Ocean and Coastal Management 202 (2021) 105498

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: http://www.elsevier.com/locate/ocecoaman

Fisheries decline, local livelihoods and conflicted governance: An Indonesian case

Carol Warren [a,*], Dirk J. Steenbergen [b]

[a] Asia Research Centre, Murdoch University, Perth, 6163, Australia
[b] University of Wollongong, NSW, 2522, Australia

ARTICLE INFO

Keywords:
Small-scale fishery
Commercial capture fishery
Conflicted governance
Livelihoods
Overfishing
Sustainability

ABSTRACT

This study investigates the social and environmental impacts of the rise and decline of the fishing industry in an Indonesian coastal community as a case study of the conflicted role of governance in marine resource management. It analyses the relationship between two distinct but intersecting fisheries in west Bali: the traditional small-scale artisanal fishery targeting diverse near shore species for the local market, and the large-scale commercial purse seine fleet that exploits the once rich Bali Strait sardine fishery. The recent collapse of the sardine fishery has had a marked impact on the livelihoods of fishers in both the artisanal and commercial sectors. A significant issue for the future of fisheries dependent communities is the need to raise the priority of equity and sustainability in resource governance. The failure of regulatory regimes to control overfishing is found to be a key factor in the unravelling of the local economy and presents an instructive case for analysing the wider implications of a fundamental conflict in the political economy of the global system between unevenly matched market-driven resource use and sustainable development practices. Methodologically, the research combines qualitative and quantitative approaches to compensate for the dearth of data available for the artisanal and commercial fishery sectors respectively. Catch statistics on the rise and decline of the commercial sardine fishery are linked to qualitative information from a longitudinal study on the livelihood impacts of resource decline in a community engaged in both fisheries. In connecting interview data on village level livelihood issues with commercial fishery data, the study highlights the imperative of good governance across scales for policy makers and development practitioners concerned with equity and sustainability of fisheries as a critically important component of global food security.

1. Introduction: fisheries and food security

Globally, fish and aquaculture production sectors are significant contributors to food and nutritional security (Kawarazuka and Béné, 2010; Hicks et al., 2019; FAO 2020). At 20 kg per capita, world-wide fish production has doubled since the 1960s to reach 179 million tonnes in 2018. The importance of the fisheries sector is projected to continue its expansion, with increasing consumption propelled by rising incomes, continued population growth and urbanisation. The fastest rate of increase is predictably in the Indo- Pacific region. At the same time, however, one-third of world fish stocks are currently classified as overfished, and there is strong evidence that another 60% is reaching the limit of sustainable yields (Ye and Gutierrez, 2017; FAO, 2018a). Indo-Pacific region fisheries are among those inadequately assessed, with serious consequences for effective governance (Hilborn et al., 2020; FAO 2020).

As an archipelagic nation, fisheries are essential to Indonesia's economy in terms of food security, employment and export revenue. As of 2012 more than half of animal protein consumption (54%) in Indonesia came from fish or seafood, having almost tripled average annual per capita consumption from 10.6 kg in the 1970s to 28.9 kg in 2011 (FAO, 2014). The total value of fish commodity exports from Indonesia reached $3.8 billion in 2013, and aimed for US$ 9.5 billion in 2019 (FAO, 2018b). An estimated six million Indonesians earned their living from fisheries in 2015/16. The industry in Indonesia remains strikingly dominated by small-scale fishers, with 90–95% of fish production estimated to come from this sector (FAO, 2014; Ariansyach, 2017). Yet it is the small-scale fisheries for which we have the least data and where livelihoods are under most immediate pressure from marine resource competition and degradation (FAO, 2005; Béné, 2007; FAO,

* Corresponding author.
E-mail addresses: c.warren@murdoch.edu.au (C. Warren), dirks@uow.edu.au (D.J. Steenbergen).

https://doi.org/10.1016/j.ocecoaman.2020.105498
Received 15 July 2020; Received in revised form 15 October 2020; Accepted 13 December 2020
Available online 2 February 2021

2014; Thurstan et al., 2015; Loneragan et al., 2018; FAO, 2020). Drawing attention to the need for more research on the important small-scale fishing sector (Béné et al., 2010; Kolding et al., 2014; Jentoft, 2018) and its articulation with industrial fishing (Aguiliera et al., 2015), this study investigates the community level impact of environmental degradation driven by global market demand and a conflicted governance regime.

1.1. Commercial and artisanal capture fisheries – a coastal community case-study

This case study analyses the evolving relationship between two distinct but intersecting artisanal and commercial fisheries to illustrate their interactive complexity and the dynamic interdependence of livelihoods, markets and governance of marine resources. These fisheries have been the mainstay of the local economy in the case study village of Perangkat (pseudonym), located in west Bali, Indonesia (Fig. 1). Over four decades the village was transformed from a government-classified impoverished community to one of relative prosperity, before the collapse of the commercial Bali Strait sardine fishery in 2010-12 reversed its development trajectory.

Local fishers traditionally depended upon small-scale line and net fishing from outrigger boats (*jukung)* for domestic consumption and sale to local markets.[1] The large-scale commercial fishery was introduced in the 1970s when a fleet of Madurese style (*selerek*)[2] vessels using purse seine gears began mooring in the Perangkat river estuary to exploit the rich sardine (*sardinella lemuru*) fishery in the Bali Strait. It accompanied the establishment of several factories across the river for processing and export to the international market. As the fleet grew in size and capacity over the following years, it offered supplementary and alternative employment to local fishers, but eventually came to threaten the marine resource base of both commercial and artisanal sectors.

This study offers instructive insights into the development trajectories of resource dependent communities through analysis of the livelihood impacts of excessive market-driven development as experienced by local fishers now facing potentially irreversible resource decline. It also implicates feedback loops with adverse impacts upon other local resources and livelihood options.[3] Today, fishers in the coastal village of Perangkat face a range of environmental challenges due to coastal erosion, mangrove destruction, the endangered species trade and, most seriously, overfishing.

1.2. Livelihood and sustainability – inter-disciplinary approaches

The evidence from the literature is clear on the connection between overfishing and stock depletion (Brewer et al., 2012; Duarte et al., 2020; Hilborn et al., 2020), as well as the need for greater attention to the impacts of resource decline on small-scale fishers (Kolding et al., 2014; Aguiliera et al., 2015; Bavinck et al., 2018). This Indonesian case-study is informed by the growing body of social science research on governance and small-scale fisheries. The interactive governance framework of Kooiman et al. (2008) and Jentoft and Chuenpagdee (2015), for example, offers an interdisciplinary approach to examining fisheries in light of competing interests and interdependencies across ecological and social domains. It highlights the two-way streams of influence between human and environmental factors, that shape the way a fishery operates, enabling deeper insights into the dynamics of resource use and the centrality of good governance in balancing equity and sustainability principles (Chuenpagdee et al., 2013). The Perangkat case study offers an opportunity to explore the wicked problems of managing the complementarities and contradictions of simultaneously interdependent and conflicting economic development and environmental sustainability policies (Jentoft 2019). This approach requires linking local level experiences to problems of national governance and global markets. It also points to the value of drawing together the different methodologies of the sciences and social sciences necessary to respond to social – ecological system synergies and challenges (cf. Coulthard et al., 2011; Thurstan 2015; d'Armengol et al., 2018; Lau et al., 2019).

In light of the interdisciplinary approach adopted for this research, Section 2 describes the mixed qualitative and quantitative methods combined to analyse case-study issues. The livelihood trajectories of fishing households are covered in Section 3, focusing particularly on the role of markets. Market expansion initially improved living standards in the village, but ultimately drove over-exploitation in the commercial sardine fishery sector, which now increasingly competes with the small-scale fishery for alternative fish stocks, as shown in Section 4. Section 5 details the social and environmental impacts of IUU practices accompanying expansion of the commercial sardine sector, followed in Section 6 by a discussion of the role of state policy and conflicted governance in failing to address implementation of precautionary management principles. Section 7 draws conclusions for the engagement of livelihood and sustainability research in developing fisheries management policy.

2. Methodology

The research for this study was conducted as a component of a larger comparative project (see Acknowledgements), which aimed to analyse livelihood vulnerability in different resource-dependent communities across Indonesia through in-depth case studies. The research questions guiding this case study of a fisheries dependent community in the Bali Strait were: What are the factors driving natural resource decline in the case-study community? What are the impacts of resource degradation on livelihoods in natural resource dependent households? What policy changes are required to reverse degradation and secure livelihoods in the long-term?

