
2) Interpolating the catches (in tonnes, or t) from a few missing years on the assumption that fisheries do not disappear from one year to the next, and then re-appear a year later, as well as extrapolating backward from 1951 to 1950, to correct for obvious encoding errors;
3) Translating the Indonesian common names used in provincial (and national statistics) into their nearest scientific equivalent using resources such as the book by Schuster and Djajadiredja (1952), Directorate General of Fisheries (1975) and FishBase (www.fishbase.org);
4) Then, between–year taxonomic harmonization was applied such as to avoid a higher taxonomic category such as, e.g., 'tuna' abruptly disintegrating into its component species, or vice-versa; and
5) Once (1) to (4) were done by province for 1973 to 2010, a catch composition of each province was extrapolated backward into the proportion of the total catch (from FAO Area 57 and 71) assigned to each province as a function of their average proportion in the catch of 1973 to 1975.

Table 1. Indonesian provinces covered in this contribution with approximate ratio of the waters that are shared between FAO Area 57 and 71.

Province	% in FAO Area		Year industrial fishing started [a]
	Area 57	Area 71	
Aceh	100	0	1967
North Sumatra	100	0	1967
West Sumatra	100	0	1968
Riau	80	20	1966 [b]
Bengkulu	100	0	1968
Lampung	30	70	1970
Banten	50	50	1971 [c, d]
West Java	60	40	1971 [c, d]
Central Java	40	60	1971 [e]
S.R. Yogyakarta	100	0	1971 [e]
East Java	40	60	1971 [e]

a): Assumed based on Butcher (2004), Bailey *et al* (1987), Morgan and Staples (2006); b): The trawl fishery started in Bagan Si Api Api in 1966 (Morgan and Staples 2006); c): In 1971, trawlers moved from Sumatra to the north coast of Java (Morgan and Staples 2006); d): "[…] and from there [trawling] spread [in] the early 1970s throughout the Malacca Straits into the Java Sea" (Bailey 1986); e): "Also, by 1971, at least 50 trawlers from Sumatra had shifted their base of operations to the north coast of Java, […] and trawlers were established at Cilacap, a port of Java's south coast." (Bailey *et al.* 1987).

Steps (1) to (5) generated time series of nominal catch by province (or the parts of provinces included in FAO Area 57; see Table 1). Also, to examine frequent, but thus far undocumented claims that the annual increase of nominal catch are (or earlier have been) generated in various provincial offices by simply adding a set percentages to previous years' catches, annual time series of the natural logarithm of the nominal catch (by taxon) were regressed against year for two of the provinces covered here (Aceh and East Java) for the years 1975 to 2010. The frequency distribution of the slopes of these regressions was then used for assessing the extent to which estimates of the illegal and/or unreported industrial catch (see below) should be adjusted to offset this form of likely over-reporting.

Small-scale fisheries (artisanal, subsistence, and recreational)

Artisanal fisheries (which deliver their catch to market) are defined, in Indonesia, by their use of vessels relying on sail or outboard engine for propulsion, while fishers operating gear without a boat are classified as small-scale, whatever the size or mobility of their gear (Priyono and Sumiono 1997; Chuenpagdee *et al.* 2006).

To allocate the catches obtained in Step (5) to industrial and artisanal fisheries, we created a list of species (or higher taxa) by province (or part thereof) and assigned to each the likely percentage of their catch presumed to be taken in 1970-2010 by industrial vessels (mainly purse seiners in the case of pelagic fishes and trawlers in the case of demersal fishes). These percentages (the mean of an independent estimate by each of the three authors; see Appendix Table A1, A2, A3) were then used to compute the catch by species groups of industrial fisheries, and province, and by subtraction, the corresponding artisanal catch. For the years before 1970, a phase-in period of 5 years was assumed, starting from the year the industrial fisheries could be assumed to have initiated their operation in a given province (Table 1).

To estimate the contribution of subsistence fisheries (wherein fishers keep fish for their own and family consumption or local distribution), the total number of fishers from 1976 to 2010 in 10 years intervals

(with interpolations for the intervening years) and total number of fishers as a fraction of the total Indonesian population (1950 to 1975) were used jointly with a catch rate of 0.20 kg·fisher^{-1}·day^{-1} (Willoughby *et al.* 1999). We treated both full-time fishers and part-time fishers as equivalent (in the context of subsistence), and thus used their total number; we also assumed that the frequency of fishing for each fisher would be 4 days per week and 40 weeks a year.

Marine recreational fishing was reported to generate a catch of 5,000 to 10,000 t·year^{-1} in the mid-1990s (pers. comm in Willoughby *et al.* (1999). Given that recreational fishing, in Indonesia, appears to be an urban-based phenomenon, we derived, from the relative population of the 10 largest cities in Indonesia, a key to allocate the midrange (7,500 t) of fish caught recreationally to the three parts of Indonesia identified above, i.e., Central Indonesia (80%; high because of the cumulative populations of Jakarta, Semarang, Bekasi, Tangerang, Depok, Palembang, and Surabaya), Western Indonesia (15%, e.g., Bandung and Medan), and Eastern Indonesia (5%, Makassar), all assumed for the year 1994. This 1994 catch of 7,500 t was decreased for previous years and increased to 2010 by making it proportional to the size of the Indonesian population.

Industrial fisheries (legal and illegal) and their discards

The industrial catch was only lightly adjusted to account for the effect of the 1980 trawl ban. The ban was effective, in the short run and in some areas such as along the coast of Java, in reducing the *visibility* of trawlers to artisanal fishers, but they largely continued to operate further offshore, out of their sight (D. Pauly, 1983; pers. obs. on Javanese trawlers with recently used – and hence shiny – drums on their main winches), or were converted to purse seiners (Butcher 2004), another industrial gear. The latter can be assumed to have led to an increase in the relative contribution of small pelagic fishes to the reported catch.

Thus, to account for the limited effects of the trawl ban, we assume that the catches of trawlers (and the corresponding discards) in the provinces of Java and Sumatra in Table (1) became, in 1980, only 30% of what they would have been had there been no ban. This fraction was decreased to 20% in 1981, and 10% in 1982 (after which things returned to business as usual), with the artisanal fisheries and the industrial pelagic fisheries being attributed this additional (formerly trawl) catch. Note that this procedure maintained the total nominal catch for the years and provinces in question. For the purpose of this report, trawler catches include the contribution of 'baby trawlers' as we agree with Martín (2012) that any gear that is dragged should be considered industrial.

As Western Indonesian trawlers, and contrary to a widespread perception of the opposite, do engage in discarding their by-catch of less valuable fish, and keep mainly the shrimp and valuable fish (D. Pauly, pers. obs. July 1976 in the Java Sea off Kalimantan; JALA 2009, for North Sumatra), we have added an assumed discarded by-catch equivalent to the landings of trawlers, i.e., to the nominal industrial catch of demersal taxa, from 1950 to 1994. We consider this conservative, as it is half the discarding rate estimated for the North Sumatra trawler fleet, where it is suggested that "two thirds of the catch by the trawler fleet operating in North Sumatra is discarded over the side, lost to the marine ecosystem and the local fishermen" (JALA 2009). As discard rates in recent decades appear to have strongly decreased (M. Badrudin, pers. obs.), the 50 % discard rates for nominal industrial catch of demersal taxa from 1995 onwards was reduced linearly to 10%.

As for tuna longliners, Kelleher (2005), suggest that their discarding rate in Western Indonesia is about 15% of their catch, and that their discards consist of post-finning shark carcasses, as well as damaged targeted species (Willoughby *et al.* 1999; Priyono 2003).

There is, in all the Indonesian provinces, a substantial amount of unreported and illegal industrial fishing, with an increasing gradient from West to East, but which seem to have abated in more recent years (Pramod *et al.* 2008). For the Indian Ocean waters of Indonesia, we will conservatively assume this to have corresponded, in the 1980s and 1990s to 30% of the reported catch that we assigned to industrial fisheries, i.e., 15% to Indonesian trawlers and 15% to foreign trawlers. For the period preceding 1980, we assumed that illegal industrial trawling grew linearly from zero in the years that industrial fishing itself began in each province (see Table 1) to 30% in 1980. Also, we shall assume, given the decline in illegal fishing alluded to above, that the non-reporting declined from 30% to 5% in the period from 1995 to 2005, then remained stable at 5%. The discards of the illegal fishery were assumed to be the same as for the reported trawl and longline fishery (see above).

The results are presented for the Western Indonesia as defined here, and for that Indonesian part of the Bay of Bengal Large Marine Ecosystem programme (BOBLME) area that overlaps with the Indonesian EEZ (Figure 1).

RESULTS AND DISCUSSION

Issues related to the nominal catch statistics

Our partitioning of provincial catch statistics within FAO Area 57 resulted in discrepancies with the catches submitted by Indonesia to FAO and disseminated through the FishStats database (Figure 2). These discrepancies were evidential throughout the time series, and were presumably due to a data transfer from Indonesia to FAO that could be improved. FAO's statistics usually remain markedly below national data, suggesting that the data transfer between the Indonesian statistical service and FAO could still be improved (Zeller *et al.* 2007). It ought to be noted that, in the later years, there was a decrease in the discrepancies, which might be due to an improvement in data transfer.

The frequency of the slopes of the natural logarithm of the nominal catch (by taxon) for the two provinces covered in this report, Aceh and East Java (Table 2), cluster around 1.5% per year. This suggests that, the annual increase of nominal catch is indeed, generated by adding a set of percentages to the previous' years catches.

Table 2. Number of regressions of log(annual catch of various taxa) vs. year (1973 to 2010) for the provinces of Aceh and East Java, arranged by the values of their slope, in steps of 0.005. Note high numbers around slopes of 0.015 to 0.020, and see Figure (3).

Lower limit	**Number of species**	
	Aceh	***East Java (FAO Area 57)***
-0.015	0	0
-0.010	0	0
0.000	7	4
0.005	1	3
0.010	5	4
0.015	**9**	**5**
0.020	4	2
0.025	3	1
0.030	1	2
0.035	0	0
0.040	2	2
0.045	1	3
0.050	0	1
>0.050	0	5

The data in Table (2) and Figure (3) suggest that there might be, indeed, in some provinces of Indonesia, a tendency for similar percentages - at least in certain species groups - to be added to the previous year's catches. This practice, if applied continuously, would generate a pattern of exponentially growing catches similar to the overall appearances of the nominal catch trends in Figure (2) and (4), and would have, in the medium to long-term, led to overestimation of actual catches, whatever their actual values. Here, we have countered this effect by giving some emphasis to reports that IUU catches have declined in later years (Pramod *et al.* 2008), and by gradually reducing the discard rates of the trawlers. This has the result that our (higher) overall reconstructed catches tend to decrease in the last 15 years, rather than increase, as the (smaller) nominal official catches do. This is however, a stopgap measure, which leaves the underlying issue unresolved.

