Intern Summary

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Thesis research title:
Characterisation, total effort and total catch estimation of the small-scale tuna fisheries in Buru & Lombok Island, Indonesia.

Introduction:
Catch-and-effort-data-recording-systems (CEDRS) are essential tools in fisheries science for stock assessments and related fishery status information, required to combat IUU fishing, and form the basis of well-regulated fisheries (Hilborn & Walters, 1992; Jennings, Kaiser & Reynolds, 2001; Stamatopoulos, 2002;). Data of small-scale fisheries is generally only collected from fishery operations instead of scientifically designed surveys due to the high costs of the latter (de Graaf *et al.*, 2011). Because fishermen pursue their own goals sampling only a subset of these fishermen may lead to biases in the collected data (Hilborn & Walters, 1992;). Hence biased estimates are systematically lower or higher than the actual true (but unknown) population value because they are derived from samples that are not representative of the entire population (Sparre & Venema, 1998;).

Stratification can be used to reduce potential biases from the sampling (Sparre & Venema, 1998; FAO, 1999; Sparre, 2000;). Stratification is the separation of all population data (e.g. fishing vessels) in groups (i.e. strata) to attain more homogeneous samples, in which any variability can be explained by differences between the strata (e.g. the partitioning of all fishing vessels per fishing gear, size, or engine power) (Sparre, 2000; Evans & Grainger, 2002; Stamatopoulos, 2002). Stratification is a consideration between increased costs and obtaining better values as sample size needs to be determined per stratum: a large sample size increases the precision of the data but increases the costs related to the data collection (FAO, 1999; Stamatopoulos, 2002; Nagelkerke & Tsehaye, 2006; Dronkers Londoño, 2016).

Market requirements for traceability and sustainably captured tuna are motivating the industry to gain interest in monitoring systems for Indonesian small-scale handline and pole-and-line tuna fisheries. A CEDRS was developed for implementation in the coastal fishing port of the village Labuhan Lombok in

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Lombok (West Nusa Tenggara) (Kochen *et al.*, 2011) in cooperation with tuna suppliers and processors by a Dutch fish trader, ANOVA Seafood, in order to meet the traceability and sustainability requirements of the Western and Central Pacific Fisheries Commission (Kochen, 2012). Later, this CEDRS was likewise implemented in a number of villages in Buru (Moluccas).

Since the sampling system in Lombok and Buru has been developed and implemented for the industry, the selection of fishermen that are sampled for catch and effort data is, inherently, not random which may lead to biases in the *CpUE* (OSB-NRC, 2000). Extrapolating these *CpUE* values for the entire fishery (i.e. total effort) could result in under- or overestimating the total catch (Hilborn & Walters, 1992; FAO, 1999). In addition, it is unknown whether tuna is caught by fisheries which are not in the sampling programme (e.g. different boat types). This study focused on the CEDRS of the small-scale tuna fisheries present in Lombok and Buru to advice on possible improvements in data collection.

Research questions:

- What is the total effort of the tuna catching fisheries in Lombok and Buru?
- Is bias present in mean positive catch rates (i.e. catch-per-unit-effort: *CpUE*) between the sampled locations of MDPI in Lombok and Buru?
- What is the activity pattern of a unit of effort of the tuna catching fisheries in Lombok and Buru?

Methods:

Total effort

To estimate the total fishing effort (i.e. total number of boats per tuna catching boat type; or total fishing trips made by tuna catching boats in 365 days), various formal and informal interview sources were used. Primary and secondary literature was consulted to gather information on the type of tuna fisheries present in Lombok and Buru. Satellite images from Google Earth Pro were used to map all coastal villages. A 'frame survey' (FAO, 1999; Stamatopoulos, 2002) was executed in Lombok and Buru. The frame survey was conducted according to a fixed protocol, during which the number of boats were counted, photographed, and interviews with fishermen conducted. About 50% of the coastlines of Lombok and Buru were surveyed on the ground during the frame survey in combination with information from local residents. Satellite images were used to check the remainder of the coastline and

double check the visited areas. Encountered fishing boat types and villages were characterised for both islands separately. The total number of coastal classified villages were categorised amongst the village categories. These village categories were used in estimating the total effort in Buru only.

