

# RECONSTRUCTING SINGAPORE'S MARINE FISHERIES CATCH, 1950-2010<sup>1</sup>

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## ABSTRACT

This contribution presents a reconstruction of the marine fisheries catch by Singaporean fishers around Singapore, i.e., within what is now the Exclusive Economic Zone (EEZ) of Singapore (i.e., the 'inshore fishery'), and in the Malaysian EEZ and beyond. Reconciled data from various sources suggest that the marine fisheries of Singapore (including time series estimates of unreported subsistence and recreational catches) peaked above 30,000 t·year<sup>-1</sup> in the early to mid 1980s, and then rapidly declined, with commercial activity in the 2000s yielding one tenth of their previous maximum.

## INTRODUCTION

Singapore is a small island state located at the tip of the Malaysian Peninsula, in the Southern South China Sea (Figure 1). Formerly a British colony, Singapore, upon independence from Britain (in 1963) joined with present-day Malaysia the former 'Federation of Malaya', which it left in 1965.

Le Mare (1949) reported that the fishing industry of Singapore started rebuilding soon after the WWII Japanese occupation ended. Work was then focused on establishing effective service and information recording (e.g., licensing, number of fishers, prices) towards development of the fisheries, with the aim of providing for the growing population. Notably, the capacity for transporting catches was a concern, documented by their first known case of dumping catch back into sea (i.e., discarding).

A Fisheries Survey project was implemented starting in 1950, which addressed the issues of unmet fish demand, irregular supplies and quality, high prices, and to curtail the unfair practices that resulted in poor returns to fishers. Consequently, catch figures from Singapore's waters were made available, based on data gathering following a sound statistical design (Kesteven and Burdon 1952).

There were already signs of heavy exploitation of Singapore waters in the early 1950s, as the exceptional profitability of fishing in 1951 and early 1952 led to an intensification of fishing. However, catch did not increase correspondingly (Burdon 1952). Indeed, Burdon (1952) suggested that the maximum catch for Singapore's marine fishing grounds could not exceed 4,000 "long tons per annum."

The fish survey project not only acquired detailed catch composition, number of fishers, fishing vessels and licensed gears by types (some of these data are now also available online), but also determined the importance of gear, depth, location as well as annual, lunar, daily and tidal cycles on Singapore's fishery and its productivity (Kesteven and Burdon 1952). Even low-value 'waste' (or 'trash') fish catches were reported, separately until 1956, before they were incorporated into the regular catch statistics. Thus, a practice of generating solid, quantitative data for the purpose of guiding the design, establishment, development and eventually management of the infrastructure of Singapore's fishing industry, attuned to its limiting factors (be these ecological, economic or political) was established early.



**Figure 1.** Exclusive Economic Zone (EEZ) for Singapore.

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The conflicts between the limited catch that could be extracted from Singapore's waters and the growing demand for fish in Singapore lead to an early geographic expansion of its marine fisheries. Thus, the report by Burdon (1952) mentions the exploitation by licensed Singaporean vessels of fishing grounds well outside of what was later to become Singapore's Exclusive Economic Zone (EEZ), notably off the Malaysian States of Johore and Trengganu. This included fishing for coral reef fishes with a very destructive method known as *'muro-ami'* (Butcher 2004) along the east coast of Peninsular Malaysia (which continued until 1959), and fishing for skipjack tuna (*Katsuwonus pelamis*) in the open waters of the southern South China Sea. This early, more or less spontaneous expansion later became explicit Government policy, along with an accelerated development of the aquaculture industry.

Time series data on marine capture fisheries landings in Singapore (1950-2010) were obtained from FAO, Southeast Asian Fisheries Development Center (SEAFDEC) and national publications (Table 1). Information in national publications is also helpful in identifying catches originating from within and outside the Singaporean EEZ. However, the available time series differ from each other (Figure 2), and thus require harmonization. This study, thus, aims at reconciling the available catch time series and, in the process, generate a credible catch time series of Singapore's marine capture fisheries within and outside of its EEZ.

## MATERIALS AND METHOD

### Singapore's population

Estimates of the population sizes of Singapore for 1960-2012 was downloaded from the World Bank online databank<sup>2</sup> and used for this contribution. Population sizes for 1950-1959 were estimated using interpolation based on data from the World Bank in addition to the census figures of Singapore for 1947 and 1957 (being 938,200 and 1,445,900 respectively).