Another issue with the nominal catch data examined here is their ability to reflect major events that affected the fisheries. Perhaps due to the fashion we assigned fish to either the artisanal or the industrial sectors, we failed to detect any consequence of 1980 trawl ban in the official catch time series (see Figure 2), and thus the slight adjustments we performed to mark this event (see Figure 5). However, this may have been due to this ban being widely ignored (see above), except perhaps in the Java Sea (outside of the area considered here), where it led to a booming (and busting) fisheries of small pelagics, especially scads, *Decapterus* spp. (Budimarto *et al.* 2015).

This may be different with the December 2004 tsunami, which is reflected in a 2005 drop of (total) nominal catch of Aceh Province, and hence also in our allocation to the artisanal and industrial sectors (Figure 6). However, there were fluctuations of similar magnitude before, and without tsunami. Also, the nominal catches of neighboring provinces display catch declines which began before 2004 (Figures 5, 7-8), so that the 2005 signal cannot be unequivocally interpreted as a reflection of the tsunami, although it is likely.

Small-scale fisheries (artisanal, subsistence, and recreational)

Small-scale fisheries catch was estimated to be 13.6 million t from 1950 to 2010 (Figure 7), with an average of around 223,000 t·year^{-1}. Artisanal (12.9 million t for 1950-2010), subsistence (689,000 t) and recreational catches (54,000 t) were small and relatively stable, with an annual average of around 211,000 t·year^{-1}, 11,000 t·year^{-1} and 880 t·year^{-1}, respectively.

Industrial fisheries (legal and illegal) and their discards

The total reconstructed industrial fisheries catch, composed of legal, illegal, and discard components, was estimated to be 31.1 million t from 1950 to 2010 (Figure 5, 7). The total reconstructed industrial catch starts in the early-mid 1960s with 30,000-80,000 t·year^{-1}, then grows steadily to around 1.0 million t·year^{-1} by the mid-1990s and remains around that amount for the rest of the time period. The reported landings of industrial fisheries made up 60.7% (just under 20 million t) of the total estimated catch, while illegal catches (3.0 million t) and discards (9.5 million t; 80% associated with shrimp trawl catch and 20% associated with tuna longline catch) made up the rest. The discards generated by the shrimp trawl fishery were 4 times higher than the discards generated by the tuna longline fishery.

The absence of industrial catch at the beginning of the time series of Figures (5, 7) is due to the fact that industrial fisheries did not exist in Indonesia until the mid-1960s, when a trawl fishery began operations off Bagan Si Api Api, a small town in Riau Province (Morgan and Staples 2006), later extending to the entire Malacca Strait (Martosubroto *et al.* 1996). Eventually, this capital-intensive mode of fishing shifted southward and eastward, and resulted in delayed industrialization of fishing in the provinces around the Indian Ocean (Bailey 1986; Butcher 2004; Morgan and Staples 2006). This shift was reflected in the gradual, but steady increase of the estimated industrial catch within the time series.

Discards from industrial fisheries were estimated to be around 9.5 million t (30% of the total reconstructed industrial fisheries catch), an amount not included in the official catch statistics (Figure 5 and 7). Discarding rates are widely assumed to be very low in Indonesia, as fishers are thought to retain by-catch for sale or family consumption. (Priyono and Sumiono 1997; Pramod *et al.* 2008), which they do to a certain extent. However, this general notion is contradicted by the frequent occurrence of discarded fish floating on the sea surface, following the passage of trawlers or tuna longliners, which then generate conflicts with small-scale fishers. Thus, while using a relatively low discard rate, we maintain that Indonesian industrial vessels, like others in Southeast Asia, keep the more valuable part of their catch and discard the rest.

Illegal fishing by foreign fleets is widespread in Indonesia; lack of enforcement by Indonesian officials, and various methods used by Indonesian and foreign individuals allow numerous transhipment activities, as well as data and license manipulations to occur. Thus, Professor R. Chuenpagdee (Memorial Univ. St. John's, pers. comm. to D. Pauly) stated that in "2006, between 1,000 and 2,000 Thai boats were estimated to operate in Indonesian fishing grounds in the South China Sea and Arafura Sea, most of whose catches were not reported to the [Thai Department of Fisheries] because they fished under private sector agreements." Also, the 'transfer lists' containing detailed information on catches being transshipped from Thai trawlers to Thai 'reefers' may also differ from the lists submitted to Indonesian fisheries officials. Thus, a reefer company and Thai fishing company may collude to underreport their catch so as to avoid higher taxes and licensing fees, respectively (Pramod *et al.* 2008). Similarly, fishing vessels from the Philippines operate illegally in Indonesian waters, and land their catch in the Philippines (Willoughby *et al.* 1999). This problem, however, may be more limited in Western Indonesia and our assumptions and hence our results (Figure 5 and 7) reflect this.

However, to round off this picture, we should mention that Indonesian fishers are also known to fish illegally outside the Indonesian EEZ, especially in Australian waters (Vince 2007; Pramod *et al.* 2008).

Reconstructed total catch

The total reconstructed for Western Indonesian marine fisheries catch in the Indian Ocean from 1950 to 2010 was estimated to be 44.7 million t (Figure 7), and increased from around 131,000 t·year^{-1} in the 1950s to around 1.4 million t·year^{-1} in the 2000s. Thus, total catches are estimated to be around 37% higher than the catch reported by FAO on behalf of Indonesia, and Indonesia's national data (adjusted to Western Indonesia). Industrial fisheries - legal and illegal – plus industrial discards made up 70% of the total estimated catch. Discards from industrial fisheries were estimated to be 21% (from shrimp trawlers catch and tuna longliners catch) of total catches, while artisanal (29%), recreational (0.1%), and subsistence fisheries (1.5%) made up the rest.

Total reported catch increased steadily, with only small fluctuations in some years (Figure 4). This smooth growth implies that various statistical offices, perhaps at *kabupaten* ('district') level, perhaps even at provincial level, added similar percentages to previous years' catches. If this suspicion is correct, this would render much of the reported Indonesian fisheries catch data highly suspicious. Here, we slightly offset the over-reporting that this practice tends to generate by accepting claims that illegal foreign fishing has declined in recent years, and therefore that unreported and illegal catches have declined, as shown in Figure (7).

The marine biodiversity of Indonesia is immense, notably its ichthyofauna (Froese 1996; Briggs 2005; and see FishBase; www.fishbase.org for updates), and a huge number of fish and invertebrates species occur in the catch of artisanal fishers and trawlers whose biology is only beginning to be elucidated (see reviews in Dwiponggo *et al.* 1986; Pauly *et al.* 1996a). Major contributing taxa in the reconstructed catch were Scombridae (mackerels, tunas, and bonitos), Carangidae (jacks and pompanos), Clupeidae (herrings, shads, and sardines), Engraulidae (anchovies), Penaeidae (penaeid shrimps), Leiognathidae (slipmouths, or ponyfishes), Arcidae (cockles), and Ariidae (sea catfishes; Figure 8).

Finally, two points may be emphasized regarding the Northwest part of Western Indonesia, i.e., the part of Indonesia that is covered by the Bay of Bengal Large Marine Ecosystem project (BOBLME) in Figure (1). The first is that this area was the most affected by the tsunami, which, in December 2004, hit Aceh and its surroundings. This natural disaster killed 170,000 persons (Gaillard *et al.* 2008) and caused enormous material damage, notably in the fisheries sector. Thus, at least 65-70% of small-scale fishing vessels in Aceh were destroyed (Australian Institute of Marine Science 2006). In 2005, the year that followed the tsunami, the catch reported for Aceh Province was markedly lower than in previous years (Figure 6). However, the fisheries statistics for Riau, Banten, and Central Java provinces also show a drop of catch in the years preceding the tsunami, while showing an increase for West Java, East Java, Bengkulu, North Sumatra, West Sumatra, Lampung, and Yogyakarta (Figures 4). Thus, while fishing operations in Aceh and other parts of Sumatra impacted by the 2004 tsunami are likely to have declined in 2005, is not obvious that Indonesian, and even Acehnese fisheries statistics, properly reflected this event.

The second point concerning that part of Indonesia that is covered by the BOBLME is that its catches made up, in the 2000s, over 20% of the catch of Western Indonesia as defined in Figure (1; see Appendix Table A6 and A7). This implies, among other things, that positive management measures implemented via the BOBLME would positively affect a vital majority of fishers and fisheries in western Indonesia.

ACKNOWLEDGEMENTS

This is a contribution of the *Sea Around Us* project, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts. We also acknowledge partial funding from the Bay of Bengal Large Marine Ecosystem project, and from the Indonesia Marine Climate Support (IMACS) project [USAID] for their support of Mr. Badrudin.

REFERENCES

Australian Institute of Marine Science (2006) Status of coral reefs in Indonesia after the December 2004 tsunami. pp. 43-56 *In* Wilkinson C, Souter D and Goldberg J (eds.), Status of coral reefs in tsunami affected countries: 2005. Australian Institute of Marine Science (AIMS), Australia.

Bailey C (1986) Government protection of traditional resource use rights - The case of Indonesian fisheries. *In* Korten DC (ed.), Community management: Asian experience and perspectives. Kumarian Press, West Hartford, Conn.

Bailey C, Dwiponggo A and Marahudin F (1987) Indonesian marine capture fisheries. International Center for Living Aquatic Resources Management (ICLARM), Makati, Metro Manila, Philippines.

Bianchi G (1996) Demersal fish assemblages of trawlable grounds off Northern Sumatra. pp. 123-130 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources and Management (ICLARM), Makati City, Philippines.

Briggs JC (2005) The marine East Indies: diversity and speciation. Journal of Biogeography 32(9): 1517-1522.