A mixed methods approach was applied to study the statistically data-rich commercial fishery and data-poor small-scale fishery sectors. Data on catches by the purse seine fleet from the commercially important Bali Strait sardine fishery were collected from the fish landing and

[1] Halim et al. (2019) develop a useful definition of the small-scale fishery sector relevant to the artisanal fishers described in this study as "a fisheries operation, managed at the household level, fishing with or without a fishing boat of <5 GT (gross tonnes), and using fishing gear that is operated by manpower alone." Their definition integrates dimensions of vessel size, fishing gear technology and the household unit of decision-making, speaking to some of the concerns raised by Smith and Basurto (2019) regarding the methodological inadequacy of typical classifications based on boat size and gear alone.

[2] See Fig. 2 for images of both the artisanal and commercial vessel types. See also J. Mellefont (2015) for an historical account and stunning images of the little-known *selerek* fleet, described as "the most spectacular fishing fleet anywhere in the world today, if traditional timber construction and rich ritual decoration are the measure".

[3] Not only does the fate of the two fisheries intersect, but the cascading effects of the over-reach of market-driven exploitation plays out in parallel ways in relation to other local resources. For example, coastal erosion intensified as a result of a destructive seagrass harvest in 2012 that was a direct response to the economic impacts of the collapse of the sardine fishery (see section 6 below).

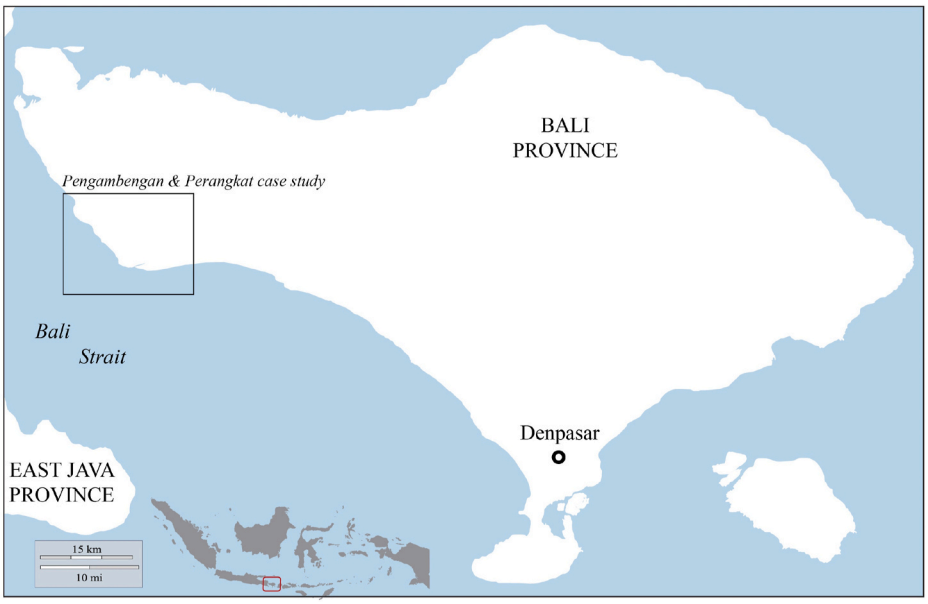


Fig. 1. Map of Bali Province showing case study location.

auction site (*Tempat Pelelangan Ikan* - TPI)[4] at Pengambengan which services the purse seine fleet moored in the river bordering the village of Perangkat. This raw data for the period 2003 to 2015 is complemented by a 2009-11 study of the Bali Strait sardine fishery conducted for the Australian Centre for International Agricultural Research (ACIAR 2011) and two studies of the purse seine fleet sardine catches by Indonesian fisheries and marine science researchers conducted in 2011 and 2015 (Purwaningsih et al., 2011; Simbolon et al., 2017). These studies largely focused on the other half of the sardine fleet serviced by the TPI across the Strait at Muncar in East Java and are further supported by the subsequent work of Saputra et al. (2017) on climatic cycles and sea surface temperatures affecting sardine catches in the Bali Strait. The quantitative data on changes taking place in the commercial sardine fishery are complemented by the first author's longitudinal qualitative research in the west Bali village of Perangkat concerning household livelihoods among fishing families engaged in the small scale, near-shore fishery as independent fishers and/or as crew on the commercial outer zone purse seine boats.

A focus group discussion conducted in Perangkat in 2006 set out the parameters of tensions between the artisanal and commercial sectors. In-depth surveys and follow-up interviews were conducted with 40 of the 1281 households (3%) in Perangkat village in 2010 and again in 2016. The selection of the 40 study households was based on random sampling, with proportional representation from the five hamlets in the village. Survey interviews with the head of household and/or spouse lasted one to two hours and included quantitative data collection alongside open-ended questions regarding socio-economic and environmental conditions. Questions focused upon changes in household income; fishers' observations of changes in size and composition of catches overtime; the relationship between the commercial and artisanal fisheries; and local perspectives on government environmental management and social protection policies. In addition, follow up interviews were conducted during annual fieldtrips with selected households and with a purposive sample of District Fisheries Department staff (n = 3), Fisheries Research Institute personnel (n = 3), current and former village and hamlet leaders (n = 7) and the heads of local fishers' co-operatives (n = 2) to obtain a range of popular and official perspectives on environmental and economic changes, and particularly on the impacts of the crisis in the Bali Strait fisheries.[5]

2.1. Data analysis

Raw annual data of fish landings from the Bali Strait commercial fishery at the government's Fish Auction and Landing Site (TPI) at Pengambengan, were analysed for changing quantity, value and (when available) species composition. The TPI provides services to the commercial fishery only. Its records do not include information on small-scale or purse seine vessels which fail to return with commercial quantities of fish. Consequently, this data could not be used to produce accurate information on production per unit effort.

No systematic quantitative data was available for the small-scale fishery, primarily because the TPI does not handle the catches of small-scale fishers. The village level trading network that does is characterised by numerous petty traders, often fishers' wives, who are at the bottom of an informal trading pyramid that extends through multiple networks beyond the village. Analysis of small-scale fishery conditions relied on the semi-structured household surveys and interviews as well as observations and informal discussions with other villagers returning from fishing, attending meetings and participating in community events. Annual fieldtrips of up to four weeks over the period 2006–2019, provided insight into the scope and impact of change.

[4] TPI Pengambengan is one of two landing sites on either side of the Bali Strait which together account for trading of almost the entire commercial sardine catch from the Bali Strait. It does not accept fish from small-scale fishers, who use local market chains to sell fish that are surplus to household consumption needs. This data therefore covers roughly half of the commercial sardine catch in the Bali Strait. It should be noted that TPI reporting formats available changed over this period, and did not enable complete comparability of detail (on species breakdown, for example) in all years, although basic data on total volume and price of fish landed was complete. See Appendix Illustration #1 for a sample of TPI data entries. TPI data sets prior to 2003 were not reliable indications of total catch because the purse seine owners were not required to sell their catches to local factories through the TPI before that date.

[5] Interviews were digitally recorded with permission of respondents. Interviews and translations from the Indonesian language were carried out by the first author with research assistance in the Balinese language by Denik Puriati.

3. Unsustainable development and the livelihood trajectories of Perangkat Fishers

Until recently, the fishing village of Perangkat was officially classified as a poor marginal community due to its remote location and subsistence economic base. Village small-scale fishers experienced a slow progression out of poverty during the late 1990s and early 2000s, primarily as a result of improved market access for their fish as well as additional income from work on the commercial fleet. The subsequent unravelling of the local economy as a consequence of the collapse of the Bali Strait fishery in 2010–12, however, presents an instructive case for analysing the relationship between the small-scale and industrial fishing sectors and the inherent conflict between unregulated resource exploitation and sustainable development scenarios.

Livelihood trajectories among fishing families in Perangkat have been shaped by dramatic shifts in material circumstances over the last several decades. There is consensus on a rough chronology of socio-economic and ecological change, and an acute awareness of the paradoxes of 'development'. As the leader of one of the village fishers' co-operatives expressed it: "Before our poverty was due to lack of markets and access to credit. We caught lots of fish that were worth little. Now credit and markets are easy, but there aren't enough fish" (Interview, 11 July 2017). Villagers' experiences of the rise and decline of their resource base reflect the local consequences of the simultaneous and asymmetric competition between market driven growth on one hand and sustainability measures on the other. The case demonstrates the consequences of conflicted governance which failed to take account of the delayed impact on livelihood options of running down environmental capital (LaTour, 2018).