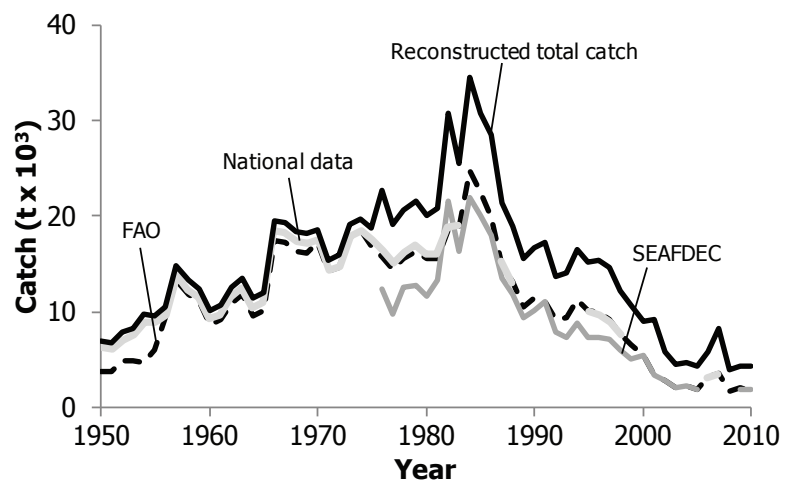
### Fishery types

In this report, given the smallness of the Singaporean EEZ (Figure 1), 'inshore fisheries' are equivalent to small-scale fisheries within the EEZ of Singapore, while industrial fisheries are those that operate outside of the Singaporean EEZ. The inshore (or 'small-scale') fisheries are further subdivided into artisanal fisheries, which sell their catch to the market, recreational fisheries, where fishing is for pleasure, and subsistence fisheries, where catches are for the direct consumption of the fishers and their families. The small-scale fisheries uses mainly motorized crafts, with non-motorized units essentially phased out by the late 1990s (Table 2).

<sup>2</sup> <http://databank.worldbank.org/data/home.aspx>

**Table 1.** National data sources with information on Singapore's fisheries catches.

Years	Primary sources	Complementary sources
1950 – 1952	Report of the Fisheries Department (Burdon 1951, 1952, 1953)	—
1953 – 1958	Report of the Fisheries Division (Singapore Department of Commerce and Industry 1955; Tham Ah Kow 1955; Singapore Department of Commerce and Industry 1956; Singapore Ministry of Commerce and Industry 1957, 1959)	—
1959	Report of Fisheries Division (Singapore Ministry of National Development 1961)	—
1960 – 1965	Review of the Primary Production Department (Singapore Primary Production Department 1966)	—
1966 – 1974	Primary Production Department Annual Report (Singapore Primary Production Department 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974)	—
1975 – 1999	Ministry of National Development Annual Report (Singapore Ministry of National Development 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1987, 1988, 1989, 1990, 1991)	Yearbook of Statistics (Singapore Department of Statistics 1974-75, 1975-76, 1976-77, 1977-78, 1978-79, 1979-80, 1980-81, 1981-82, 1982-83, 1983-84, 1985-86, 1986, 1987, 1988, 1989, 1990, 1991, 1996)
1976 – 2005	Southeast Asian Fisheries Development Center ( <a href="http://fishstat.seafdec.org/">http://fishstat.seafdec.org/</a> ; last accessed 12 July 2013)	—
2006–2007	Agri-Food & Veterinary Authority of Singapore (AVA).	<a href="http://www.ava.gov.sg/">www.ava.gov.sg/</a> ; last accessed 27 June '13; data for 2000-2011.



**Figure 2.** Reported and reconstructed catch for Singapore (including recreational and subsistence catches).

Reported and reconstructed catch for Singapore (including recreational and subsistence catches).



### Commercial (artisanal and industrial)

Resources accessed for catch information, fisheries related development and political activities are available to the public through the National Library of Singapore or through the Internet. Sources used to complement the main data sets other than the FAO FishStat database are presented in Table 1. Other species composition data from 1976 onwards are available online through the website of the Southeast Asian Fisheries Development Center (SEAFDEC).<sup>3</sup> However, it could not be ascertained if local catch composition data for 1950 to 1975 have survived the successive transfers of the former Fisheries Department and its changes in strategy (see [www.ava.gov.sg/AboutAVA/History/](http://www.ava.gov.sg/AboutAVA/History/) accessed 18 March 2012). Currently the different components of the former Fisheries Department are subsumed under the Agri-Food & Veterinary Authority of Singapore (AVA).

### Discards

The quantities of landed ‘waste’ or ‘trash’ fish, defined as fish used as animal feed and fertilizers in Burdon (1952), or as “small, low-valued species” in Sinoda *et al.* (1978) were published for the years 1950-1956 and 1974-1975 (Table 3). Data on ‘waste’ fish were added when available, and interpolated between years when they were not, and weight units, reported in ‘long tons’ until 1968, were all converted to (metric) tonnes. Data reported by Sinoda *et al.* (1978) for 1974-75 were portions of trawl catches only such that their proportions in relation to the total (1974, reconstructed; 1975, national) catch data for the years in question were calculated. Likewise, 1950-1956 figures were converted into proportions of total catch for their respective years, such that a mean ‘waste’ fish component could be calculated. Then, the resulting mean was multiplied by the values reported for ‘marine fishes nei’ for the rest of the years to distinguish between ‘marine fishes nei’ and ‘marine fishes nei (waste)’.

**Table 3.** Amount of so-called ‘waste’ fish that was landed in Singapore, 1950– 1975 for use as animal feed or fertiliser.

Year	Amount (t)	Source
1950	2,670	Burdon (1951)
1951	1,849	Burdon (1952)
1952	1,486	Burdon (1953)
1953	1,919	Tham Ah Kow (1955)
1954	2,615	Singapore Department of Commerce and Industry (1955)
1955	2,709	Singapore Department of Commerce and Industry (1956)
1956	3,641	Singapore Ministry of Commerce and Industry (1957)
1974	1,574	Sinoda <i>et al.</i> (1978)*
1975	1,156	—

\* The amounts reported by Sinoda *et al.* (1978) pertain only to Kangkar fish market, which was, however, a major fish landing site.