Buchary EA (1999) Evaluating the effect of the 1980 trawl ban in the Java Sea, Indonesia: An ecosystem-based approach. MSc thesis, University of British Columbia, Vancouver. 143 p.

Buchary EA, Pitcher TJ and Ganapathiraju P (2006) An Estimation of Compliance of the Fisheries of Indonesia with Article 7 (Fisheries Management) of the FAO (UN) Code of Conduct for Responsible Fishing. p. 36 *In* Pitcher TJ, Kalikoski D and Pramod G (eds.), Evaluations of Compliance with the FAO (UN) Code of Conduct for Responsible Fisheries. Fisheries Centre Research Reports 14 (2). University of British Columbia, Vancouver, Canada.

Budimartono V. M. Badrudin and Pauly D (2015) A reconstruction of the marine fisheries of Central and Eastern Indonesia, 1950-2010. p. 2-26 *In:* D. Pauly and V. Budimartono (eds.). Marine Fisheries Catches of Western, Central and Eastern Indonesia, 1950-2010. Fisheries Centre Working Paper #2015-61, University of British Columbia, Vancouver.

Butcher JG (1996) The marine fisheries of the Westen Archipelago: Toward an economic history, 1850 to the 1960s. pp. 24-39 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources and Management (ICLARM), Makati City, Philippines.

Butcher JG (2002) Getting into trouble: the diaspora of Thai trawlers, 1965–2002. International Journal of Maritime History 14(2): 85–121.

Butcher JG (2004) The closing of the frontier - A history of the marine fisheries of Southeast Asia c. 1850-2000. Institute of Southeast Asian Studies, Singapore.

Chuenpagdee R, Liguori L, Palomares MD and Pauly D (2006) Bottom-Up, Global Estimates of Small-Scale Marine Fisheries Catches. Fisheries Centre Research Report 14 (8). University of British Columbia, Vancouver, Canada.

Directorate General of Capture Fisheries (2011) Statistik perikanan tangkap Indonesia, 2010 [Capture fisheries statistics of Indonesia, 2010]. Directorate General of Capture Fisheries Jakarta, Indonesia. 182 p.

Directorate General of Fisheries DoA (1975) Ketentuan kerja pengumpulan, pengolahan, dan penyajian data statistik perikanan: Standard statistik perikanan [Provision of work collecting, processing, and presentation of statistical data fishery: Standard fishery statistics]1. Directorate General of Fisheries, Department of Agriculture. iv + 207 p.

Dwiponggo A, Hariati T, Banon S, Palomares ML and Pauly D (1986) Growth, mortality and recruitment of commercially important fishes and penaeid shrimps in Indonesian waters. International Center for Living Aquatic Resources Management (ICLARM) Technical Reports 17, International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines. 91 p.

FAO (1999) Indonesia: Fisheries and fisheries management overview. pp. 60-63 *In* Report of the regional workshop on the precautinary approach to fishery management. Bay of Bengal Programme, Chennai, Indonesia.

Froese RSMLaECC (1996) Checklist of marine fishes of Indonesia, compiled from published literature. pp. 217-275 *In* Pauly D and Martosubroto P (eds.), Baseline studies of diversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. Philippines, Makati City.

Gaillard JC, Clavé E, Vibert O, Denain JC, Efendi Y, Grancher D and Setiawan R (2008) Ethnic groups' response to the 26 December 2004 earthquake and tsunami in Aceh, Indonesia. Natural Hazards 47(1): 17-38.

Harper S, O'Meara D, Booth S, Zeller D and Pauly D (2011) Fisheries catches from the Bay of Bengal Large Marine Ecosystem since 1950. Report to the Bay of Bengal Large Marine Ecosystem Project 16, Bay of Bengal Large Marine Ecosystem (BOBLME). 97 p.

Hermes R (1996) Small-scale fisheries development project in Lombok, Nusa Tenggara Barat, Indonesia. p. 133 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management, Makati City, Philippines.

JALA (2009) When fishing turns deadly: The environmental and social impacts of illegal trawling in North Sumatra. JALA - the Advocacy Network for North Sumatra Fisherfolk, Medan Johor, Indonesia. 6 p.

Jati IRAP, Vadivel V, Nohr D and Biesalski HK (2012) Dietary formulation to overcome micronutrient deficiency status in Indonesia. Nutrition & Food Science 42(5): 362 - 370.

Kelleher K (2005) Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper 470, FAO, Rome.

Kleisner K and Pauly D (2011) Performance in managing marine resources in the Bay of Bengal. Report to the Bay of Bengal Large Marine Ecosystem Project 17, Bay of Bengal Large Marine Ecosystem (BOBLME). 146 p.

Lohmeyer U, p. In: . (eds.) . ICLARM Studies and Reviews 23. (1996) Narrative and major results of the Indonesian-German JETINDOFISH Project, August 1979 to July 1981. pp. 77-90 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Martín J (2012) The small-scale coastal fleet in the reform of the common fisheries policy. Policy Department Structural and Cohesion Policies - European Parliament.

Martosubroto P (1996) Narrative and major results of the Indonesian Module (I) of the JETINDOFISH Project, November 1980 to October 1981. pp. 131-134 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Aquatic Resources Management (ICLARM), Makati City, Philippines.

Martosubroto P, Sujastani T and Pauly D (1996) The mid 1970s demersal resources on the Indonesian side of the Malacca Strait. pp. 40-46 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center fot Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

McManus J (1996) Marine bottomfish communities from the Indian Ocean coast of Bali to mid-Sumatra. pp. 91-101 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Morgan GR and Staples DJ (2006) The history of industrial marine fisheries in Southeast Asia. Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific (FAO-RAP), Bangkok. i + 28 p.

Partnership SF (2009) Scoping Out: Indonesian tuna fisheries. Sustainable Fisheries Partnership.

Pauly D (1977) The Leiognathidae (Teleostei): Their species, stocks and fisheries in Indonesia, with notes on the biology of Leiognathus splendens (Cuvier). Marine Research in Indonesia (19): 73-93.

Pauly D (1986) On identifying fish species rather than assessing fish stocks: a review of two books on the taxonomy of the neritic fishes of the Western Indian Ocean. Naga, the International Center for Living Aquatic Resources Management (ICLARM) Quarterly 9(3): 21.

Pauly D (1996a) Fleet-operational, economic and cultural determinants of by-catch uses in Southeast Asia. Solving By-Catch: Considerations for Today and Tomorrow 96, University of Alaska, Sea Grant College Program, Fairbanks. 285-288 p.

Pauly D (1996b) Biodiversity and the retrospective analysis of demersal trawl surveys: a programmatic approach. pp. 1-6 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Pauly D, Cabanban A and Torres FSB (1996a) Fishery biology of 40 trawl-caught teleosts of Western Indonesia. pp. 135-216 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Pauly D and Martosubroto P, editors (1996) Baseline studies in biodiversity: The fish resources of western Indonesia. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines. 390 p.

Pauly D, Martosubroto P and Saeger J (1996b) The Mutiara 4 surveys in the Java and southern South China Sea, November 1974 to July 1976. pp. 47-54 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Pramod G, Pitcher TJ, Pearce J and Agnew D (2008) Sources of information supporting estimates of unreported fishery catches (IUU) for 59 countries and the High Seas. Fisheries Centre Research Reports 16 (4). University of British Columbia, Vancouver, Canada. 242 p.

Priyono BE (2003) Socioeconomic and bioeconomic analysis of coastal resources in central and northern Java, Indonesia. pp. 479-516 *In* Silvestre G, Garces L, Stobutzki I, Ahmed M, Valmonte-Santos RA, Luna C, Lachica-Alino L, Munro P, Christensen V and Pauly D (eds.), Assessment, management, and future directions for coastal fisheries in Asian countries. WorldFish Center Conference Proceedings 67. WorldFish Center.

Priyono BE and Sumiono B (1997) The marine fisheries of Indonesia, with emphasis on the coastal demersal stock of the Sunda shelf. pp. 38-46 *In* Silvestre G and Pauly D (eds.), Status and Management of tropical coastal fisheries in Asia. International Center for Living Aquatic Resources Management (ICLARM) Conference Proceedings 53. International Center for Living Aquatic Resources Management (ICLARM).

Roy C (1996) Variability of sea surface features in the Western Indonesian Archiperago: Inferences from the COADS data set. pp. 15-23 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management, Makati City, Philippines.

Sarjono I (1980) Trawlers banned in Indonesia. INternational Center for Living Aquatic Resources Management (ICLARM) Newsletter 3(4): 3.

Schuster WH and Djajadiredja R (1952) Local common names of Indonesian fishes. W.V. Hoeve, Bandung, Indonesia.

Torres FSB, Bienvenida SL, Prein M and Pauly D (1996) Using the NAN-SIS and FiSAT software to create a trawl survey database for western Indonesia. pp. 276-283 *In* Pauly D and Martosubroto P (eds.), Baseline studies in biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Venema S (1996) Results of surveys for pelagic resources in Indonesian waters with the R/V Lemuru, December 1972 to May 1976. pp. 102-122 *In* Pauly D and Martosubroto P (eds.), Baseline studies of biodiversity: The fish resources of western Indonesia. ICLARM Studies and Reviews 23. International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines.

Veron JEN, Devantier LM, Turak E, Green AL, Kininmonth S, Stafford-Smith M and Peterson N (2009) Delineating the coral triangle. Galaxea, Journal of Coral Reef Studies 11(2): 91-100.

Vince J (2007) Policy responses to IUU fishing in Northern Australian waters. Ocean & Coastal Management 50(8): 683-698.

Wever L, Glaser M, Gorris P and Ferrol-Schulte D (2012) Decentralization and participation in integrated coastal management: Policy lessons from Brazil and Indonesia. Ocean & Coastal Management 66: 63–72.
Willoughby N, Monintja D and Badrudin M (1999) Do fisheries statistics give the full picture? Indonesia's non-recorded fish problems. *In* Report of the regional workshop on the precautinary approach to fishery management, Chennai, India. 163-172 p.
Yamamoto T (1980) A standard statistical system for current fishery statistics in Indonesia. A report prepared for the Fisheries Development and Management Project, Indonesia. Food and Agriculture Organization of the United Nations (FAO), Rome. 79 p.
Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. Fishery Bulletin 105(2): 266-277.