In the 1960s there were annual lean periods (*paceklik*) in low fishing season, but customary reciprocity, domestic animal husbandry, and gleaning provided for very basic subsistence in those relatively short periods of low yields. Most villagers' homes were of bamboo and thatch, and children rarely studied beyond primary school. New opportunities began to open up when fish processing factories were established across the river in Pengambengan to exploit the rich Bali Strait sardine fishery. However, establishment of the commercial purse seine sardine fleet, most of whose owners and crew were from outside the village, initially met opposition from Perangkat's small-scale fishers. As one local fisher complained, "Competition between traditional village fishers and modern fishers from Java who started coming around the 1970s has been great. Before that traditional fishers did well. But since they started coming, from year to year catches have been falling." (FGD, Perangkat 26 July 2006).

From the outset local fishers had complained about the failure of government to enforce regulations on zonation. The commercial fleet was supposed to target different pelagic species and to operate in the distant fishing zone beyond the 12 nautical mile coastal area utilized by small scale fishers.[6] But as purse seine operations expanded over the decades, and young villagers began to take up new opportunities for income as labour on the purse seine vessels, dependence on this income muted resistance to the impacts of the expanding commercial fleet on the artisanal resource base.

3.1. Market drivers – progress and regress

The years following the Indonesian economic crisis from 1998 were paradoxically the high point of economic prosperity for Perangkat fishing households, when the devaluation of Indonesian currency advantaged fish exports to the international market, and the *rupiah* price of fish rose dramatically.[7] With new economic opportunities and higher fish prices, villagers began to brick and tile their homes; most households came to own motor bikes, mobile phones, and were able to send their children on to secondary school in that period.

As a result of greater market incorporation, Perangkat was no longer a remote or marginalised community by the late 1990s. But the collapse of the Bali Strait sardine fishery since 2010 marked the rapid decline of the local economy with depletion of the marine resources that had provided basic livelihoods to villagers for generations. Interviews with Perangkat small-scale fishers over the last decade indicate concern with lengthening low yield (*paceklik)* periods as weather patterns are becoming less predictable and the diverse artisanal target species (*tongkol, layang, layur, etc.*)[8] less abundant. The different seasonal patterns of the sardine fishery had offered supplementary income-earning opportunities during these low catch periods in the small-scale fishery until the 2010 reversal of the commercial sardine fleet's fortunes following a bumper sardine harvest in 2009. The dramatic decline of the commercial sardine fishery beginning in 2010 (See Fig. 3) led to closure of some Pengambengan factories and forced the largest cannery to resort to importing frozen sardines from India to maintain its operations at a much reduced level (interviews 2010–2019).

4. Collapse of the Bali Strait sardine fishery – causes and consequences

Considerable uncertainty surrounds the wide variations in sardine abundance that are associated with climatic oscillations. Sardine stock assessments along the coast of Peru and Chile experienced a rise and decline in abundance roughly parallel to the Bali Strait over the period 2000 to 2015 (Chavez et al., 2003; Shreiber et al. 2011; Ortiz 2020).[9] Causes of abundance and distribution cycles for sardine species have been demonstrated to relate to ocean temperatures and upwelling. Saputra, Arthana and Hendrawan (2017) found a strong positive correlation of increased sardine abundance during El Niño (ENSO) periods and decline during La Niña and Indian Ocean Dipole (IOD) negative events in the Bali Strait. The sharp rise and collapse of sardine catches in the Bali Strait in years 2009–2012 corresponded with the El Niño cycle of 2009–10. But the authors found that during the subsequent period of 2012–16, the ENSO-IOD cycle no longer had the predicted influence on sardine abundance. Their conclusion that these aberrant catch patterns were attributable to overfishing concurs with the implication of other studies detailed below that the long-term decline in full-size sardine catches beyond estimated sustainable yield has been caused by the expansion of the commercial fleet and the use of net mesh sizes that capture immature size sardines (*protolan* and *sempinit*) (2017, pp 145-46).[10] The fact that global stock trends studied by Hilborn et al. (2020) show a systematically strong relationship between reduction in fishing pressure and stock abundance in well managed fisheries over the

[6] Regulation of the inshore 12 nautical mile zone is decentralised to provincial government, which also licenses boats under 30 GT (gross tonnage). Boats under 5 GT (recently raised to <10 GT) did not require licenses. For a discussion of Indonesian regulations affecting small-scale fishers, see Lucas (2009); CEA/Packard (2016); Halim et al. (2019).

[7] The price of sardines (*sardinella lemuru*) recorded at the Pengambengan landing and auction site (TPI- *Tempat Pelelangan Ikan*) rose from Indonesian *rupiah* IDR 424 per kilogram in 1995 to IDR 6000/kg in 2016. Over this period the *rupiah* devalued by approximately 400%, although the cost of living, especially in rural areas, did not change as rapidly (TPI Pengambengan 1993–1998 & 2003–2016); see also Erdmann and Pet (1999). The exchange rate varied over this period from 3000 to 13,000 rupiah to the U.S. dollar. See also OECD 2016.

[8] Eastern little tuna (*tongkol*), scad (*layang*), hairtail (*layur*). See Bailey et al., 1987; See also species information at http://www.fao.org/fishery/.

[9] http://sustainablefisheries-uw.org/fishery-feature/the-pacific-sardine-sardinops-sagax/; See also Badjeck et al., 2010).

[10] The 1992 Memorandum of Understanding between the Governors of East Java and Bali Provinces set minimum net mesh size at 1 inch and the maximum sardine catch limit for the Bali Strait fishery at 28 thousand tons per annum. (Saputra et al., 2017).

entire period 1975 and 2015, irrespective of climatic oscillations, points to the centrality of governance failure in explaining resource decline in this Indonesian case. The 2019 IPCC report finds that changes in fish stock distribution due to warming oceans have reduced catch potential especially in tropical ocean areas, posing risks to food security. This is likely to disproportionately impact upon small-scale fishers, whose ranges tend to be highly localised.

4.1. The impact of illegal, unreported, and unregulated (IUU) practices

To whatever extent climate change is impacting global fisheries, and sardine species in particular (FAO, 2018a, IPCC , 2019),[11] poor governance has undoubtedly been a major contributing factor in the case of the Bali Strait. Weak enforcement of regulations allowed overcapacity and use of illegal gears by the sardine fleet to continue unchecked (ACIAR 2011). Despite restrictions agreed in a Memorandum of Understanding between East Java and Bali provincial governments in 1992, purse seine boat numbers and sizes grew over the years at the two dominant sardine fleet locations of Muncar (east Java) and Pengambengan (west Bali) on opposite sides of the Strait to take advantage of what was widely treated as a limitless resource. The number of purse seine vessels exceeded agreed limits (ACIAR 2011, p. 43) and vessel tonnage was underreported (Perangkat interviews 2010–2019). The sardine catch from the combined Muncar and Pengambengan fleets reached 58.6 thousand tons in 2009, more than twice the MoU limit (Saputra et al., 2017, p142).[12]

Total landings at Pengambengan had risen from 6.6 million kg in 2005 to 21.8 million kg in 2009, but then dropped dramatically to 6.0 million kg in 2011 and 2.7 million kg at its lowest point in 2012. As important as total productivity, is the declining proportion of full-size sardines (*lemuru*), indicated by species composition data for 2011 and 2015 shown in Fig. 4. Since roughly half the purse seine sardine fleet fishing the Bali Strait land their catches at this official auction site, its records are a significant indicator of the rapidly declining health of the sardine fishery.

Most destructive for the long term, is the use of illegal 1 cm mesh net sizes which means that juvenile fish are scooped up along with the main catch by the growing commercial fleet to be sold for low value fish meal. The photograph in Fig. 2b shows scrap fish being scoured from purse seine nets after unloading the main catch at the TPI. At that time full size *lemuru* class sardines could bring as much as *rupiah* (IDR) 6000 per kg (US$ 0.46), while the fingerlings (*sempinit*) shown in the photograph, too small and damaged to be accepted at the TPI, were sold by women gleaners to make fish meal for animal feed and aquaculture at only IDR 250/kg (US$ 0.02).