Due to the early and detailed focus of Singapore authorities and fisheries on optimizing the utilization of resources, Singapore fisheries utilised and landed non-targeted by-catch efficiently, resulting in the virtual absence of discarding, so common in other fisheries and countries. Thus, no discards could be estimated here. While these landed and utilized ‘waste’ fish were nationally recorded, this study suggests these data were not incorporated into the data Singapore reported to the FAO.

### Taxonomic composition (excluding discards)

The commercial reconstructed catches were disaggregated into taxa by maintaining the available inshore (artisanal) and offshore (industrial) catch compositions, and interpolating for years where this information was unavailable.

No national data were found on the taxonomic composition of marine fisheries catches for 1953-1955, and thus the mean catch composition for 1950-1952 was used for these years, as this was more detailed than FAO data for 1953-1955. FAO’s taxonomic catch composition was used to disaggregate, for each year from 1956 to 1975 the highest of either Singapore national data or FAO data. From 1976-onwards, FAO and SEAFDEC data were used and compared to each other. Catches of taxa unique to each data set were adopted as presented. For taxa occurring in both sets of statistics, the higher value was used for reconstructing the amounts of each taxonomic category.

Exceptions were made when the catches were unusually low compared with preceding and succeeding entries (1980, artisanal; 1987, industrial; 1989, artisanal), i.e., when the number of fishers and fishing vessels indicated it was better to replace them also with interpolated values; also the catch composition for 2007 was used for 2008.

The number of commercial crabbers from 1971-2010 was set as the mean of crab licenses issued from 1950 to 1970 making it possible for ‘*Indo-Pacific swamp crab*’ and ‘*marine crabs nei*’ catches in the time series to be estimated for missing years (mainly in the first half of the series) using a regression of crab catch against number of reported crab licenses in the later years.

### Recreational fishing

Weekends and public holidays are the usual days for recreational fishing in Singapore. For example, in June 2013, a photograph of a 40 kg giant trevally (*Caranx ignobilis*) caught and released within the local waters of Singapore was posted.<sup>4</sup> The earliest report of recreational fishing found in the present study was a feature in ‘*The Straits Times*’, 24 July 1938, mentioning catches of almost 100 catties (60.5kg) from Singapore Straits. Highlights of the

<sup>3</sup> <http://fishstat.seafdec.org/>

<sup>4</sup> <http://www.fishingkaki.com/forum/viewtopic.php?t=244278>



day's catch were a 24 lbs (10.8 kg) bass and an 8 lbs painted sweetlip (3.6 kg). Presently, boats vary from 23 ft fiberglass open deck (outboard) to 53 ft wooden (inboard) boats<sup>5</sup> and they can be chartered for fishing any day of the week. Average number of anglers that could be taken is 8. Up to 50 boats with anglers may be seen around Singapore on weekends.<sup>6</sup> On 31 January 1971, the *The Straits Times* columnist Clement Mesenas wrote that 40,000 of Singapore's population of two million people are anglers of one kind or other.

The recreational catch of Singapore was estimated by combining information gathered from two fishing supplies stores with information from the websites of fishing interest groups in Singapore (Table 4). Photographs found within these websites (posted within the years 2009-2013 by months) that had fish from which the length could be estimated were selected (n = 450), the fish they displayed were measured, and length-weight relationships (from [www.fishbase.org](http://www.fishbase.org)) were used to compute individual weights. Data generated from the photos were used to determine a mean monthly catch estimate (n=19). To generate an annual catch estimate, mean monthly catch was multiplied by the number of charter boats (n=50), months in a year (n=12), and then doubled to provide for shore/beach catches, as the managers of fishing supplies stores interviewed estimated that the number of boat-based fishers is twice the number of regular shore-based fishers and equal to the number of irregularly fishing shore-based fishers. Finally, the numbers of recreational fishers from 1950 through 2010 were estimated by interpolation using the published 40,000 anglers in 1971 as anchor point, related to the population size of Singapore from 1950 to 2010.

The annual recreational catch estimated for 2009-2012<sup>7</sup> was divided by the mean of the number of fishers estimated above to generate an estimated catch per recreational fisher. This estimate of individual recreational fish catch was in turn multiplied with the estimated number of recreational fishers for each year from 1950-2010 to generate the recreational catch data series. Crab catch reports were available from postings of shore/beach fishers. Production of a recreational crabber was set at 10% of a commercial crabber following a comment that suggests commercial crabbers deploy at least 50 traps while recreational crabbers deploy 4-6 traps.<sup>8</sup> The number of recreational crabbers was estimated by first determining the proportion of online discussion threads on crabbing in relation to those on total marine fishing (P; bottom of Table 4). The proportion (P) was applied to the mean number of fishers in 2009-2012, and their catch was extended backward to 1950 in the same manner as the recreational fish catch.

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### Taxonomic composition

The taxonomic composition of the estimated recreational catch was assumed to be the same as that of the inshore commercial catch for the corresponding years (but without '*Indo-Pacific swamp crab*' and '*marine crabs nei*').