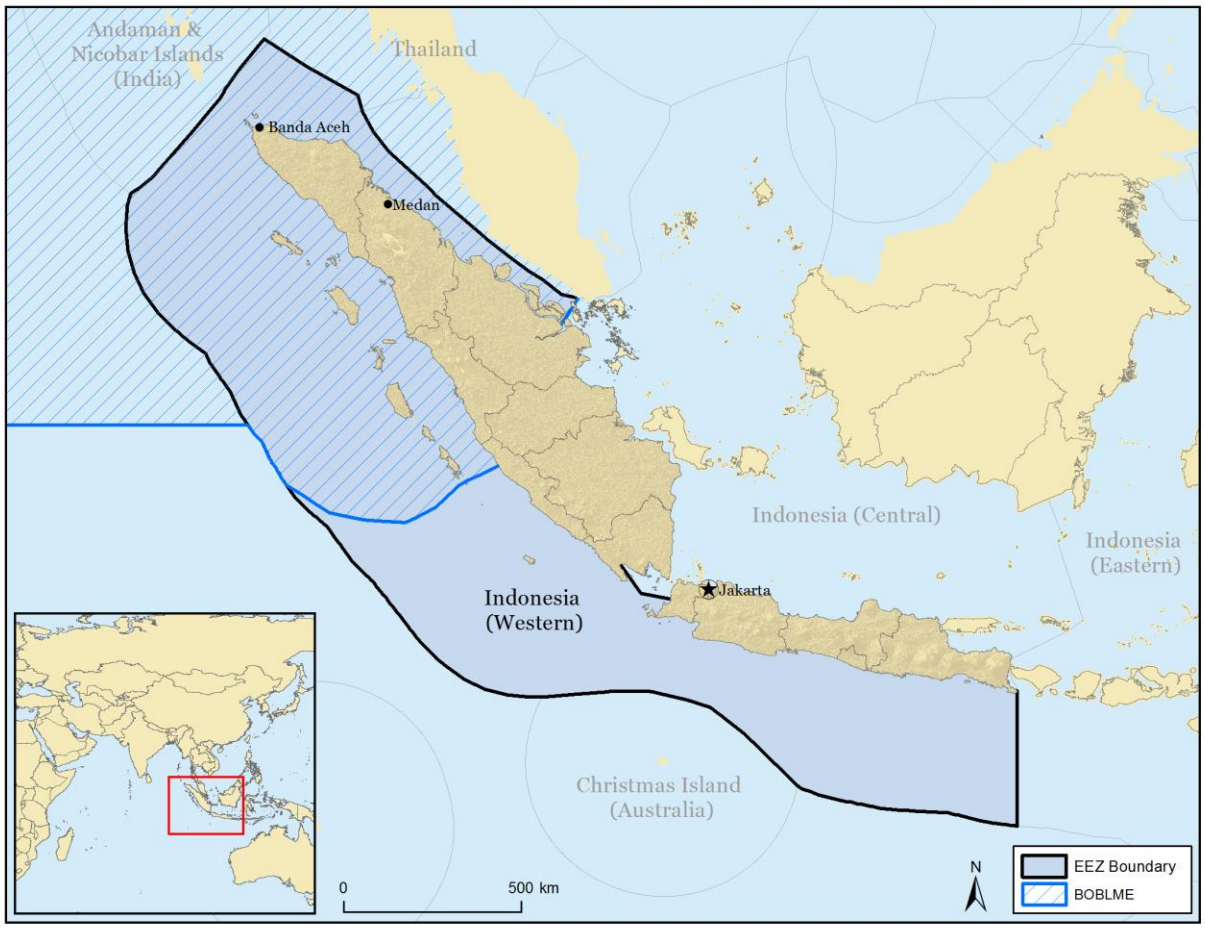

Figure 1. Map of western Indonesia, with its EEZ, and the area covered by the Bay of Bengal Large Marine Ecosystem project (BOBLME).

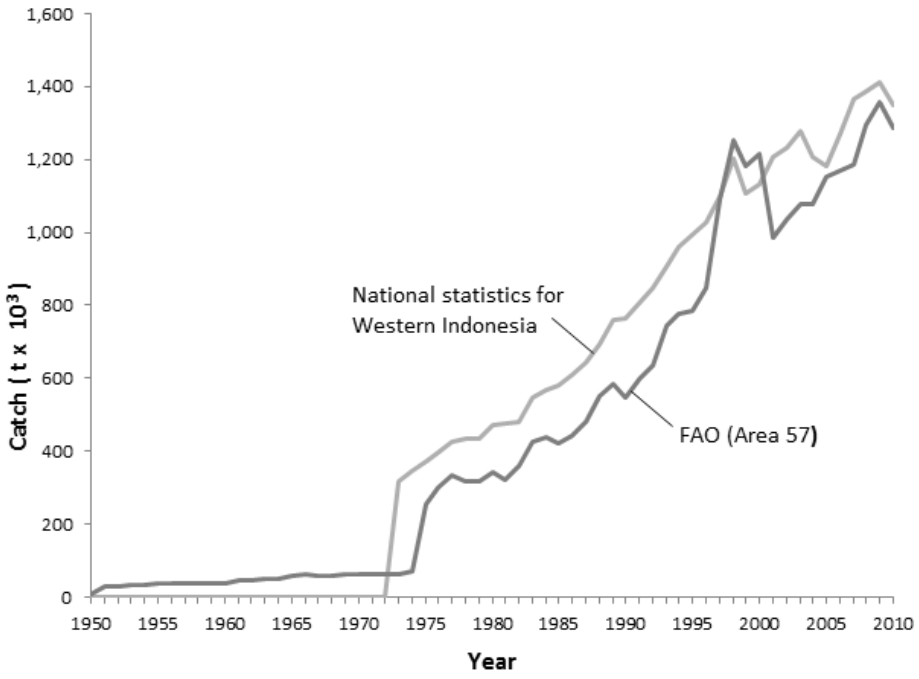

Figure 2. Nominal catch statistics available from the Ministry of Marine Affairs and Fisheries for what we define as Western Indonesia, plus catches from Bali, and East and West Nusa Tenggara (Indian Ocean only), see Table 1), compared and data from FAO Area 57. See text for discrepancies between the two lines.

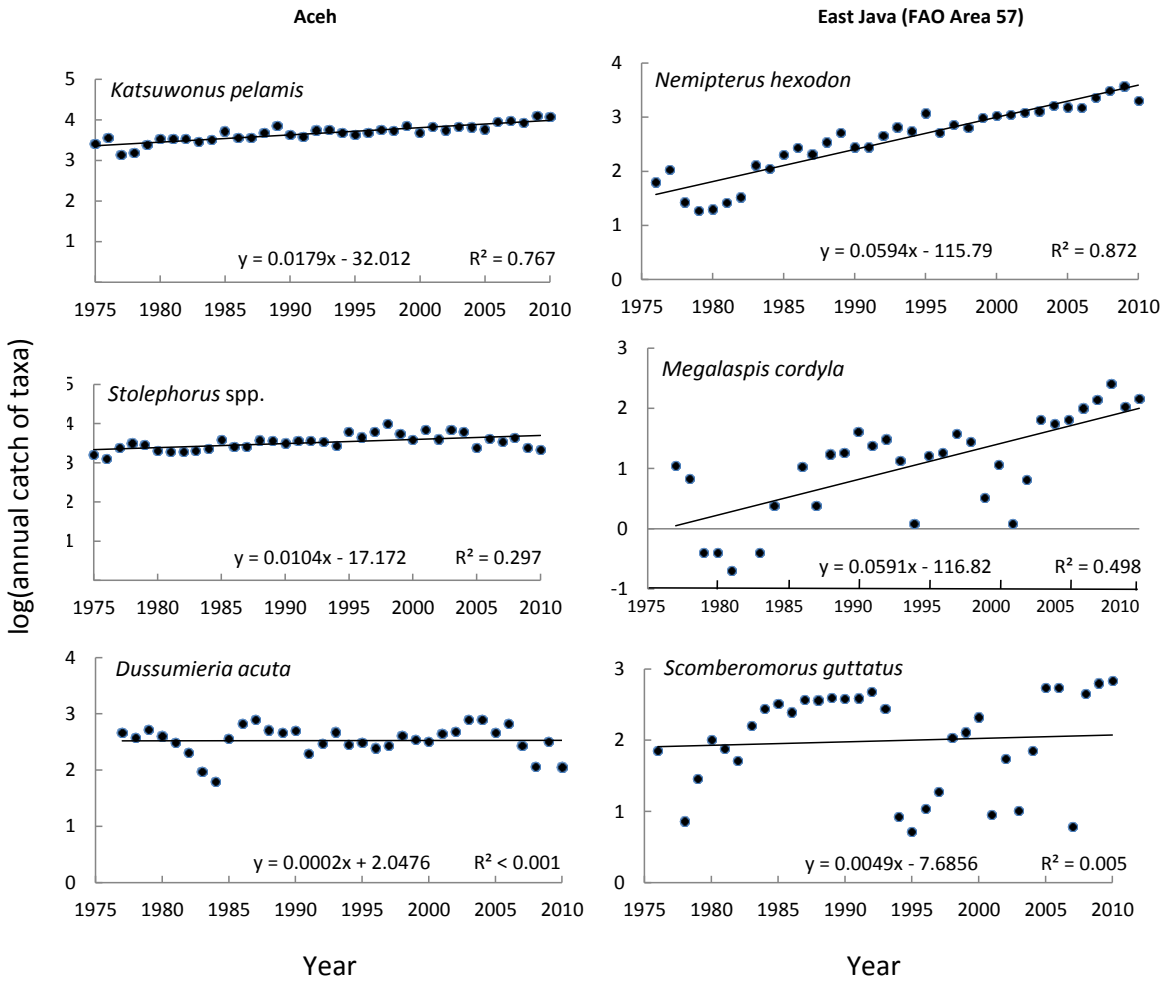

Figure 3. Example of catch increases in two provinces of Indonesia (Aceh and East Java). Top: increase that are suspiciously regular. Center: slightly less regular increases. Bottom: fluctuating catches, such as usually encountered in reality.