A crucial indicator of the unsustainability of both the commercial and artisanal fisheries is the changed composition of the commercial catch in the period since the sardine crisis began. Purse seine catches sold at the TPI since the collapse have been dominated by lower value juvenile sardines (*protolan*) and varying proportions of non-*sardinella* species that are normally targeted by small scale fishers. In 2011, only 23.7% of the total purse seine catch was identified as *lemuru* sardines in TPI Pengambengan data. 2012 data begin to differentiate between full size '*lemuru*' and smaller '*protolan*' for the first time. By 2015 *lemuru* accounted for only 8.7% of the catch (Fig. 4).[13]

A 2015 study of production levels and catch composition in the Bali Strait found that 91% of the sardine catches sampled were composed of sardines less than 18 cm and deemed 'illegal' (Simbolon et al. 2017, p. 842). That study involved 120 random catch samples in February–March 2015 from the purse seine fleet on the east Java side of the Bali Strait with its landing site (TPI) at Muncar. The authors conclude that the small mesh size of the purse seine fishing gear threatens the sustainability of the stock. They recommend policies to reduce fishing pressure through implementation of tighter regulation of net mesh size and limitations on total purse seine vessel numbers (2017, 840-42). Purwaningsih, Widjaja and Partiwi (2011), researching the east Java sardine fleet at the height of the crisis, conclude that the increase in numbers of purse seine boats has been responsible for exceeding the maximum sustainable yield for the Bali Strait sardine stock and the consequent decline in revenue. Their simulations lead them to predict the end of the industry by 2040. Earlier studies had estimated that the Bali Strait pelagic fisheries were already exhibiting excess effort and approaching maximum sustainable yield by the 1980s (Bailey et al. 1987, 42–44).

Fig. 5 shows the extent of juvenile sardinella (*protolan*) predominance over mature *sardinella lemuru* at the Pengambengan fish landing site (TPI) in 2015. Of the total reported catches landed at the TPI by the purse seine fleet for that year, only 8.7% were classified as full size *lemuru*, concentrated in the months of July–September. Juvenile *protolan* sardines accounted for 79% of the total, dominating catches during January to April and October to December that year. Other fish types, primarily *tongkol*, dominate in the lowest season of May–June. Notably, in the immediate aftermath of the sardine fishery collapse, 2011 fish landings of non-sardine species comprised an exceptional 76.3 percent of the total reported fish volume sold at the Pengambengan TPI.[14] Although they represented only 6% of total landings by 2015, the extent of non-sardine catches by the commercial fleet are important for their impact on the small-scale fishery sector.

Artisanal fishers were already under pressure from increasingly erratic weather, lengthening periods of low abundance (*paceklik*), and higher fuel prices. They also faced increased competition from grounded purse seine crew in Perangkat and neighbouring villages who have been shifting to artisanal fishing in the near shore zone to support their households.

5. Impacts of fisheries decline on local livelihoods

The effects of resource decline have been felt across the village. Alongside fishers in both artisanal and commercial sectors, traders and shop owners estimated their incomes were reduced by 20–50 percent (Perangkat interviews, 2010-19). The impacts of resource decline have been mitigated to some extent by fishers' ability to seek work in other sectors of the economy outside the village. Many fishers have turned to casual construction labour in the district capital. In some households young adult family members are sent to tourism centres to supplement household incomes. These alternative work opportunities are usually low-waged, irregular and vulnerable.[15] More basic local coping strategies involve intensified dependence on gleaning alongside traditional forms of reciprocity. Gift giving of fish remains a widespread practice; although the passing of small strings of fish to relatives and friends by successful small-scale fishers and purse seine crew is inevitably

[11] Water temperature change and acidification are likely to lead to range shifts, with decline in species richness anticipated in tropical areas according to the IPCC (2019).

[12] Villagers stated that official statistics for the unprecedented harvest in 2009 do not reflect the actual scale of the catches that year because large quantities of fish had to be dumped at sea when the Pengambengan factories proved unable to process or stockpile the excessive loads (Perangkat interviews, 2010-19).

[13] See Appendix illustration #2 for size comparison of *lemuru* and *protolan* classed sardines.

[14] These were predominantly tongkol, which accounted for 48%, and layang 21% of the total catch respectively. Source: TPI Pengambengan, Data Produksi/Pendaratan, Tahun 2011.

[15] During the covid-19 pandemic, tourism and construction jobs were the most directly affected by the accompanying economic downturn.

Fig. 2. 2a) Artisanal (*jukung*) and 2b) commercial (*selerek*) fishing vessels (photographs by C. Warren).

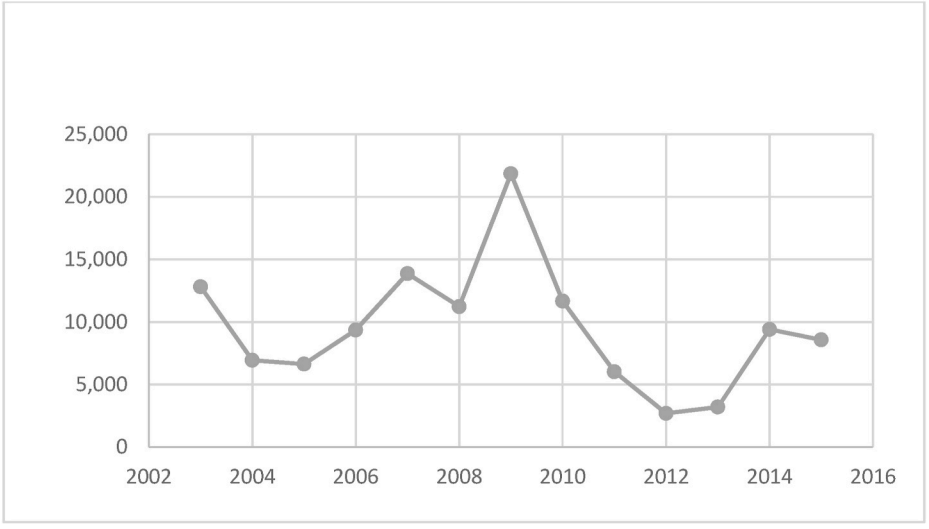


Fig. 3. Annual purse seine fish landings by weight (tons) at Pengambengan Landing and Auction Site (TPI) 2003–2015
Source: Pengambengan Fish Landing and Auction site (TPI) annual production reports 2003–2015.

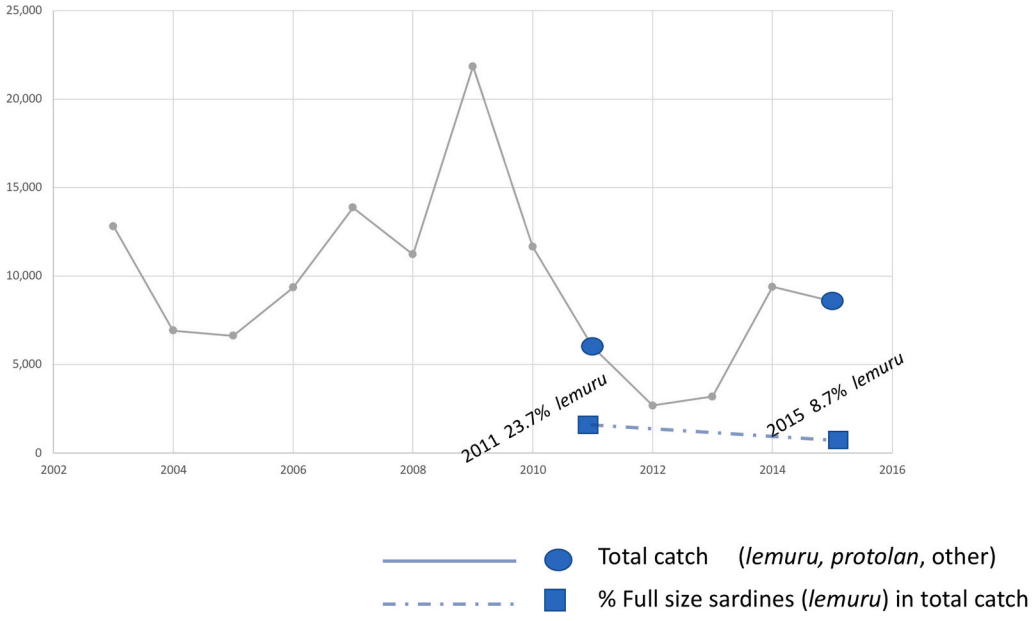
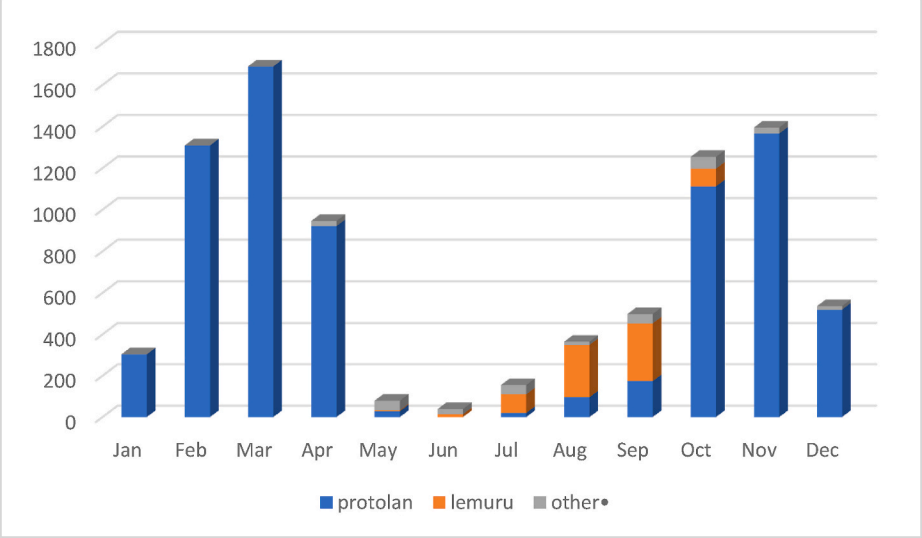


Fig. 4. Annual purse seine fish landings by weight (tons) with declining percentage of full size sardine (*lemuru*)
Sources: Pengambengan Fish Landing and Auction site (TPI) annual reports 2003-2015
Note: *lemuru* class full size sardines as a declining percentage of the slightly improved 2015 catch.