### Subsistence fishing

Estimation of subsistence catch for Singapore was made possible by the link between subsistence fishers and non-powered vessels mentioned by the Singapore Ministry of Commerce and Industry (1957) and by the reported catches of 'minor gears' by the Singapore Primary Production Department (1966) for the years 1966-1972 (Table 2). The numbers of fishers using non-powered boats (i.e., subsistence fishers) for 1950-2010 were estimated using a spreadsheet growth function anchored in data gathered from 1951-1960. The percentage contribution to catches by minor gears for the years 1966-1972 were averaged, and the mean (4.35%) was then used to infer the catch of minor gears for the rest of the years in the series 1950-2010 from the reconstructed inshore catch values.

The subsistence catch was then calculated for the years 1951-1960 by multiplying the annual percentage of catch with minor gears (1951-1960) thus estimated by the fraction of subsistence catch to minor gears. A regression between catch by subsistence fishing and number of subsistence fishers for the period 1951-1960 was then performed and used to complete data for 1950-2010.

### Taxonomic composition

The taxonomic composition of the subsistence catch was assumed to be the same as the reconstructed catch of the inshore (artisanal fishery).

**Table 4.** List of most accessible fishing interest groups in Singapore on the internet. Web addresses last accessed 5 August 2013.

Organization	Website	Members	No. of discussion threads		
			Total	Marine fishing	Crabbing <sup>a</sup>
Fishing Kakis	<a href="http://www.fishingkaki.com/">www.fishingkaki.com/</a>	406,739	1,066,343	8,080	287
Singapore Bikers	<a href="http://www.singaporebikes.com/forums/archive/index.php/t-149965.html">www.singaporebikes.com/forums/archive/index.php/t-149965.html</a>	225	612	5	2
Wat the Fish	<a href="http://www.wat-the-fish.com/search.php?searchid=206010">www.wat-the-fish.com/search.php?searchid=206010</a>	2,778	14,252	-	14
Go fishing	<a href="http://www.gofishing.sg/index">www.gofishing.sg/index</a>	692	1,679	173	
Handline Fishing	<a href="http://forums.handlinefishing.com">http://forums.handlinefishing.com</a>	717	2,003	475	25
Sum				8,733	328

<sup>a</sup>Proportion of crabbing to marine fishing topics (P) equals 0.0376.

<sup>5</sup> <http://www.handlinefishing.com/whosfishing/fishingcharters.htm>

<sup>6</sup> <http://news.xin.msn.com/en/singapore/sport-fishing-gaining-popularity-in-singapore>

<sup>7</sup> <http://databank.worldbank.org/data/views/reports/tableview.aspx>

<sup>8</sup> <http://www.fishingkaki.com/forum/viewtopic.php?t=170558&highlight=crabbing>

## RESULTS AND DISCUSSION

Reconstructed total catches during the period 1950-2010 were estimated at 893,000 t, which is 1.3 times the reported landings of 662,000 t as presented by the FAO, on behalf of Singapore. Reconstructed total catches averaged 8,130 t·year<sup>-1</sup> in the early 1950s, steadily increased to a peak of 34,600 t in 1984 and subsequently declined to 5,130 t·year<sup>-1</sup> in the late 2000s. Examining reconstructed total catches of Singapore by sector, industrial catches dominated with nearly 49% (all of which is taken outside the EEZ), while artisanal and recreational catches comprised approximately 42% and 8%, respectively (Figure 3a). Subsistence catches contributed the lowest proportion at 1% (Figure 3a).

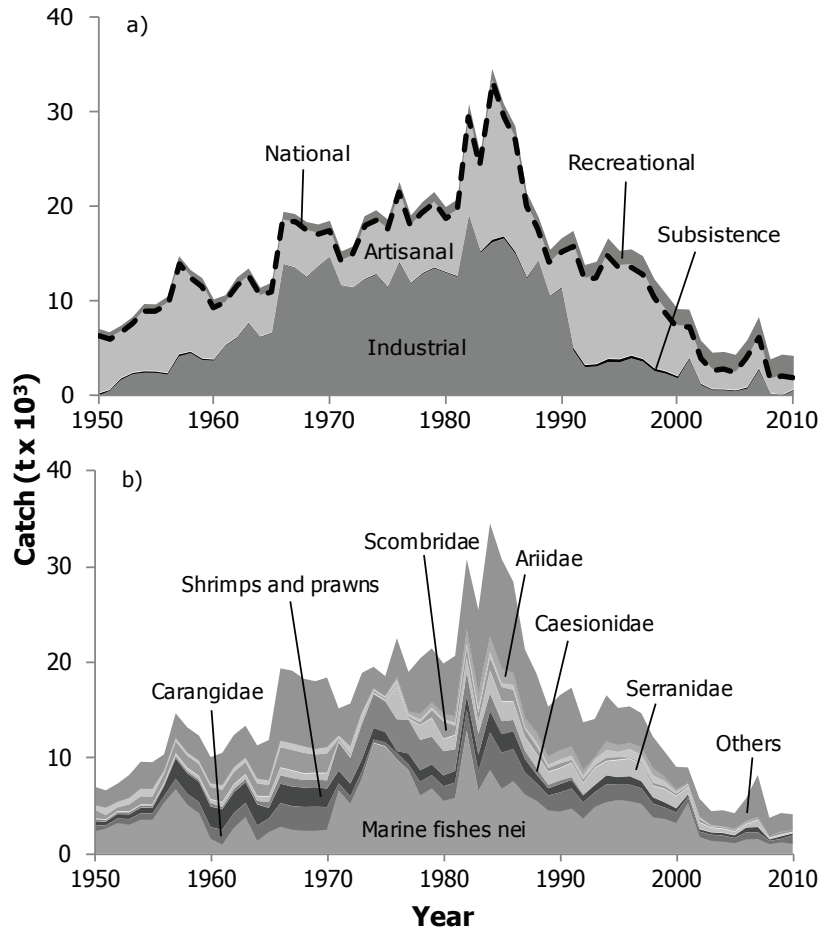
The reconstruction, by accounting for industrial, recreational and subsistence catches, added on average about 50% to the reported landings data (Figure 2). Exclusive of recreational and subsistence catches, i.e., essentially a reconciliation of national data, FAO and SEAFDEC data, the reconstruction added on average about 30%. The differences between published and reconstructed data were greatest with SEAFDEC, and this was persistent throughout the time series (Figure 2).