In Lombok, the boat types, *penongkol* and *mandar* (handline gear, HL), as well as *pole & line* boats (pole-and-line gear, PL) were included. The total effort data on these boat types was gained from the harbourmaster based on port issuances for the sailing approval of fishing boats from 1st January 2014 until 31st December 2014.

In Buru, three total effort scenarios (i.e. minimal, observed, and maximum) were used per coastal village since the number of boats present on the beach did not always correspond to what the locals residents stated in the interviews (i.e. either less or more, e.g. because fishermen were at sea). Village adjacent beach length was used as index for village surface area which was assumed to be related to village population, which in turn was expected to be an index for number of boats present assuming that local residents mostly rely on fish for their daily protein intake. Hence, an estimate of number of boats in unvisited villages was calculated based on a relationship between the adjacent beach length of each village (measured with Google Earth Pro) within the village categories (i.e. estimated total effort).

Catch-per-unit-effort

I-Fish data was used for catch-per-unit-effort (*CpUE*) calculations per boat type present in Lombok and Buru. *CpUE* was defined as kilogram per fishing trip per gear type. For both Lombok and Buru the *CpUE* was calculated for two catch categories:

- 'Total tuna' catch (kg) per fishing trip (i.e. YFT, BET, SKJ and ALB tuna without bycatch irrespective of the weight of the specimen)
- 'Big YFT' (i.e. specimens > 10 kg) per trip

The *CpUE* in Buru was calculated per sampled village separately in order to test if statistical differences were present in the mean positive *CpUE* data between the four sampled villages.

Activity pattern

No activity pattern was calculated for the boats in Labuhan Lombok since the total effort was available in the unit 'total trips'.

For Buru, mean activity per *jonson* boat (i.e. number of mean fishing trips per *jonson* boat per year) was calculated based on the I-Fish data from Waepure and Waelihang only, because these villages were sampled year-round.

Total tuna catch estimate

For Lombok, a subtotal tuna catch estimate was calculated for the 'total tuna' and 'big YFT' catch categories per stratum (i.e. gear type). Addition of these subtotal estimates resulted in the total tuna catch estimate.

For Buru, the total tuna catch estimate was calculated likewise. However, gear type was not stratified (i.e. all HL), but different total effort scenarios resulted in three different total catch estimates.

Results:

Lombok

The *penongkol*, *mandar* and *pole & line* boat types target and catch tuna in Lombok and are included in the total catch estimate1268 port clearances (i.e. total effort) were issued to HL boats and 83 to PL boats in Labuhan Lombok in 2014 (Table 1).

Table 1. Catch estimate of Lombok of the 'total tuna' and 'big YFT' catch categories.

Boat type	Gear type	*CpUE* (kg/trip)	Total effort (trip/year)	Activity pattern	Subtotal tuna catch estimate (kg)	Total tuna catch estimate (kg)
			'Total tuna'			
Penongkol + Mandar	HL	1073	1,268	N/A	1,360,894	1,451,506
Pole & line	PL	1092	83	N/A	90,612	
			'Big YFT'			
Penongkol + Mandar	HL	442	1,268	N/A	560,494	560,619
Pole & line	PL	2	83	N/A	125	

Buru

Only the *jonson* boat type catches tuna in Buru. This boat type was encountered along the coastline, with the estimate total number of *jonson* in Buru ~949 (Table 2).

Table 2. Total tuna catch estimate of Buru of the 'total tuna' and 'big YFT' catch categories.

Boat type	Gear type	Total effort scenario	*CpUE* (kg/trip)	Total effort (boat)	Activity pattern (trip/boat/year)	Total tuna catch estimate (kg)
				'Total tuna'		
Jonson	HL	Minimum	39	823	21	674,037
Jonson	HL	Observed	39	948	21	776,412
Jonson	HL	Maximum	39	1,027	21	841,113
				'Big YFT'		
Jonson	HL	Minimum	33	823	21	570,339
Jonson	HL	Observed	33	948	21	656,964
Jonson	HL	Maximum	33	1,027	21	711,711

Discussion & conclusions:

Boat types

Labuhan Lombok was the main village in Lombok deemed important with respect to tuna fisheries, since only here *penongkol*, *mandar*, and *pole & line* boat types land. Other boat types in Lombok catch tuna but were excluded from the total tuna catch estimation. Consequently, the current total tuna catch estimate for Lombok is an underestimation. The induced bias could not be quantified since no (reliable) *CpUE* and total effort value of these boats could be acquired.