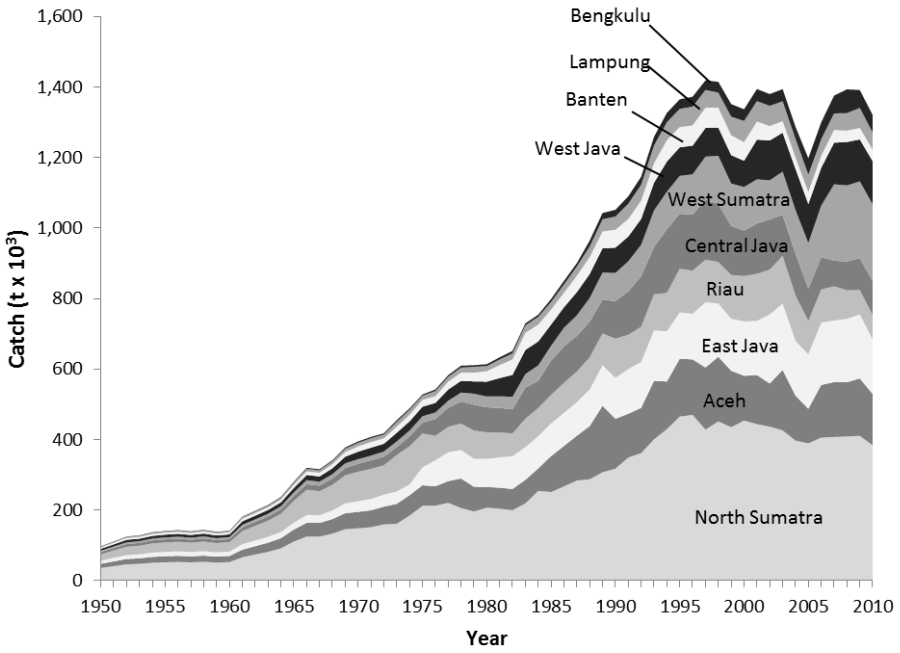

Figure 4. Nominal catch of Western Indonesia, as defined in Figure (1), by provinces 1950-2010. The catch for Yogyakarta is too small to be shown in the graph. Note relatively smooth increase in most provinces (see text).

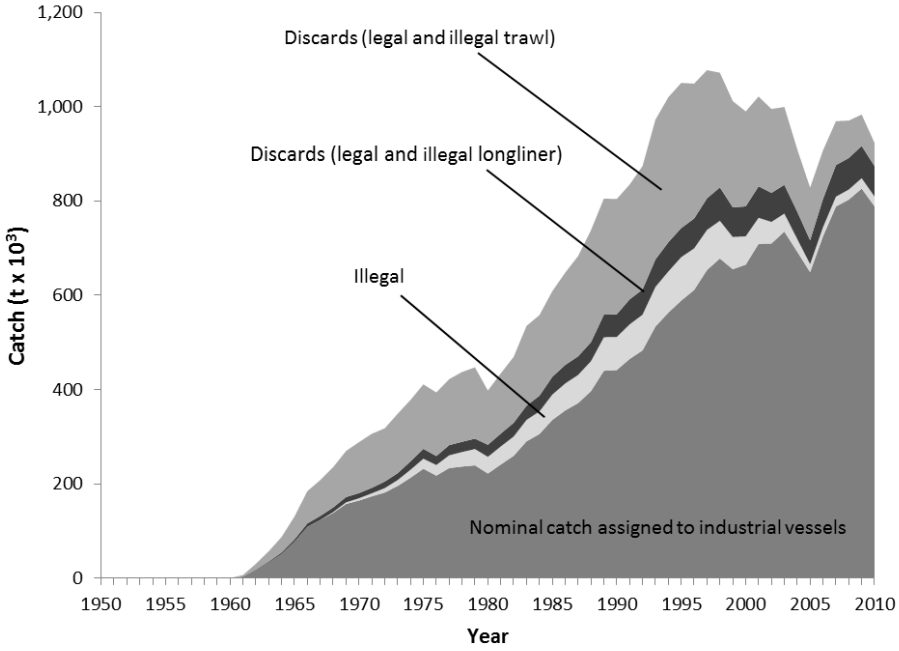

Figure 5. Reconstructed industrial fisheries catches for Western Indonesia (as defined in Figure 1), by components, 1950-2010 (see Appendix Table A4 for tabular data). Discards from longliners include non-targeted species, as well as post-finning shark carcasses. The catch decline in the early 1980s is mainly due to our procedure to mark the 1980 trawl ban, while the temporary catch decline in the early to mid-2000s, which appears to mark the 2004 tsunami, is discussed in the text.

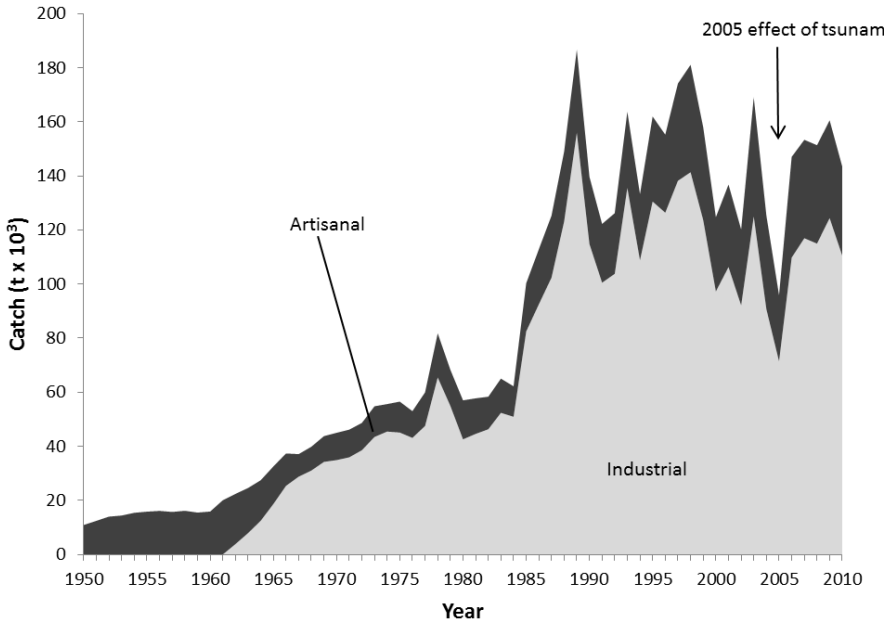

Figure 6. Nominal fisheries catch of Aceh Province (1950-2010), separated into artisanal and industrial catch (as described in the text), and exhibiting a drop in 2005, as would be expected given the devastation that followed the December 2004 tsunami. Note, however, similar catch fluctuations in the preceding years (see text).

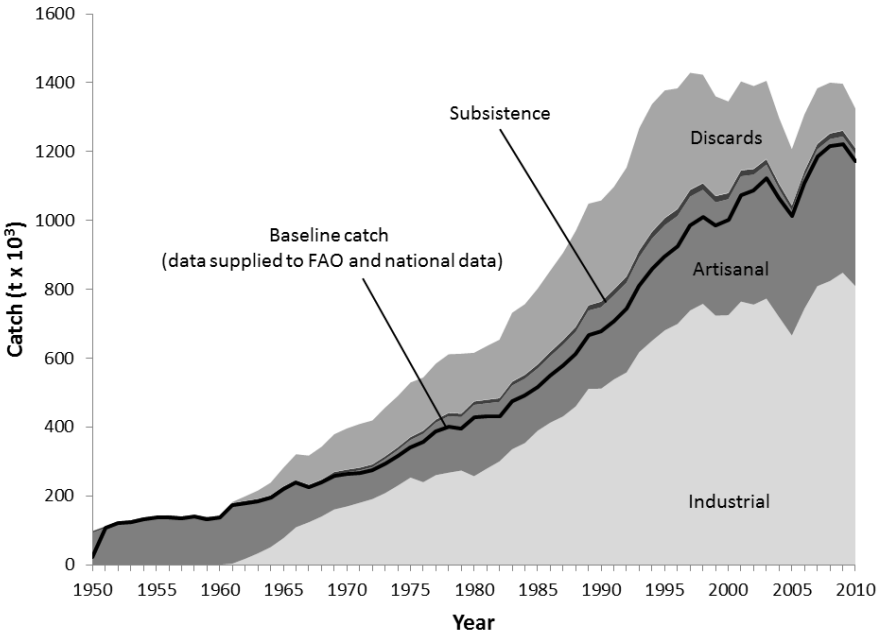

Figure 7. Total reconstructed catches for Western Indonesia (as defined in Figure 1), by sectors, 1950-2010 (see Appendix Table A4 for the corresponding tabular data). The catch of recreational fisheries is too small to be shown on this graph.

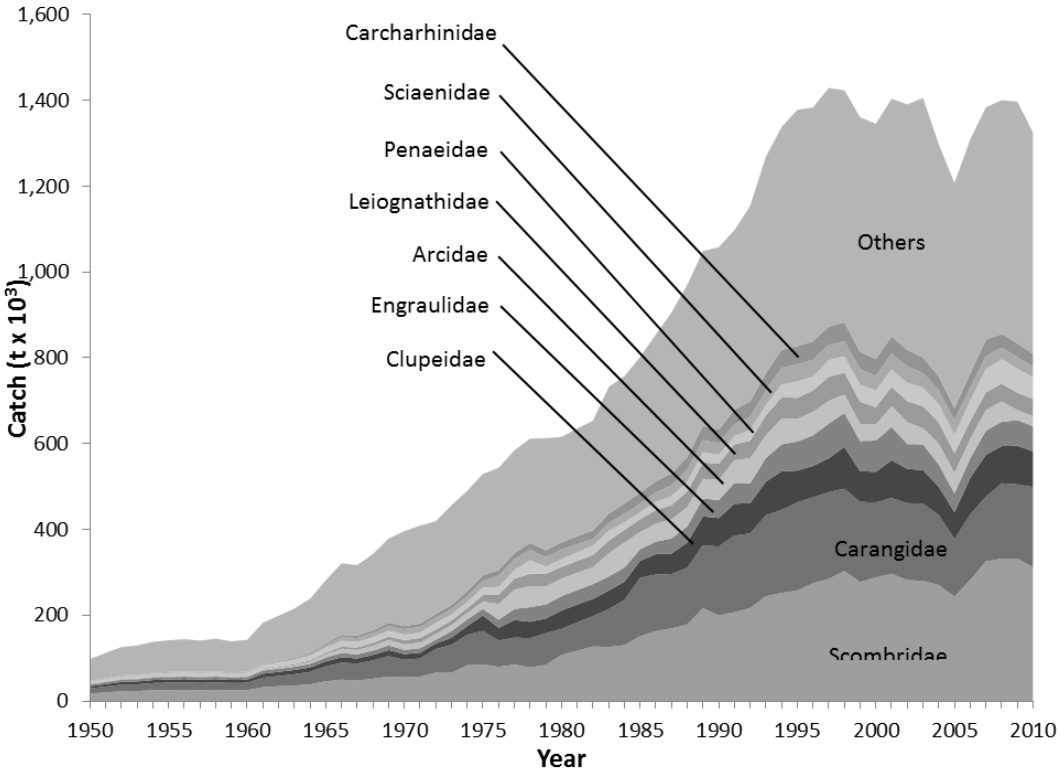

Figure 8. Total reconstructed catches for Western Indonesia (as defined in Figure 1), by major taxa, 1950-2010. All other taxa (n=28) were grouped into 'Others' (see Appendix Table A5 for the corresponding tabular data).