The ‘waste’ fish which was separately reported by Singapore until 1956 (Table 3) accounts for the very visible difference between the FAO and national catches (Figure 2) for the early period of the time series. Thus, fish caught and retained for animal feed or fertiliser were not accounted for in national data reported to the FAO. For the period 1957-1975, Singapore’s catch sums were consistently higher than FAO’s. Also, from 1950-52, there were 24-26 taxonomic categories listed in the catch composition whereas FAO’s lists only 5 taxa for the same period.

Most of the high catch figures were reported around the first half of 1980s, including FAO’s maximum value of 24,686 tonnes in 1984, which coincides with a period featuring relatively high numbers of fishing units in the range of 100 – 500 tons (Table 2).<sup>9</sup> Figure 3a shows commercial fisheries catches declined from 1984 on, and by 2008 reached levels below the catch of 1950, when the largest vessels were 45 tons (Burdon 1951). The decline in catches corresponds both to the decrease in the number of fishers and fishing vessels (Table 2). The small peak in 2007 is due to an exceptionally large inshore catch of blood cockles. The decline of catches, along with the decline in the number of fishers and fishing vessel from 1984 onwards (Table 2) suggests that fishing around Singapore and beyond ceased to be a profitable activity, given the state of the resource base. Furthermore, the declining catches may also suggest that the growing land-based economy of Singapore offered more interesting opportunities for investments and employment.

The number of recreational fishers, however, can be expected to continue growing. It was even reported that some 950 recreational sized speedboats were sold in 2012, about 200 more than in 2011.<sup>10</sup> The growing significance of marine recreational catches could be seen in Figure 3a as their amounts complement the commercial production for a sum of catches that hovered above 4,000 t. As expected, given the assumed trend in the number of recreational fishers (Table 2) and their assumed constant individual catch, the lowest and highest estimated recreational catch of 539 t and 2,137 t were obtained for 1950 and 2010, respectively.

The disappearance of non-powered boats by the early 2000s (Table 2) also means the disappearance of official records for subsistence fisheries. Nevertheless, online postings on “catching crabs after work” were found<sup>11</sup> together



**Figure 3.** Reconstructed total catches of Singapore from 1950-2010, a) by fishing sectors, where artisanal, subsistence and recreational are deemed to occur within Singapore’s EEZ, while industrial occurs outside their EEZ, mainly in neighbouring Malaysia and Indonesia. Data reported by FAO are overlaid as line graph; and b) by families, showing the 10 most abundant families individually, with the ‘others’ group accounting for 31 minor taxonomic categories.

<sup>9</sup> See also [http://fishstat.seafdec.org/statistical\\_bulletin/mf\\_boat\\_action.php](http://fishstat.seafdec.org/statistical_bulletin/mf_boat_action.php) (last accessed 11 June 2013).

<sup>10</sup> <http://news.xin.msn.com/en/singapore/sport-fishing-gaining-popularity-in-singapore>

<sup>11</sup> <http://www.fishingkaki.com/forum/viewtopic.php?t=102152&highlight=crabbing>

with the author's personal knowledge of heads of families regularly fishing for their family's consumption. However, it is difficult to differentiate recreational from subsistence fishing, especially for recent times, where the difference between personal drivers of 'pleasure' versus 'food needs' is increasingly blurred. Several anglers armed only with very basic fishing rods or simple baited lines tied to railings, trees or shrubs were seen during the field interviews conducted by the author. They generally avoided communication when approached because of language differences. Those willing to communicate did confirm that catches will be for personal consumption, that average catch is 3-6 fish, mostly sea catfish. This suggests continuation of subsistence fishing (Figure 3a, Table 2), although numbers of subsistence fishers is declining. Both the highest (199 t·year<sup>-1</sup>) and lowest (88 t·year<sup>-1</sup>) estimated subsistence catch were obtained for the 1950s. Estimated catches after 1957 were always above 100 t·year<sup>-1</sup> and the number of subsistence fishers in 2010 was estimated to still be above 1,500. In contrast to many southeast Asian countries, the trend in subsistence catches was not consistent over time.