Figs. 5. 2015 Monthly catches by fish type and weight (tons) at TPI Pengambengan
Source: Pengambengan Fish Landing Site (TPI) monthly records, 2015
*Non-sardine species landed at TPI Pengambengan, primarily *tongkol*.

declining with the resource.

5.1. Livelihood precarity

Unfortunately, there are no official records that could be used to measure the scale of the changes taking place in the small-scale fishery. As the purse seine fleet began to take larger volumes of other fish stocks such as *tongkol* that are the primary target of small-scale fishers, this impacted directly on artisanal fishers' fortunes. Small-scale fishers have long complained that purse seine boats fish illegally in near shore waters zoned for artisanal fishers when unsuccessful with their target sardine catch. This practice has intensified in the post-2010 period. Fishing households surveyed in 2016 estimated incomes dropping to an average of IDR 39,000 rupiah per day, roughly US$ 3 (Perangkat survey interviews 2016). As one of the survey respondents remarked, 'Life 10 years ago was better than now. Fish were more plentiful and the price of fuel was cheaper … Now, there are no fish to be had' (Respondent #20, 2016 Survey). The sense of precarity arising from the crisis in the sardine fishery and its impact on the small-scale sector is indicated by survey responses to questions on difficulties covering costs of basic needs in the areas of education, health and food expenditure, mapped onto the fisheries decline data in Fig. 6. In 2010 immediately following the high point of sardinella catches of the previous year, 20% of respondents indicated they experienced difficulties in one or more of the three areas of household consumption compared to 48% in the 2016 survey, several years after the crash.[16]

Observations from the fishing household where the first author stayed in 2017 will serve to indicate the vagaries of small-scale fishing incomes in this period of resource decline. Sudi was head of one of the village fishing cooperatives and regarded as a knowledgeable and successful small-scale fisher. Over 17 consecutive days in September, which was not normally a seasonal period of scarcity in the small-scale sector, he fished 13 days with no catches on four of these. Over the nine 'successful' outings he brought in a total of 117 kg mainly of *tongkol*, but with a wide spread of catch size from less than 1 kg to a substantial 60 kg haul, representing his worst and best day's catches. His net cash income, after subtracting for fuel, ice and other costs amounted to IDR 42,000 or ~ US$3.23 per day, which without his wife's home based piecework income, would have pulled their family of three below the international poverty line.[17]

Sudi, among a small number of artisanal fishers and former purse seine crew, had replaced his traditional wooden outrigger (*jukung*) in 2017 with a larger fibreglass outrigger craft using government incentives aimed at improving the situation of small-scale fishers. This enables him to go further out to sea and has potential to increase catch sizes when successful. At the same time, the greater capital cost of these vessels, with twice the engine power and fuel costs required for longer journeys, also increases the risk of debt and default.

6. Discussion: the role of state policy in resource decline

Fisheries are central to the current Indonesian government's food security priorities. Capture fisheries and aquaculture provide a significant source of protein to the Indonesian population which consumes 32 kg per person annually, nearly double the global average, as well as contributing exports worth US$ 4.2 billion in 2017. An estimated 90% of Indonesian fishers, some 2.5 to 3.7 million people, depend directly upon the small-scale fishery sector for their incomes and household food security (FAO, 2014; Ariansyach, 2017; FAOSTAT, 2018 [18]). Yet the Indonesian government's failure to enforce regulations disproportionately affects small-scale fishers.

6.1. Privileging commercial interests

Teh and Pauly (2018) address the policy neglect that has arisen from lack of recognition of the importance of small-scale fisheries in their study of the relative contribution of this sector to food security in Cambodia, Malaysia, Thailand and Vietnam. They conclude that small scale fisheries had been the primary source of fish for human consumption in those four countries until overtaken by state-promoted industrial fishing after 2002.

[16] See Warren (forthcoming) for a detailed analysis of the livelihood trajectories of Perangkat village households. See also McCarthy & Sumarto (2018) for a more general overview of social protection policies under the Jokowi Presidency.

[17] The international poverty line is set at US$1.90 per capita per day. http://povertydata.worldbank.org/poverty/country/IDN.

[18] http://www.fao.org/fishery/facp/IDN/en.

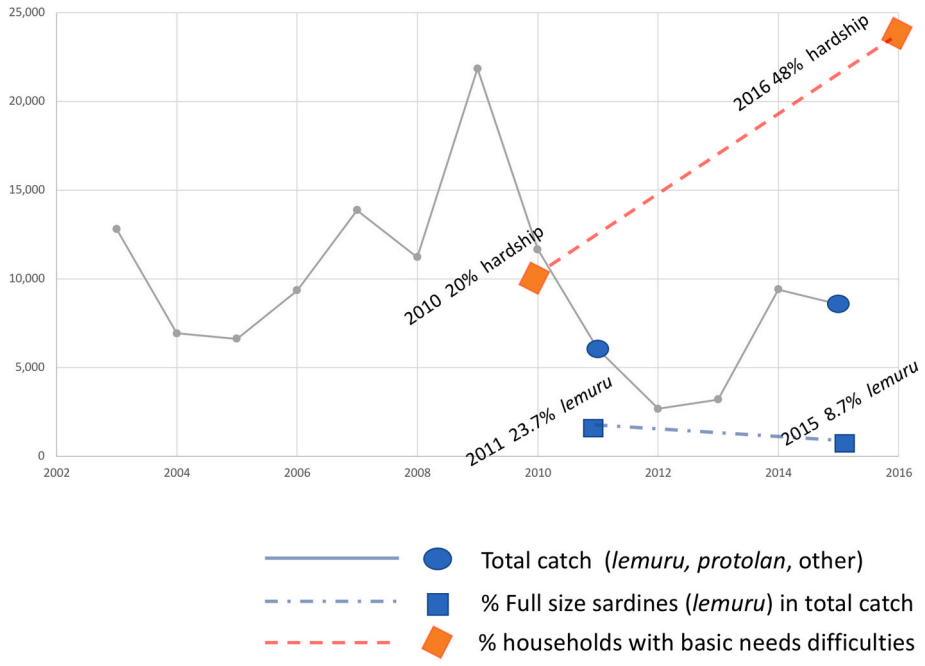


Fig. 6. Livelihood impacts of fisheries decline
Sources: Fish Landing Site (TPI) annual records; Perangkat household surveys 2010 & 2016.

> "The rise of industrial fishing has come at the expense of small-scale fisheries, as small-scale catches from the four countries have declined from comprising 80% of total reconstructed catch in the mid-1960s to 35% in 2013 …. The overall decline in small-scale catches shown in this study concurs with fishers' perceptions of reduced catches regionally …. Not surprisingly, the unequal distribution of marine resources has been the root cause of on-going conflict between small-scale fishers and large commercial fishing operators across Southeast Asia" (Teh and Pauly, 2018, p. 6). [19]

Much of the reported decline in Southeast Asian capture fisheries arises from governments privileging large-scale commercial fishers through under-regulated, production-driven economic development policies in this sector (Butcher, 2004; Béné et al., 2010). Until very recently, Indonesian government fisheries policy has been primarily aimed at massively intensifying exploitation of its fisheries resources. In the same period that Perangkat fishers were experiencing the worst of the impacts of the collapse of the Bali Strait fishery, the then Minister of Maritime Affairs and Fisheries was promoting a 'blue revolution' to double Indonesia's fish production to 22 million tons by 2014.[20] Subsequent government policies under President Joko Widodo combine increased production goals with commitments to conservation and pro-poor development objectives that on paper at least had potential to bring these often conflicting goals into some degree of congruence.