Appendix Table 1. Percentage (2000-2010) of the catch of taxa (in Indonesian statistics) that are caught by industrial gears (trawlers for demersal taxa, seiners or longliners for pelagic taxa), with the rest being artisanal fisheries. The percentages are the mean of estimates by the 3 authors, based on the characteristics of each taxon. Area A = Aceh, North Sumatra, West Sumatra, and Riau; Area B = Bengkulu, Lampung, Banten, West Java, Central Java, Special Region of Yogyakarta, and East Java.

Common name, Bahasa Indonesia (English)	**Scientific name**	**Area A**	**Area B**
Invertebrates			
Cephalopods			
Cumi-cumi (Common squids)	*Loligo* spp.	63	63
Sotong (Cuttlefishes)	*Sepia* spp.	70	70
Crustaceans			
Udang putih/Jerbung (Shrimps/prawns)	*Fenneropenaeus* spp.	63	60
Udang dogol (Metapenaeus shrimps)	*Metapenaeus* spp.	70	70
Binatang berkulit keras lainnya (Miscellaneous crustaceans)	Miscellaneous crustaceans	40	40
Udang lainnya (Miscellaneous shrimps)	Miscellaneous shrimps	60	60
Udang windu (Penaeus shrimps)	*Penaeus* spp.	72	72
Udang rebon (Akiami paste shrimp)	*Acetes* spp.	0	0
Molluscs			
Kerang darah (Granular ark)	*Tegillarca granosa*	8	8
Remis (Hard clams)	*Meretrix* spp.	10	10
Binatang lunak lainnya (Miscellaneous molluscs)	Miscellaneous molluscs	20	20
Jellyfishes			
Ubur-ubur (Rhopilema Jellyfishes)	*Rhopilema* spp.	22	23
Sea cucumbers			
Teripang (Sea cucumber)	*Stichopus* spp.	63	65
Teleostei (Bony fishes)			
Manyung (Giant catfish)	*Netuma thalassina*	77	77
Tongkol krai (Frigate tuna)	*Auxis thazard thazard*	82	82
Ekor kuning/Pisang-pisang (Redbelly yellowtail fusilier)	*Caesio cuning*	55	55
Kuwe (Jacks)	*Caranx* spp.	77	77
Selar (scads)	*Selaroides* spp.	75	75
Golok-golok/Parang-parang (Dorab wolf-herring)	*Chirocentrus dorab*	78	78
Ikan lidah (Tonguefishes)	Cynoglossidae	78	78
Ikan laying (Scads)	*Decapterus* spp.	77	75
Tongkol (Kawakawa)	*Euthynnus affinis*	86	86
Julung-julung (Halfbeaks)	*Hemiramphus* spp.	80	80
Cakalang (Skipjack tuna)	*Katsuwonus pelamis*	93	93
Kapas-kapas (False trevally)	*Lactarius lactarius*	77	77
Kakap putih (Barramundi)	*Lates calcarifer*	78	78
Peperek (Slipmouths or ponyfishes)	Leiognathidae	67	67
Kakap merah/Bambangan (Snappers)	*Lutjanus* spp.	78	78
Tetengkek (Torpedo scad)	*Megalaspis cordyla*	82	82
Ikan lainnya (Miscellaneous fishes)	Miscellaneous fishes	50	50
Belanak (Mullets)	Mugilidae	53	53
Biji nangka (Yellowstripe goatfish)	*Upeneus vittatus*	55	55
Kurisi (Ornate threadfin bream)	*Nemipterus hexodon*	75	75
Bawal putih (Silver pomfret)	*Pampus argenteus*	77	77
Bawal hitam (Black pomfret)	*Parastromateus niger*	80	80
Kuro/Senangin (Threadfins)	*Polynemus* spp.	75	75
Ikan sebelah (Indian halibut)	Psettodidae	80	80
Kembung (Short mackerel)	*Rastrelliger brachysoma*	80	80
Lemuru (Bali sardinella)	*Sardinella lemuru*	53	83
Tembang (Sardinellas)	*Sardinella* spp.	63	63
Gulamah/Tigawaja (Yellow drum)	*Nibea albiflora*	52	52
Tenggiri (Narrow-barred Spanish mackerel)	*Scomberomorus commerson*	77	77
Tenggiri papan (Indo-pacific king mackerel)	*Scomberomorus guttatus*	77	77
Kerapu karang (Chocolate hind)	*Cephalopholis boenak*	68	62
Teri (Anchovies)	*Stolephorus* spp.	53	50
Madidihang (Yellowfin tuna)	*Thunnus albacares*	88	88
Tuna mata besar (Bigeye tuna)	*Thunnus obesus*	92	92
Tongkol abu-abu (Longtail tuna)	*Thunnus tonggol*	88	88
Layur (Hairtails)	*Trichiurus* spp.	73	75
Elasmobranchii (Sharks and rays)			
Pari kembang/Pari macan (Stingrays)	*Dasyatis* spp.	78	78
Cucut lanyam (Sharks)	*Carcharhinus* spp.	80	80

Appendix Table A2. Organisms likely to be discarded by trawlers in Western Indonesia especially when they are juveniles; names and maximum lengths are from FishBase (www. fishbase.org), SeaLifeBase (www.sealifebase.org), and the *Sea Around Us* database (www.seaaroundus.org).

Common name (Bahasa Indonesia)	Common name (English)	Taxon name	Max. length (cm)
Kerang darah	Granular ark	*Tegillarca granosa*	4
Remis	Hard clams	*Meretrix* spp.	5
Sotong	Cuttlefishes	*Sepia* spp.	10
Peperek	Ponyfishes	Mainly *Leiognathus* spp.	12
Kuro/Senangin	Threadfins	*Polynemus* spp.	20
Selar	Yellowstipe scad	*Selaroides leptolepis*	20
Kerapu karang	Chocolate hind	*Cephalopholis boenak*	21
Kurisi	Threadfin bream	*Nemipterus* spp.	21
Cumi-cumi	Common squids	*Loligo* spp.	25
Biji nangka	Yellowstriped goatfish	*Upeneus vittatus*	25
Teripang	Sea cucumber	*Stichopus* spp.	40
Gulamah/Tigawaja	Yellow drum	*Nibea albiflora*	44
Julung-julung	Halfbeaks	*Hemiramphus* spp.	45
Layur	Hairtails	*Trichiurus* spp.	49
Ekor kuning/Pisang-pisang	Redbelly yellowtail fusilier	*Caesio cuning*	54
Ikan sebelah	India halibut	*Psettodes erumei*	60
Golok-golok/Parang-parang	Dorab wolf-herring	*Chirocentrus dorab*	100
Kuwe	Jacks	*Caranx* spp.	102
Belanak	Mullets	Mugilidae	120
Manyung	Giant catfish	*Netuma thalassina*	145
Pari kembang/Pari macan	Stingrays	*Dasyatis* spp.	150
Cucut lanyam	Sharks	*Carcharhinus* spp.	240

Appendix Table A3. Organisms usually discarded, irrespective of their size and age, and included in the 'miscellaneous fishes group'. Names are from FishBase (www.fishbase.org).

Family name	Common name (English)
Anacanthidae	Leatherjackets
Antennaridae	Frogfishes
Apogonidae	Cardinalfishes
Balistidae	Triggerfishes (except for *Abalistes stellaris)*
Blenniidae	Combtooth blennies
Callionymidae	Dragonets
Centriscidae	Snipefishes and shrimpfishes
Chaetodontidae	Butterflyfishes
Dactylopteridae	Flying gurnards
Diodontidae	Porcupinefishes (burrfishes)
Echeneidae	Remoras
Fistulariidae	Cornetfishes
Gobiidae	Gobies
Labridae	Wrasses (except for *Napoleon wrasse*)
Monocanthidae	Filefishes
Ostraciidae	Boxfishes
Parapercidae	Grub fish
Platycephalidae	Flatheads
Pomacanthidae	Angelfishes
Pomacentridae	Damselfishes
Scaridae	Parrotfishes (<25 g)
Scorpaeonidae	Scorpionfishes
Syngnathidae	Pipefishes
Tetraodontidae	Puffers
Triacanthidae	Triplespines
Triglidae	Searobins
Uranoscopidae	Stargazers

Appendix Table A4. Reported landings vs. reconstructed total catch (in tonnes), and catch by sector, with discards shown separately, for Western Indonesia, 1950-2010.