Fisheries catches of Singapore were dominated by 'marine fishes nei' (31%) and Carangidae (9.3%). Shrimps and prawns (7.5%), fusiliers (Caesionidae; 10%), groupers (Serranidae; 5.8%) and tuna (Scombridae; 5.0%) also contributed a significant portion to total catches. Clupeids, a small, schooling pelagic species (3.1%) and catfish (Arridae; 3.0%) were common as well. The remainder of the taxonomic composition comprised 31 families and contributed 29% to the total reconstructed catches (Figure 3b).

The presence of significant fractions of 'marine fishes nei' and 'marine fishes nei (waste)' illustrates the fact that a detailed taxonomic resolution down to the level of family or even species cannot be easily achieved, even by a statistical system as efficient as Singapore's. Overall, official marine capture fisheries data from within Singapore waters showed that catches did exceed the 4,000 "long tons per annum" estimated a sustainable by Burdon (1952) and that this development was possible because of the sound foundations set by the leadership of the Fisheries Department of the then Colony of Singapore.

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#### REFERENCES

- Burdon TW (1951) Report of the Fisheries Department, 1950. Government Printing Office, Singapore. 67 p.
- Burdon TW (1952) Report of the Fisheries Department, 1951. Government Printing Office, Singapore. 93 p.
- Burdon TW (1953) Report of the Fisheries Department, 1952. Government Printing Office, Singapore. 91 p.
- 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 (ISEAS), Singapore. 442 p.
- Kesteven GL and Burdon TW (1952) Fisheries Survey Report No.1. An introduction to the Fisheries Survey of the colony of Singapore, with a consideration of the methodology employed. Government Printing Office, Singapore. 119 p.
- Le Mare DW (1949) Annual Report of the Fisheries Department, Federation of Malaya and Singapore for the Year 1948. Government Printing Office, Singapore. 72 p.
- Singapore Department of Commerce and Industry (1955) Report of the Fisheries Division 1954. Government Printing Office, Singapore. 27 p.
- Singapore Department of Commerce and Industry (1956) Report of the Fisheries Division 1955. pp. 189-202 In Anon. (ed.) Report of the Department of Commerce and industry. Government Printing Office, Singapore.
- Singapore Department of Statistics (1974-75) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 220 p.
- Singapore Department of Statistics (1975-76) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 225 p.
- Singapore Department of Statistics (1976-77) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 230 p.
- Singapore Department of Statistics (1977-78) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 242 p.
- Singapore Department of Statistics (1978-79) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 257 p.
- Singapore Department of Statistics (1979-80) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 261 p.
- Singapore Department of Statistics (1980-81) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 265 p.



- Singapore Department of Statistics (1981-82) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 265 p.
- Singapore Department of Statistics (1982-83) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 282 p.
- Singapore Department of Statistics (1983-84) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 278 p.
- Singapore Department of Statistics (1985-86) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 304 p.
- Singapore Department of Statistics (1986) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 304 p.
- Singapore Department of Statistics (1987) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 306 p.
- Singapore Department of Statistics (1988) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 334 p.
- Singapore Department of Statistics (1989) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 334 p.
- Singapore Department of Statistics (1990) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 338 p.
- Singapore Department of Statistics (1991) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 367 p.
- Singapore Department of Statistics (1996) Yearbook of Statistics: Singapore. Singapore National Printers Ltd., Singapore. 287 p.
- Singapore Ministry of Commerce and Industry (1957) Report of the Fisheries Division 1956. pp. 185-211 In Anon. (ed.) Report of the Ministry of Commerce and Industry. Government Printing Office, Singapore.
- Singapore Ministry of Commerce and Industry (1959) Report of the Fisheries Division 1958. pp. 192-220 In Anon. (ed.) Report of the Ministry of Commerce and Industry. Government Printing Office, Singapore.
- Singapore Ministry of National Development (1961) Report of the Fisheries Division 1959. Government Printing Office, Singapore. 27 p.
- Singapore Ministry of National Development (1975) Annual Report. Government Printing Office, Singapore. 47 p.
- Singapore Ministry of National Development (1976) Annual Report. Government Printing Office, Singapore. 39 p.
- Singapore Ministry of National Development (1977) Annual Report. Government Printing Office, Singapore. 40 p.
- Singapore Ministry of National Development (1978) Annual Report. Government Printing Office, Singapore. 41 p.
- Singapore Ministry of National Development (1979) Annual Report. Government Printing Office, Singapore. 31 p.
- Singapore Ministry of National Development (1980) Annual Report. Government Printing Office, Singapore. 39 p.
- Singapore Ministry of National Development (1981) Annual Report. Government Printing Office, Singapore. 39 p.
- Singapore Ministry of National Development (1982) Annual Report. Government Printing Office, Singapore. 39 p.
- Singapore Ministry of National Development (1983) Annual Report. Government Printing Office, Singapore. 43 p.
- Singapore Ministry of National Development (1984) Annual Report. Government Printing Office, Singapore. 47 p.
- Singapore Ministry of National Development (1985) Annual Report. Government Printing Office, Singapore. 59 p.
- Singapore Ministry of National Development (1987) Annual Report. Government Printing Office, Singapore. 47 p.
- Singapore Ministry of National Development (1988) Annual Report. Government Printing Office, Singapore. 50 p.
- Singapore Ministry of National Development (1989) Annual Report. Government Printing Office, Singapore. 46 p.
- Singapore Ministry of National Development (1990) Annual Report. Government Printing Office, Singapore. 48 p.
- Singapore Ministry of National Development (1991) Annual Report. Government Printing Office, Singapore. 52 p.
- Singapore Primary Production Department (1966) Annual report. Government Printing Office, Singapore. 57 p.
- Singapore Primary Production Department (1967) Annual report. Government Printing Office, Singapore. 65 p.
- Singapore Primary Production Department (1968) Annual report. Government Printing Office, Singapore. 45 p.
- Singapore Primary Production Department (1969) Annual report. Government Printing Office, Singapore. 39 p.
- Singapore Primary Production Department (1970) Annual report. Government Printing Office, Singapore. 44 p.
- Singapore Primary Production Department (1971) Annual report. Government Printing Office, Singapore. 34 p.
- Singapore Primary Production Department (1972) Annual report. Government Printing Office, Singapore. 38 p.
- Singapore Primary Production Department (1973) Annual report. Government Printing Office, Singapore. 47 p.
- Singapore Primary Production Department (1974) Annual report. Government Printing Office, Singapore. 38 p.
- Sinoda M, Lim PY and Tan SM (1978) Preliminary study of trash fish landed at Kangkar fish market in Singapore. Bulletin of the Japanese Society for the Science of Fish 44(6): 595-600.
- Tham Ah Kow (1955) Report of the Fisheries Division. pp. 201-250 In Anon. (ed.) Report of the Department of Commerce and Industry. Government Printing Office, Singapore.