The high-profile Minister of Marine Affairs and Fisheries from 2014 to 2019, Susi Pudjiastuti, introduced domestically popular policies to eliminate illegal fishing by unregistered foreign vessels in Indonesian waters,[21] and less popular regulations attempting to reign in illegal, unreported and unregulated (IUU) activities in the domestic industry (CEA, 2016). Major reforms introduced by the controversial Minister have the goal of reducing illegal fishing practices while increasing incomes and security for small-scale fishers. Subsidised gear, credit and insurance programs are aimed at supporting small-scale fishers. On the conservation front, national regulations to reinforce existing minimum 1-inch net mesh size rules and ban trawl and purse seine gear were issued. Negative reactions from the industrial fisheries sector, however, led to presidential intervention to relax their enforcement in 2017, a mark of the extent to which conflicted governance hobbles policies aimed at long term sustainability.[22]

6.2. *Conflicted governance*

Despite several visits and strong words from the Minister regarding illegal fishing practices and gear, no changes to the use of illegal net sizes by the purse seine fleet at TPI Pengambengan and no policing of the inshore zone were evident as of 2019. Several fishers described attending one of the meetings the Minister held at Pengambengan in 2016: "She was quite angry over fishery laws being broken …. [We] had the opportunity to complain about illegal purse seine fishing. She took lots of notes and proposed using community monitoring to prevent illegal fishing." While many small-scale fishers approved of her hard-line approach and rhetorical commitment to protecting small-scale fishers, others were sceptical and felt they would be better to take matters into their own hands by destroying the offending purse seine nets with their sickles. (Survey interviews #13 12 September 2016; #15 28 August 2016; and #18 11 September 2016).

Other than the rare opportunity to make representations on such occasions, local fishers feel unable to seriously influence government policy. The strong customary (*adat*) sanctions that are the foundation of traditional forms of local governance in Bali (Warren 1993) and in some traditional Indonesian fisheries (Brosius et al., 2005; Steenbergen, 2016; Lau et al., 2019) are difficult to apply beyond village boundaries or where competing interests within the community neutralise collective

[19] See also Bavinck et al. (2018) on the importance of distributive justice for sustainable use of marine environments.
[20] *Kompas*, February 17, 2011; *Bali Post*, February 20, 2011.
[21] At least 360 foreign vessels found to be fishing illegally in Indonesian waters were sunk between 2015 and 2017 (*Jakarta Post*, January 10, 2018).
[22] *Jakarta Post*, March 13, 2018. Selerek purse seine nets use 1 cm mesh, despite national regulations that permitted net mesh no smaller than 1 inch (Peraturan Menteri Kelautan dan Perikanan No Per. 02/MEN/2011). Trawl and purse seine gear are now banned under Ministerial Regulation Permen No. 2/MEN/2015.

action. That proved the case with the damaging seagrass harvest which took place at the height of the Bali Strait fisheries crisis, when villagers were encouraged by outside traders to harvest all accessible seaweed and seagrasses along the village shoreline for much needed cash (Warren 2016). Despite understanding the ecosystem importance of seagrasses, neither local customary nor state authorities initially took action to prevent the mass destructive harvest, resulting in a dramatic abrasion incident only a few months afterward that ripped several metres from the already badly eroded village coastline. (See Appendix illustration #3).

To the extent success can be claimed for development policies aimed at economic growth and poverty alleviation over the late 20th century, these outcomes carry a heavy environmental sting in the tail, now being experienced by Perangkat and other natural resource dependent communities. Market expansion has proved a double-edged sword for resource dependent communities and cannot be excluded from governance measures to achieve sustainability. Nor can the livelihood issues of villagers who are the producers and consumers of fish, a food source of high nutritional significance, be marginalised (Kooiman et al., 2008; Jentoft 2019). Restoration of the health of the commercial Bali Strait sardine fishery will depend upon a dramatic reduction in capture fishing effort – an estimated 50 percent according to the ACIAR 2011 report - to assure long term sustainability of the stock.[23]

The sustainability of the other fish stocks in the Bali Strait that are the mainstay of the artisanal fishery has not been estimated to date, but their viability will be heavily affected by whether government policies are enforced on large-scale commercial fishers, who are now also competing for the target fish of the small-scale sector. Unless livelihood enhancement policies are implemented in the context of improved governance and better understanding of the relationships between small-scale fisheries and the commercial fishing sector, there is little likelihood of long-term improvement in the situation of small-scale fishers or the households and communities dependent upon sustainable use of the coastal resource base. Not least important is the urgency of demonstrably greater preparedness on the part of the government to end the illegal practices employed by the more politically and economically powerful commercial fishery's backers and to seriously engage the artisanal sector in resource management decisions (Jentoft 2019).

For the small-scale sector, credit and insurance provision, storage and marketing improvements and value-adding through local processing are among the development policy initiatives currently underway. These are undoubtedly essential to produce better outcomes for the artisanal sector, including for women who are primarily involved in local fish trading and processing (CEA, 2016; Loneragan et al., 2018; Stacey et al., 2019). At the same time, development policies must provide for sustainable stewardship of marine resources. Grants for technological improvements have been aimed at encouraging small-scale fishers to go further out to sea by subsidizing larger, more durable and powerful fibreglass boats and equipment. But these do not always compensate for resource decline and may merely accelerate it. Nor do benefits of technological 'upgrade' necessarily outweigh costs. The newly introduced and government promoted fibreglass boats enable further reach, larger hauls and faster return, but require double the engine power and fuel, increasing costs, debt and the potential for loss of assets. Furthermore, the new technologies undermine the local economy and boat-building skills while moving small-scale fishers even further to dependence on the double-edge sword of the external market. Concerns have also been raised by Halim, Wirawan, Loneragan et al. (2018) regarding the Indonesian government's change in the definition of small-scale fishing vessels from < 5 GT to <10 GT, which they argue will expand the scale of unregulated and unreported fishing in Indonesia and potentially increase competition for marine resources in the inshore zone.

7. Conclusion

Conflicted governance complicates any assumptions that implementing sustainability policies is a straight-forward matter. Short versus long-term priorities, development versus conservation objectives and private versus public interests make the question of conflicted governance a central consideration in sustainable resource management (Agrawal 2003; Delgado-Serrano 2017).

Quantitative and qualitative data have been drawn together in this study to expose the dilemmas of resource decline experienced at community level, and to address the urgent need for a data-informed basis to drive fisheries management from local to global scales (Hilborn et al., 2020; Free et al., 2020; FAO 2020, p99).[24] In the absence of comprehensive data to underpin policy and practice, particularly for the small-scale sector, Free et al. (2020) argue, "In capacity limited systems, management could focus instead on implementing 'primary fisheries management' …, which uses best available science and precautionary principles to manage fisheries while also establishing or strengthening participatory co-management to incentivise sustainable stewardship." Effective co-management, or for that matter any level of improved participation of small-scale fishers in governance of the fishing sector, requires serious attention to the asymmetries of the political economy framework and the role of markets that affect decision-making and implementation of regulatory regimes (D'Armengol, 2018; Nunan, 2020).

It is widely recognised that small-scale fisheries are an understudied but important dimension of marine resource sustainability and livelihood security in coastal communities, because of the substantial rural populations they support, their cultural attachment to place and embedded local knowledge (Jentoft 2018; Steenbergen and Warren 2018; Frawley et al., 2019). In the case of the small-scale fishers of Perangkat, because of their complex involvement in both the commercial and artisanal fishing sectors, as both purse seine fleet crew and independent near shore fishers, their inclusion in policy-making and regulatory enforcement could offer the prospect of an improved basis for data collection for the small-scale fishery, as well as greater understanding, cooperation and sustainable management of the two increasingly intersecting fisheries.[25] Dutra et al. (2015), show that participatory strategies support shared understandings of management issues and modify attitudes and group interactions.

Resolving the policy dilemmas posed by tensions between sustainability and development, not to mention the vested political and economic interests at play, demands case studies with multi-disciplinary breadth and temporal depth in order to enable more refined understandings of the complexity of factors affecting outcomes. In bringing quantitative and qualitative data over time to case study analysis, this research contributes a study in microcosm of both the complementary

[23] This conclusion was based on data presented in Buchary's (2010) doctoral dissertation, cited in ACIAR 2011, Appendix 2.6, p3. See also Simbolon et al. (2017, 842). These studies do not quantify the level of reduction in fishing pressure required to achieve sustainability, but similarly conclude that enforcement of restrictions on mesh net sizes and the total number of fishing units is essential to the viability of the Bali Strait fishery (2015, pp 840–842).