Year	Reported landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discard
1950	21,426	98,400	0	93,200	4,720	444	0
1951	106,866	112,100	0	106,900	4,800	452	0
1952	120,495	125,800	0	120,500	4,890	460	0
1953	124,065	129,500	0	124,100	4,980	468	0
1954	132,358	138,000	0	132,400	5,140	483	0
1955	136,060	141,700	0	136,100	5,180	487	0
1956	138,363	144,200	0	138,400	5,290	498	0
1957	134,934	140,900	0	134,900	5,410	509	0
1958	139,117	145,200	0	139,100	5,530	521	0
1959	133,088	139,300	0	133,100	5,660	533	0
1960	136,478	142,800	0	136,500	5,800	522	0
1961	173,097	182,600	3,380	169,700	5,940	535	2,980
1962	179,470	198,900	17,300	162,200	6,090	548	12,770
1963	185,137	215,600	33,150	152,000	6,250	562	23,670
1964	195,418	238,500	51,120	144,300	6,410	576	36,060
1965	220,717	281,500	76,980	143,700	6,570	591	53,590
1966	238,047	321,000	108,880	129,200	6,750	606	75,580
1967	224,605	317,000	123,380	101,500	6,920	622	84,520
1968	238,156	342,700	139,980	99,800	7,100	638	95,150
1969	258,738	378,900	160,660	101,400	7,290	655	108,930
1970	263,877	395,900	169,310	99,400	7,480	672	119,050
1971	267,637	408,800	179,910	94,200	7,670	689	126,260
1972	274,363	419,100	190,840	92,800	7,860	706	126,820
1973	294,280	456,400	207,890	99,000	8,060	724	140,700
1974	315,970	490,100	229,870	103,100	8,260	742	148,130
1975	341,242	529,400	253,240	109,300	8,460	761	157,660
1976	358,068	543,900	239,920	140,700	8,670	779	153,820
1977	385,875	584,500	260,390	152,500	9,000	798	161,730
1978	400,656	611,500	267,490	164,100	9,340	818	169,730
1979	394,533	613,000	273,670	155,400	9,670	837	173,350
1980	429,028	615,800	257,230	207,200	10,010	857	140,510
1981	430,537	635,200	279,180	189,600	10,340	876	155,130
1982	432,074	653,600	300,280	172,900	10,680	897	168,920
1983	475,291	732,000	335,590	185,100	11,010	917	199,430
1984	492,653	757,100	353,580	187,000	11,350	937	204,260
1985	516,366	802,000	389,330	180,900	11,680	956	219,220
1986	548,639	854,600	412,860	193,100	12,590	976	235,120
1987	579,435	906,000	431,040	208,200	13,500	995	252,300
1988	613,210	970,100	460,140	216,600	14,410	1,014	277,880
1989	667,052	1,048,900	510,960	227,300	15,320	1,033	294,200
1990	677,989	1,058,100	511,620	236,600	16,230	1,052	292,590
1991	709,243	1,097,600	538,380	244,200	17,140	1,070	296,750
1992	743,842	1,154,100	558,710	260,700	18,050	1,089	315,470
1993	809,742	1,268,700	617,860	276,000	18,960	1,107	354,720
1994	859,946	1,338,100	650,550	296,800	19,870	1,125	369,690
1995	894,198	1,378,000	680,840	305,400	20,780	1,143	369,800
1996	924,754	1,383,900	699,400	313,600	20,180	1,160	349,580
1997	984,435	1,429,000	738,710	330,700	19,570	1,178	338,840
1998	1,009,182	1,423,500	757,950	331,200	18,960	1,195	314,230
1999	984,411	1,360,600	723,640	329,000	18,360	1,212	288,330
2000	1,001,816	1,345,900	725,000	336,900	17,750	1,230	265,060
2001	1,073,235	1,404,100	764,390	364,100	17,150	1,248	257,220
2002	1,087,543	1,390,600	755,660	377,600	16,540	1,266	239,570
2003	1,124,118	1,405,800	773,290	388,900	15,940	1,284	226,330
2004	1,063,855	1,297,700	719,250	371,500	15,330	1,303	190,340
2005	1,012,047	1,207,300	665,980	363,000	14,730	1,322	162,270
2006	1,110,076	1,308,900	744,510	384,800	15,220	1,341	163,020
2007	1,185,849	1,384,000	809,160	397,600	15,720	1,360	160,240
2008	1,215,235	1,400,600	824,310	412,300	16,220	1,379	146,350
2009	1,222,141	1,397,300	848,360	395,800	16,720	1,398	135,070
2010	1,172,322	1,325,200	809,310	383,600	17,220	1,417	113,630

Appendix Table A5. Reconstructed total catch (in tonnes) for Western Indonesia, by major taxa, 1950-2010. 'Others' contain 28 additional taxonomic categories.

Year	Scombridae	Carangidae	Clupeidae	Engraulidae	Arcidae	Leiognathidae	Penaeidae	Carcharhinidae	Other
1950	17,700	12,000	5,000	3,890	83	1,140	5,233	1,365	387
1951	20,200	13,600	5,750	4,450	82	1,260	5,983	1,588	453
1952	22,700	15,200	6,490	5,010	81	1,380	6,733	1,810	519
1953	23,300	15,600	6,640	5,170	81	1,410	7,054	1,867	533
1954	25,100	16,800	7,120	5,490	122	1,510	7,445	1,921	559
1955	25,700	17,100	7,300	5,640	122	1,570	7,765	1,976	572
1956	26,200	17,400	7,390	5,750	122	1,590	8,127	2,035	587
1957	25,500	16,900	7,210	5,580	122	1,550	8,110	1,984	575
1958	26,300	17,500	7,480	5,770	122	1,600	7,964	2,041	588
1959	25,100	16,700	7,120	5,490	123	1,530	8,202	1,934	564
1960	25,600	17,100	7,240	5,620	123	1,590	8,335	1,992	578
1961	32,400	22,000	9,240	7,160	532	1,960	10,162	2,790	785
1962	34,500	24,100	9,610	7,420	1,876	2,220	10,585	3,538	1,302
1963	36,300	26,200	9,900	7,660	3,344	2,570	10,733	4,396	1,908
1964	39,000	29,100	10,450	8,100	4,969	2,970	11,330	5,412	2,588
1965	46,200	34,400	11,770	9,120	7,222	3,660	12,352	6,909	3,659
1966	49,800	39,600	12,780	9,880	9,748	4,990	13,628	8,617	4,950
1967	48,100	39,400	12,010	9,320	10,458	5,680	13,042	8,993	5,572
1968	52,000	42,800	12,840	9,950	11,233	6,800	13,171	9,824	6,386
1969	57,300	47,600	14,050	10,860	12,355	8,140	14,009	11,066	7,325
1970	55,400	40,600	13,370	9,970	12,948	9,810	12,777	12,555	7,449
1971	57,200	42,100	13,670	10,120	13,268	10,780	12,550	13,052	7,942
1972	66,300	54,900	13,120	8,820	13,173	10,240	15,436	12,319	8,549
1973	65,900	65,300	16,450	15,250	14,437	10,620	13,578	13,057	9,457
1974	83,800	70,700	20,260	15,790	15,293	10,440	14,433	14,274	11,471
1975	85,400	77,800	36,400	15,230	16,882	15,530	17,122	15,418	13,119
1976	79,800	61,400	29,480	19,100	36,478	21,900	17,662	26,675	13,311
1977	85,200	62,700	41,030	25,830	44,681	25,950	20,082	25,094	14,725
1978	78,600	68,100	38,100	33,980	49,091	28,530	31,800	24,371	15,610
1979	84,500	73,500	34,570	32,390	42,323	29,550	16,882	22,111	15,476
1980	107,300	61,000	43,080	33,410	40,701	27,020	17,828	22,922	16,970
1981	117,200	65,900	41,760	33,850	40,121	27,930	19,709	19,188	18,559
1982	127,200	70,600	40,440	34,290	39,343	28,960	21,621	15,282	20,162
1983	126,100	88,000	43,350	33,070	54,093	29,180	23,040	18,123	21,889
1984	130,400	105,300	42,480	32,890	58,202	29,540	17,962	20,064	23,627
1985	151,300	135,700	40,000	26,950	39,988	29,910	15,768	20,287	25,231
1986	162,900	132,100	47,500	29,120	41,535	31,650	18,805	22,611	26,835
1987	169,400	126,600	48,110	34,850	45,093	32,680	20,997	25,355	27,160
1988	178,600	132,000	59,220	37,700	44,640	36,830	22,055	28,973	29,328
1989	216,500	146,900	67,100	41,630	45,918	38,360	23,900	28,397	32,901
1990	199,500	160,600	66,560	41,710	47,433	37,450	20,472	27,610	31,371
1991	207,100	178,600	74,380	48,640	52,926	37,100	19,567	27,227	33,485
1992	216,600	173,900	70,690	46,610	58,468	40,690	24,200	31,612	35,793
1993	244,500	188,200	78,890	54,900	53,067	46,400	23,912	34,834	39,973
1994	252,000	193,600	89,840	63,140	59,922	49,410	30,127	38,786	41,985
1995	257,600	205,400	74,470	67,670	52,603	49,320	37,906	40,003	42,333
1996	274,700	200,200	73,390	71,200	54,896	49,740	32,326	39,255	42,943
1997	285,200	201,700	79,270	80,890	52,741	56,250	38,694	35,677	42,582
1998	303,100	191,800	97,650	78,700	43,406	50,930	37,740	35,865	43,473
1999	277,500	186,400	71,550	70,700	39,810	51,640	39,201	36,840	39,923
2000	288,200	175,000	71,570	72,590	37,667	40,200	39,418	32,965	39,551
2001	296,700	176,500	88,370	77,440	48,404	44,960	40,406	37,135	40,139
2002	281,900	179,600	79,940	57,960	50,909	48,520	42,563	39,217	37,556
2003	280,300	179,500	78,290	60,170	38,006	51,350	43,238	33,655	36,298
2004	270,400	163,300	65,940	51,830	48,479	49,390	42,556	32,258	32,144
2005	243,300	133,800	63,200	44,020	47,409	46,210	42,736	34,258	27,789
2006	282,200	152,400	85,350	45,440	45,421	42,010	47,061	30,920	32,960
2007	325,600	150,700	98,050	56,320	47,700	41,590	54,467	29,481	38,204
2008	332,000	175,700	86,620	56,560	47,651	41,160	56,961	27,625	31,375
2009	331,900	173,300	89,900	59,710	23,800	40,060	56,622	26,169	32,409
2010	311,600	187,300	83,440	58,530	23,674	39,690	50,124	24,602	30,244

Appendix Table A6. Total reconstructed catches for provinces (Aceh, North Sumatra, West Sumatra, and Riau, in part) covered by the BOBLME, by sector, 1950 – 2010.