In Buru, the only tuna catching boat type is the *jonson*. Other boat types in Buru were excluded from the total tuna catch estimation. Based on information from local residents and literature (van Oostenbrugge, 2003; Tahapary & Tanjaya, 2011) these boat types were considered not relevant to tuna fisheries since they are not used to catch tuna. Hence the exclusion of these boat types is expected to not bias the total tuna catch estimate in Buru.

Total effort

In Lombok, the total effort estimate was based on port clearances but it is not clear whether these boats returned to land their catches. Data on the total number of boats per boat type of the suppliers that are not affiliated in the sampling program are required to exclude this potential bias.

In Buru, the method to estimate the number of *jonson* boats in villages for which no total effort information was known was applicable in remote villages in which the

number of *jonson* boats is expected to be related to the protein needs of the population. The current study does not account for the migration fluxes of *jonson* fishermen (Duggan & Kochen, 2016) since the recorded total effort variation was not monitored throughout the year and over the entire island at the same time (i.e. no full enumeration (FAO, 1999; Stamatopoulos, 2002)).

Catch-per-unit-effort

In Lombok, the *CpUE* of the *penongkol* and *mandar* boats could not be calculated separately.

In Buru, no bias was found in the *CpUE* of the mean positive catches of the *jonson* fishermen between the villages Waepure, Waelihang, Wamlana (all three located in north Buru), and Nalbessy (located in south Buru) for the 'total tuna' and 'big YFT' catch categories. The frame survey confirmed that the fishermen in the four sampled villages do not differ in their boat and gear characteristics but operational characteristics such as trip duration, and fuel & ice usage were not accounted for. In addition, the fishermen in Nalbessy utilise different fishing grounds compared to the fishermen in Waepure, Waelihang, and Wamlana, which can potentially induce bias (Hilborn & Walters, 1992; Sparre & Venema, 1998). The *CpUE* data did not span a full year for all four locations, meaning that the *CpUE* may currently be biased. In addition, *CpUE* was calculated based only on *jonson* fishermen from category 1 villages which are expected to be full-time large YFT targeting fishermen that supply the export industry, hence all having similar boat, gear, and operational characteristics. In contrast, *jonson* fishermen in village categories 2 and 3 are not necessarily full-time YFT targeting fishermen that supply the export industry. As a result, the 'total tuna' and 'big YFT' *CpUE* of these *jonson* fishermen is expected to be lower than that of village category 1 *jonson* fishermen, generating an overestimation of the total catch.

Activity pattern

The estimated activity pattern of *jonson* boats in Buru was highly variable with a mean of 21 fishing trips per *jonson* per year. Due to the current set-up of the CEDRS (see full report), this value is likely to be highly biased but this could not be quantified.

Follow-up steps for MDPI:

- Fishermen migration is advised to be studied since this affects the total fishing effort during the year and may give insights in the seasonality of the fishery.
- Only a limited number of villages in Buru have to be sampled throughout the year to gain a reliable overall catch-per-unit-effort (*CpUE*) estimate. This may save resources for MDPI since fewer staff is needed
- A *CpUE* analysis including all data from the I-Fish database should be conducted to include seasonal effects of multiple years and increase accuracy and precision to check if the previous recommendation holds true.
- *Jonson* fishermen from village categories 2 and 3 should be included in the sampling programme to elucidate if their *CpUE* is comparable to fishermen from category 1 villages.
- Distinguish the *penongkol* and *mandar* boat types in the data collection protocol due to their reported differences in target species' size.
- Based on the I-Fish data, the location sampling rolling schedule was not strictly followed. Whether or not sampling occurred on each day of the year should be clearly included in the data collection system.
- Introduce a unique vessel identification system of the fishing fleets in the data collection system.

Unloading the tuna catches in Buru island.