[24] Hilborn et al. (2020) in a comparative study of world fisheries management and fish stock status estimate that regions without intensive management have "on average 3-fold harvest rates and half the abundance as assessed stocks." They explicitly point to the need for improved stock abundance and exploitation data from the South and Southeast Asia region.

[25] The latest global FAO report on the world's fisheries notes the growing recognition of the importance of small-scale fisheries and the need to collect data on unassessed minor tuna and tuna-like species such as tongkol that are in need of harvest control rules and substantial additional efforts regarding data reporting and assessment. (FAO, 2020, pp 49, 99ff).

and conflicting inter-relationships between the relatively data-rich commercial and the data-poor artisanal fisheries in the Bali Strait. It exposes the fundamental tensions between state policies aimed at improving small-scale fishers' welfare and simultaneously satisfying the accumulation interests of the large-scale commercial industry, while assuring resource security to both sectors.

This case study points to the paradoxical role of market expansion in both improving and undermining the livelihoods and food security of coastal villagers dependent upon these marine resources. It demonstrates that the two objectives of livelihood enhancement and sustainable resource use will continue to find themselves at odds without proactive, inclusive, fair and evidence-based governance oriented toward both short and long-term sustainable yield as well as food security goals (Cinner et al., 2009; Brewer et al., 2012; Warren and Visser 2016; Ye and Gutierrez 2017; Frawley et al. 2019). For starters, implementing existing regulations regarding gear types, net mesh sizes and fishing zone restrictions are imperative steps to good governance and proper stewardship of Indonesia's marine resources.

Addressing the wider sphere of global debates on conservation and development in rural transformation, the Bali Strait case study further demonstrates the urgency of bringing the socially oriented concerns of livelihood studies into sharper alignment with environmental science and resource governance research (Kooiman et al., 2008; Fox et al., 2009; Coulthard et al., 2011; Gollan et al., 2019). Policy makers must address the political tension between short-term productivity driven approaches to the dilemmas of resource dependent communities faced with over-exploitation, and those approaches focused on the long-term sustainability issues that ultimately underpin the potential for food security and rural development. The balance will not be struck unless the commercial sector's disproportionate capacity to influence policy and flagrantly violate regulatory efforts is curbed. This stewardship space needs to be filled through global-to-local regulatory regimes which link research to governance and trade to sustainability. This could be done in the context of implementing existing international agreements to prevent Illegal, Unreported and Unregulated fishing (IUU) and the Code of Conduct for Responsible Fisheries, which incorporates the development of plans of action including regular monitoring, and is in turn linked to national reporting on Sustainable Development Goal indicators including access rights and livelihood protections for small-scale fishers (Bavinck et al., 2018; FAO, 2020, pp95ff).

Without concerted policy attention and research collaboration across the social, environmental and governance divides, as Teitelbaum et al. (2018, 12) argue, policy makers will fail to produce the imperative integration of "environments and natural resources as a component of community well-being" that is ultimately essential to sustaining rural livelihoods, global food security and the environmental systems upon which these integrally depend.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The funding for this research was provided by the Australian Research Council under project number DP140103828. All subjects involved in formal interviews for this study gave informed consent to participation and use of data according to Human Research Ethics protocols established by the Australian Research Council. Permits covering different stages of this project - No.2009/161 and No.2016/104 - were issued by Murdoch University's Human Research Ethics Committee. Pseudonyms are used throughout the article for village and local informants' names.

As well as acknowledging the contributions of the villagers of 'Perangkat' and local officials, without whose involvement this research would not have been possible, credit is due to the invaluable assistance of staff from Yayasan Wisnu, the sponsorship of the Bali Peace and Democracy Institute, and advice of colleagues at the Fisheries Department, Udayana University. Special thanks go to Denik Puriati, field coordinator and research assistant over more than a decade, and to Ketut Erawan for encouragement and support for this local level research. I am also grateful for comments on early drafts of this article by Dedi Adhuri, Lesley Brain, Gede Hendrawan, Neil Loneragan, John McCarthy, Andrew McWilliam, Jeffrey Mellefont, Gerben Nooteboom, Mike van Keulen, and Budy Wiryawan.

Appendix A

Illustration #1 Sample TPI data sheet for February 2–12, 2015 listing boat name, owner, purchaser of catch, type of fish, production weight in kg, value by kg and total value in Indonesian rupiah.

PEMERINTAH KABUPATEN JEMBRANA
DINAS KELAUTAN, PERIKANAN DAN KEHUTANAN
DAFTAR PEMBELIAN / PENJUALAN MELALUI PELELANGAN IKAN
DI TPI PENGAMBENGAN
DATA PRODUKSI BULAN PEBRUARI 2015

NO	NAMA PERAHU	PEMILIK/ PENGURUS PERAHU	PEMBELI	JENIS IKAN	JUMLAH PRODUKSI (Kg)	HARGA SATUAN (Rp.)	JUMLAH HARGA (Rp.)
02 Februari 2015							
1	[redacted]		STP	Protolan	1,512	3,000	4,536,000.00
2			STP	Protolan	1,102	3,000	3,306,000.00
3			STP	Protolan	1,304	3,000	3,912,000.00
JUMLAH					**3,918**		**11,754,000.00**
03 Februari 2015							-
1	[redacted]		STP	Protolan	3,090	3,000	9,270,000.00
2			STP	Protolan	1,000	3,000	3,000,000.00
JUMLAH					**4,090**		**12,270,000.00**
08 Februari 2015							
1	[redacted]		Ariadi	Protolan	3,250	3,000	9,750,000.00
2			STP	Protolan	1,404	3,000	4,212,000.00
			BBM	Protolan	2,768	3,000	8,304,000.00
3			BBM	Protolan	1,624	3,000	4,872,000.00
4			STP	Protolan	2,988	3,000	8,964,000.00
			Yudi	Protolan	4,518	3,000	13,554,000.00
			Daman	Protolan	4,440	3,000	13,320,000.00
JUMLAH					**20,992**		**62,976,000.00**
09 Februari 2015							
1	[redacted]		Sultan	Protolan	1,116	3,000	3,348,000.00
2			SMN	Protolan	3,112	3,500	10,892,000.00
3			BO	Protolan	4,654	3,500	16,289,000.00
			Yudi	Protolan	1,424	3,000	4,272,000.00
JUMLAH					**10,306**		**34,801,000.00**
10 Februari 2013							-
1	[redacted]		Sultan	Protolan	2,392	3,500	8,372,000.00
2			SMN	Protolan	2,156	3,500	7,546,000.00
			Yudi	Protolan	640	3,500	2,240,000.00
3			BMP	Protolan	3,574	4,500	16,083,000.00
4			Daman	Protolan	1,312	3,500	4,592,000.00
5			STP	Protolan	800	3,500	2,800,000.00
6			H. Tayib	Protolan	1,750	3,000	5,250,000.00
JUMLAH					**12,624**		**46,883,000.00**
11 Februari 2015							
1	[redacted]		Ariadi	Protolan	1,050	3,500	3,675,000.00
2			STP	Protolan	2,346	3,500	8,211,000.00
			Yudi	Protolan	786	3,500	2,751,000.00
3			Sultan	Protolan	500	3,500	1,750,000.00
			BBM	Protolan	850	3,000	2,550,000.00
4			STP	Protolan	1,284	3,200	4,108,800.00
5			STP	Protolan	1,512	3,200	4,838,400.00
			Yudi	Protolan	428	3,000	1,284,000.00
6			STP	Protolan	2,082	3,200	6,662,400.00
7			SMN	Protolan	4,144	4,500	18,648,000.00
8			BBM	Protolan	5,400	3,000	16,200,000.00
JUMLAH					**20,382**		**70,678,600.00**
12 Februari 2015							-
1	[redacted]		STP	Protolan	1,458	3,500	5,103,000.00
			Bustam	Protolan	800	3,000	2,400,000.00
2			H. Maridi	Protolan	1,048	3,200	3,353,600.00
			BBM	Protolan	2,608	3,200	8,345,600.00
			Yudi	Protolan	1,502	3,000	4,506,000.00
3			BMP	Protolan	880	4,000	3,520,000.00
			SMN	Protolan	1,848	3,200	5,913,600.00
			Bustam	Protolan	628	3,000	1,884,000.00
4			BBM	Protolan	2,272	3,000	6,816,000.00
5			BBM	Protolan	1,500	3,000	4,500,000.00
			Yudi	Protolan	2,226	3,000	6,678,000.00
6			BBM	Protolan	2,440	3,000	7,320,000.00
7			STP	Protolan	1,168	3,000	3,504,000.00
			Daman	Protolan	1,926	3,000	5,778,000.00
			BO	Protolan	4,364	3,000	13,092,000.00
8			STP	Protolan	3,188	3,500	11,158,000.00
9			STP	Protolan	3,332	3,500	11,662,000.00
			BO	Protolan	4,456	3,000	13,368,000.00
			Daman	Protolan	676	3,000	2,028,000.00

Note: columns refer to: number, name of boat, owner, buyer, fish type, total production (kg), price per kg; total price by date. The names of boats and boat owners are redacted.