Year	Reported landings	Reconstructed total catch	Industrial (Legal)	Industrial (Illegal)	Artisanal	Subsistence	Discards
1950	15,600	70,500	0	0	67,900	2,650	0
1951	77,768	80,500	0	0	77,800	2,690	0
1952	87,652	90,400	0	0	87,700	2,740	0
1953	90,303	93,100	0	0	90,300	2,790	0
1954	96,386	99,300	0	0	96,400	2,880	0
1955	99,037	101,900	0	0	99,000	2,910	0
1956	100,773	103,700	0	0	100,800	2,970	0
1957	98,245	101,300	0	0	98,200	3,040	0
1958	101,236	104,300	0	0	101,200	3,110	0
1959	96,933	100,100	0	0	96,900	3,180	0
1960	99,474	102,700	0	0	99,500	3,260	0
1961	125,881	132,200	3,380	0	122,500	3,340	2,980
1962	130,685	146,900	17,300	0	113,400	3,420	12,770
1963	134,761	161,800	32,990	0	101,800	3,510	23,540
1964	142,207	181,600	50,780	0	91,400	3,600	35,780
1965	161,020	217,400	75,780	0	85,200	3,690	52,670
1966	173,274	247,300	100,880	0	72,400	3,790	70,240
1967	163,565	243,100	109,240	294	54,300	3,880	75,390
1968	173,285	260,000	116,930	1,639	56,400	3,990	81,120
1969	188,216	284,800	127,000	3,318	61,200	4,090	89,160
1970	190,046	291,800	126,080	4,794	64,000	4,200	92,750
1971	192,667	298,400	127,830	6,395	64,800	4,300	95,070
1972	199,295	308,400	134,730	8,412	64,600	4,410	96,240
1973	214,855	338,100	146,790	10,874	68,100	4,520	107,810
1974	233,577	367,700	161,870	14,347	71,700	4,640	115,100
1975	243,030	384,700	166,240	16,826	76,800	4,750	120,050
1976	234,480	355,800	135,110	15,600	99,400	4,860	100,850
1977	247,674	374,800	141,610	17,827	106,100	5,070	104,220
1978	256,401	390,600	142,790	19,973	113,600	5,280	108,920
1979	243,337	377,700	139,370	21,277	104,000	5,490	107,560
1980	259,699	372,200	124,060	20,685	135,600	5,700	86,130
1981	249,615	367,300	129,900	21,618	119,700	5,900	90,200
1982	239,532	360,500	134,220	22,323	105,300	6,110	92,530
1983	263,547	404,700	149,420	24,281	114,100	6,320	110,570
1984	288,955	442,700	166,440	27,060	122,500	6,530	120,200
1985	305,292	476,400	191,450	32,211	113,800	6,740	132,160
1986	332,723	520,100	209,110	35,301	123,600	6,990	145,130
1987	356,119	556,800	222,190	37,442	133,900	7,250	156,020
1988	377,472	596,400	237,610	39,695	139,900	7,500	171,770
1989	420,204	663,000	271,410	46,006	148,800	7,760	189,050
1990	415,288	650,200	263,250	43,507	152,000	8,010	183,360
1991	422,053	655,900	268,720	43,897	153,300	8,260	181,720
1992	436,313	679,700	274,790	44,360	161,500	8,520	190,460
1993	488,724	772,900	315,450	51,392	173,300	8,770	224,010
1994	497,190	780,100	317,150	50,541	180,000	9,030	223,360
1995	553,529	860,400	360,340	57,779	193,200	9,280	239,790
1996	574,422	864,400	374,480	55,673	199,900	9,210	225,120
1997	582,174	847,600	379,110	50,686	203,100	9,130	205,600
1998	627,586	889,400	414,620	50,318	213,000	9,050	202,450
1999	606,469	840,000	401,380	42,873	205,100	8,980	181,720
2000	619,120	832,800	412,040	37,942	207,100	8,900	166,800
2001	642,263	842,200	427,060	34,065	215,200	8,830	157,080
2002	619,943	797,500	407,310	26,794	212,600	8,750	142,020
2003	680,922	855,600	452,460	23,962	228,500	8,670	141,990
2004	638,048	778,300	408,500	16,259	229,600	8,600	115,370
2005	597,690	711,800	374,660	10,047	223,000	8,520	95,520
2006	675,607	795,500	435,190	11,975	240,400	8,750	99,170
2007	752,701	876,800	497,010	13,590	255,700	8,990	101,560
2008	749,077	859,900	485,650	13,439	263,400	9,220	88,150
2009	754,483	860,600	508,330	14,041	246,200	9,450	82,610
2010	723,760	816,500	490,000	13,119	233,800	9,680	69,940

Appendix Table A7. Total reconstructed catches for provinces (Aceh, North Sumatra, West Sumatra, and Riau, in part) covered by the BOBLME, by major taxa, 1950 – 2010.

Year	Scombridae	Carangidae	Arcidae	Engraulidae	Penaeidae	Clupeidae	Sciaenidae	Polynemidae	Others
1950	15,000	8,680	62	1,640	4,240	2,770	1,150	1,990	34,900
1951	17,200	9,820	62	1,880	4,840	3,190	1,340	2,300	39,900
1952	19,300	10,950	62	2,120	5,440	3,610	1,530	2,600	44,800
1953	19,800	11,270	62	2,180	5,690	3,690	1,580	2,660	46,100
1954	21,400	12,090	93	2,320	6,020	3,960	1,620	2,850	48,900
1955	21,900	12,360	93	2,390	6,270	4,060	1,670	2,910	50,300
1956	22,300	12,570	93	2,430	6,560	4,110	1,720	2,970	51,000
1957	21,700	12,220	93	2,360	6,530	4,010	1,680	2,880	49,800
1958	22,400	12,650	93	2,440	6,420	4,160	1,730	2,970	51,500
1959	21,400	12,060	93	2,320	6,600	3,960	1,640	2,850	49,200
1960	21,800	12,330	93	2,380	6,700	4,030	1,680	2,920	50,800
1961	27,600	15,930	504	3,030	8,180	5,130	2,400	4,250	65,200
1962	29,400	17,730	1,847	3,140	8,530	5,350	3,140	5,190	72,500
1963	31,100	19,660	3,305	3,240	8,640	5,500	3,970	6,180	80,200
1964	33,500	22,190	4,930	3,420	9,120	5,820	4,950	7,400	90,300
1965	40,000	26,510	7,151	3,860	9,980	6,550	6,380	9,330	107,600
1966	42,700	30,500	9,530	4,180	10,980	7,110	7,790	11,190	123,300
1967	41,000	30,150	10,130	3,950	10,490	6,690	7,960	10,890	121,900
1968	44,100	32,440	10,743	4,230	10,660	7,170	8,470	11,700	130,500
1969	48,400	35,650	11,682	4,630	11,370	7,890	9,320	12,870	143,000
1970	46,600	29,810	12,057	4,270	10,440	6,960	10,270	12,110	159,200
1971	47,900	30,500	12,236	4,350	10,290	7,150	10,450	12,380	163,100
1972	55,600	39,400	12,182	3,790	12,750	6,760	9,890	11,630	156,400
1973	54,800	50,220	13,218	6,560	10,980	11,380	10,340	25,100	155,400
1974	71,100	52,930	14,273	6,520	12,540	12,530	11,600	26,280	159,900
1975	68,100	54,960	15,955	6,740	12,890	16,830	12,900	23,080	173,200
1976	56,900	27,400	34,912	10,390	13,540	14,890	22,800	9,020	165,900
1977	59,300	30,930	43,247	15,190	15,970	17,510	20,490	10,890	161,300
1978	53,400	33,940	46,505	19,600	24,400	16,200	19,640	12,620	164,300
1979	56,500	33,500	40,196	18,600	11,700	11,570	16,200	12,280	177,100
1980	66,300	30,990	39,183	17,550	13,070	10,790	17,640	10,920	165,700
1981	68,500	32,970	38,280	17,680	14,240	10,960	13,050	11,330	160,300
1982	70,700	34,700	37,140	17,810	15,430	11,130	8,220	11,550	153,900
1983	66,700	42,310	51,582	18,270	16,210	10,650	10,200	11,980	176,800
1984	72,600	51,120	55,569	18,710	13,120	13,170	11,800	12,310	194,300
1985	96,900	64,710	37,386	14,780	10,490	15,320	12,400	12,970	211,400
1986	105,800	65,850	38,278	17,340	12,740	19,930	13,880	13,900	232,400
1987	110,800	66,400	40,545	22,750	14,860	20,950	14,530	16,280	249,700
1988	122,500	73,220	40,921	24,480	15,290	18,860	15,410	16,530	269,300
1989	154,500	83,280	41,615	25,040	17,730	19,570	16,990	16,990	287,300
1990	135,900	88,870	42,769	23,140	14,100	19,550	15,730	16,680	293,500
1991	137,200	95,870	47,620	28,820	13,740	20,740	16,700	15,970	279,200
1992	137,800	93,130	52,503	27,550	17,520	16,170	18,890	17,150	298,900
1993	160,500	105,600	46,675	34,100	17,330	21,950	21,190	18,660	346,900
1994	160,100	95,040	52,224	42,660	22,460	20,890	23,500	18,540	344,800
1995	179,600	104,370	46,412	48,920	31,250	20,770	25,940	24,980	378,200
1996	189,500	103,390	49,369	49,480	25,850	23,930	25,650	22,120	375,200
1997	192,600	96,140	45,842	55,070	31,610	22,140	21,930	20,470	361,800
1998	212,000	93,840	37,644	61,590	30,720	25,170	22,560	21,100	384,800
1999	188,100	92,470	33,468	53,700	31,010	29,720	23,070	19,660	368,800
2000	199,700	91,350	31,841	53,150	30,510	29,090	20,570	18,490	358,100
2001	204,200	87,830	31,525	57,230	32,220	31,920	23,120	18,650	355,500
2002	178,200	89,480	35,835	37,290	34,480	22,160	25,380	16,570	358,100
2003	192,800	96,340	28,813	46,430	34,960	27,890	21,790	20,950	385,600
2004	174,400	80,370	36,033	33,840	34,310	18,340	20,590	16,350	364,000
2005	150,800	70,890	39,064	28,330	35,590	16,230	22,290	14,660	333,900
2006	185,400	88,390	39,244	32,440	36,350	20,840	21,630	16,810	354,500
2007	223,400	90,840	37,579	37,380	47,990	39,800	20,350	15,980	363,500
2008	212,500	104,810	43,123	40,650	45,610	35,950	17,780	12,280	347,200
2009	214,300	105,310	18,932	47,060	49,340	32,520	17,150	12,330	363,600
2010	209,600	121,370	19,119	43,580	42,440	34,700	15,530	11,060	319,100