**Appendix Table A1.** FAO vs. reconstructed total catch (in tonnes), and catch by sector for Singapore, 1950-2010.

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational
1950	3,800	7,080	7	6,310	226	539
1951	3,800	6,690	544	5,510	88	552
1952	4,800	7,390	1,712	4,970	147	563
1953	4,800	8,300	2,310	5,290	125	575
1954	4,700	9,680	2,463	6,480	147	588
1955	5,900	9,640	2,448	6,450	137	602
1956	9,300	10,460	2,274	7,440	135	616
1957	13,300	14,750	4,194	9,750	197	609
1958	11,800	13,280	4,527	7,960	150	644
1959	11,000	12,420	3,796	7,820	146	658
1960	8,700	10,170	3,739	5,630	110	693
1961	9,200	10,610	5,296	4,530	74	717
1962	10,800	12,480	6,114	5,550	88	738
1963	11,800	13,450	7,655	4,960	76	757
1964	9,600	11,390	6,190	4,370	58	777
1965	10,200	11,950	6,627	4,460	66	796
1966	17,500	19,440	13,855	4,710	60	816
1967	17,200	19,210	13,525	4,800	48	834
1968	16,400	18,360	12,481	4,950	83	849
1969	16,100	18,100	13,680	3,510	50	864
1970	17,301	18,490	14,661	2,900	54	876
1971	14,303	15,260	11,652	2,680	40	887
1972	14,701	15,780	11,419	3,410	45	905
1973	17,802	18,980	12,265	5,710	79	923
1974	18,558	19,610	12,792	5,790	86	938
1975	16,929	18,630	11,411	6,180	92	952
1976	15,743	22,600	14,017	7,510	115	965
1977	14,352	19,070	11,842	6,160	89	977
1978	15,572	20,490	12,880	6,530	92	992
1979	16,331	21,540	13,468	6,970	94	1,004
1980	15,481	19,950	13,014	5,840	80	1,016
1981	15,531	20,750	12,559	7,030	97	1,067
1982	18,560	30,870	18,872	10,720	156	1,116
1983	18,817	25,530	15,121	9,150	135	1,132
1984	24,686	34,610	16,222	16,960	268	1,161
1985	22,411	30,880	16,626	12,880	214	1,159
1986	19,939	28,490	14,999	12,130	207	1,156
1987	14,839	21,420	12,385	7,730	138	1,169
1988	13,152	18,880	14,275	3,350	58	1,197
1989	10,587	15,430	10,510	3,610	71	1,233
1990	11,432	16,650	11,400	3,880	84	1,282
1991	11,068	17,430	4,838	11,020	239	1,326
1992	9,178	13,810	3,053	9,180	211	1,366
1993	9,280	14,160	3,125	9,400	238	1,400
1994	11,278	16,630	3,601	11,280	308	1,446
1995	10,102	15,310	3,569	9,940	306	1,488
1996	9,943	15,470	3,977	9,660	283	1,548
1997	9,250	14,750	3,636	9,250	263	1,602
1998	7,733	12,300	2,639	7,730	265	1,661
1999	6,489	10,740	2,353	6,490	225	1,670
2000	5,371	9,150	1,885	5,370	191	1,701
2001	3,342	9,090	3,884	3,340	123	1,743
2002	2,769	5,810	1,175	2,770	109	1,761
2003	2,085	4,520	622	2,090	82	1,732
2004	2,173	4,610	600	2,170	88	1,754
2005	1,920	4,300	506	1,920	81	1,796
2006	3,103	5,870	785	3,100	129	1,854
2007	3,522	8,290	2,735	3,480	146	1,930
2008	1,623	3,820	176	1,540	70	2,038
2009	2,121	4,320	-	2,120	99	2,102
2010	1,732	4,180	598	1,390	64	2,137

**Appendix Table A2.** Reconstructed total catch (in tonnes) by major taxa for Singapore, 1950-2010. 'Others' contain 31 additional taxonomic categories.

Year	Marine fishes not identified	Carangidae	Shrimps and prawns	Caesionidae	Serranidae	Scombridae	Clupeidae	Ariidae	Others
1950	2,380	659	386	196	28	933	526	49	1,920
1951	2,700	312	381	129	41	441	787	88	1,810
1952	3,270	455	449	166	63	400	624	58	1,900
1953	3,090	574	476	192	53	731	690	86	2,400
1954	3,600	668	560	224	61	851	804	100	2,810
1955	3,590	665	557	223	61	848	800	100	2,800
1956	5,370	671	1,045	112	224	895	448	-	1,700
1957	6,750	1,107	2,106	221	332	1,218	443	-	2,570
1958	5,170	1,124	2,117	225	337	1,236	450	-	2,620
1959	4,290	1,130	2,114	226	339	1,243	452	-	2,630
1960	1,650	1,176	2,145	353	353	1,293	470	-	2,740
1961	1,040	1,509	2,124	232	464	1,277	580	-	3,380
1962	2,780	1,507	2,152	348	464	1,276	580	-	3,370
1963	3,880	1,484	2,130	342	457	1,256	571	-	3,320
1964	1,430	1,554	2,188	359	478	1,315	598	-	3,470
1965	2,340	1,402	1,082	584	584	1,168	584	-	4,210
1966	2,890	2,441	2,010	888	777	2,108	777	-	7,560
1967	2,570	2,454	2,017	893	781	2,120	781	-	7,600
1968	2,460	2,462	2,016	783	671	2,126	783	-	7,060
1969	2,470	2,475	2,023	787	675	1,912	675	-	7,080
1970	2,560	2,350	1,922	855	748	2,030	748	-	7,280
1971	6,640	750	1,304	2,999	107	214	321	107	2,820
1972	5,280	755	1,312	2,695	108	216	755	216	4,440
1973	7,910	748	1,215	3,741	107	214	748	214	4,080
1974	11,620	317	1,202	3,586	97	203	157	215	2,210
1975	11,240	392	1,088	3,257	88	184	142	195	2,040
1976	9,870	659	208	3,348	3,467	179	436	368	4,060
1977	8,740	627	1,114	3,557	106	196	248	385	4,100
1978	6,120	1,432	1,193	3,186	1,522	266	293	732	5,750
1979	6,850	1,388	1,098	2,921	1,946	793	276	643	5,620
1980	5,570	1,514	1,117	2,552	1,242	1,833	238	655	5,230
1981	5,860	1,609	1,199	2,269	1,477	949	294	811	6,290
1982	12,860	2,156	1,497	2,504	1,526	1,061	391	1,485	7,390
1983	6,620	2,056	1,676	2,218	1,192	948	505	1,628	8,690
1984	8,740	3,950	2,197	1,915	2,372	1,372	516	1,729	11,820
1985	6,810	3,769	1,940	1,374	2,060	1,481	368	1,662	11,420
1986	7,600	3,351	1,852	1,214	1,916	1,198	508	1,345	9,510
1987	6,210	2,294	1,411	872	1,417	785	221	1,064	7,140
1988	5,570	1,819	911	694	1,455	778	430	1,144	6,080
1989	4,560	1,554	740	370	1,331	380	356	966	5,160
1990	4,460	1,971	868	378	1,269	475	393	1,089	5,740
1991	4,770	2,088	869	309	1,471	296	420	1,084	6,120
1992	3,740	1,656	715	119	1,183	326	360	752	4,950
1993	4,940	1,522	742	25	1,774	228	605	371	3,950
1994	5,430	1,853	927	1	1,470	345	795	1,018	4,790
1995	5,660	1,584	784	1	1,783	265	548	819	3,860
1996	5,520	1,721	875	28	1,798	107	869	764	3,790
1997	5,250	1,622	720	10	1,747	195	811	890	3,500
1998	3,860	1,416	637	22	1,168	297	790	860	3,250
1999	3,690	1,169	535	16	1,344	285	507	594	2,590
2000	3,270	1,080	433	13	1,225	227	200	362	2,340
2001	5,350	619	254	1	716	158	186	194	1,620
2002	1,830	525	228	5	670	321	193	168	1,870
2003	1,420	620	227	4	433	120	88	159	1,450
2004	1,330	621	253	11	362	138	49	191	1,650
2005	1,180	523	259	17	327	124	27	241	1,600
2006	1,570	726	475	5	309	133	42	262	2,340
2007	1,620	694	517	3	706	171	6	224	4,350
2008	1,080	317	137	7	124	217	2	88	1,840
2009	1,270	333	255	7	101	215	2	199	1,940
2010	1,100	866	195	7	85	225	2	118	1,590