Illustration #2 Sardine classes: *lemuru* (lower), *protolan* (upper).

Illustration #3 Coastal erosion following sea-grass harvest Perangkat, 2012. (photograph by C.Warren)

References

ACIAR, 2011. Project No. FIS/2006/142. *Developing new Assessment and Policy Frameworks for Indonesia's Marine Fisheries, Including the Control and Management of Illegal, Unregulated and Unreported (IUU) Fishing.* Prepared by Ron West, ANCORS. University of Wollongong for the Australian Centre for International Agricultural Research, Canberra. https://www.aciar.gov.au/file/78521/download?token=dJt1kjGO.

Agrawal, A., 2003. Sustainable governance of common-pool resources: context, methods and politics. Annu. Rev. Anthropol. 32, 243–262. https://doi.org/10.1146/annurev.anthro.32.061002.093112.

Aguiliera, S.E., Cole, J., Broad, K., et al., 2015. Managing small-scale commercial fisheries for adaptive capacity: insights from dynamic social-ecological drivers of change in Monterey Bay. PloS One 10 (3), 1–22. https://doi.org/10.1371/journal.pone.0118992.

Ariansyach, I., 2017. Fisheries country profile: Indonesia. SEAFDEC Southeast Asia Fisheries Development, Bangkok.

Badjeck, J.-C., Allison, E., Halls, A., Dulvy, N., 2010. Impacts of climate variability and change on fishery-based livelihoods. Mar. Pol. 34 (3), 375–383. https://doi.org/10.1016/j.marpol.2009.08.007.

Bailey, C., Dwiponggo, A., Marahudin, F., 1987. Indonesian Marine Capture Fisheries. International Center for Living Aquatic Resources Management & Marine Fisheries Research Institute, Ministry of Agriculture Indonesia, Jakarta.

Bavinck, M., Jentoft, S., Scholtens, J., 2018. Fisheries as social struggle: a reinvigorated social science research agenda. MarXiv Papers. https://doi.org/10.31230/osf.io/c68xa.

Béné, C., et al., 2007. Increasing the Contribution of Small-Scale Fisheries to Poverty Alleviation and Food Security. Food and Agriculture Organisation of the United Nations, Rome.

Béné, C., Hersoug, B., Allison, B., 2010. Not by rent alone. Analysing the pro-poor functions of small-scale fisheries in developing countries. Dev. Pol. Rev. 28, 325–358. https://doi.org/10.1111/j.1467-7679.2010.00486.x.

Brewer, T., Cinner, J.E., Fisher, R., Green, A., Wilson, S.K., 2012. Market access, population density, and socioeconomic development explain diversity and functional group biomass of coral reef assemblages. Global Environmental Change. https://doi:10.1016/j.gloenvcha.2012.01.006.

Brosius, P., Tsing, A., Zerner, C., 2005. Communities and Conservation: Histories and Politics of Community-Based Natural Resource Management. Altamira Press, London.

Buchary, E.A., 2010. In Search of Viable Policy Options for Responsible Use of Sardine Resources in the Bali Strait, Indonesia. PhD Thesis. University of British Colombia, Vancouver, Canada.

Butcher, J., 2004. The Closing of the Frontier: A History of the Marine Fisheries of Southeast Asia 1850 - 2000. KITLV Press, Leiden.

CEA (California Environmental Associates], 2016. Indonesia Fisheries: 2015 Review. Prepared for The David and Lucile Packard Foundation. https://www.packard.org/wp-content/uploads/2016/09/Indonesia-Fisheries-2015-Review.pdf.

Chavez, F.P., Ryan, J., Lluch-Cota, S.E., Ñiquen, C.M., 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299, 217–221. https://doi.org/10.1126/science.1075880.

Chuenpagdee, R., Jentoft, S., Bavinck, M.J., Kooiman, J., 2013. Governability – New Directions in Fisheries Governance. Governability of Fisheries and Aquaculture: Theory and Applications. In: Bavinck, M.J., Chuenpagdee, R., Jentoft, S., Kooiman, J. (Eds.), vol. 7. Springer, New York, pp. 3–8.

Cinner, J.E., McClanahan, T.R., Daw, T.M., Graham, N., Maina, J., Wilson, S.K., Hughes, T.P., 2009. Linking social and ecological systems to sustainable coral reef fisheries. Curr. Biol. 19, 206–212. https://doi.org/10.1016/j.cub.2008.11.055.

Coulthard, S., Johnson, D., McGregor, J.A., 2011. Poverty, sustainability and human wellbeing: a social wellbeing approach to the global fisheries crisis. Global Environ. Change 21, 453–463. https://doi.org/10.1016/j.gloenvcha.2011.01.003.

Delgado-Serrano, M., 2017. Trade-offs between conservation and development in community-based management initiatives. Int. J. Commons 11 (2), 969–991. https://doi.org/10.18352/ijc.792.

Duarte, C.M., Agusti, S., Worm, B., 2020. Rebuilding marine life. Nature 580, 39–51. https://doi.org/10.1038/s41586-020-2146-7.

Dutra, X., Thebaud, O., Boschetti, F., Smith, A., Dichmont, C., 2015. Key issues and drivers affecting coastal and marine resource decisions: participatory management strategy evaluation to support adaptive management. Oceans and Coastal Management. https://doi.org/10.1016/j.ocecoaman.2015.08.011.

D'Armengol, L., et al., 2018. A systematic review of co-managed small-scale fisheries: social diversity and adaptive management improve outcomes. Global Environ. Change 52, 212–225. https://doi.org/10.1016/j.gloenvcha.2018.07.009.

Erdmann, M.V., Pet, J., 1999. *Krismon & DFP*: some observations on the effects of the Asian financial crisis on destructive fishing practices in Indonesia. SPC *Live Reef Fish Information Bulletin* No 5, 22–26.

FAO, 2014. Fishing and aquaculture country profiles: the Republic of Indonesia. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/fishery/facp/IDN/en.

FAO, 2018a. The state of world fisheries and aquaculture: meeting the sustainable development goals. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/documents/card/en/c/I9540EN/.

FAO, 2018b. Fishery and Aquaculture Country Profile: the Republic of Indonesia. http://www.fao.org/fishery/facp/IDN/en.

FAO, 2020. The State of World Fisheries and Aquaculture: Sustainability in Action. Food and Agriculture Organization of the United Nations, Rome.

Fox, J., Adhuri, D., Therik, T., 2009. Searching for a livelihood: the dilemma of small-boat fishermen in Eastern Indonesia'. In: Resosudaromo, B., Jotzo, F. (Eds.), Working with Nature against Poverty: Development, Resources and the Environment in Eastern Indonesia. Institute of Southeast Asian Studies (ISEAS), Singapore, pp. 201–225.

Frawley, T., Finkbeiner, E., Crowder, L., 2019. Environmental and institutional degradation in the globalized economy: lessons from small-scale fisheries in the Gulf of California. Ecol. Soc. 24 (1) https://doi.org/10.5751/ES-10693-240107.

Free, C.M., Jensen, O.P., Anderson, S.C., Gutierrez, N.L., Kleisner, K.M., Longo, C., et al., 2020. Blood from a stone: performance of catch-only methods in estimating stock biomass status. Fish. Res. 223, 105452. https://doi.org/10.1016/j.fishres.2019.105452.

Gollan, N., Voyer, M., Jordan, A., Barclay, K., 2019. Maximising community wellbeing: assessing the threats to the benefits communities derive from the marine estate. Ocean Coast Manag. 168, 12–21. https://doi.org/10.1016/j.ocecoaman.2018.10.020.

Halim, A., Wiryawan, B., Loneragan, N.R., Hordyk, A.V., Sondita, F.A., White, A.T., Koeshendrayana, S., Ruchimat, R., Pomeroy, R.S., Yuni, C., 2019. Developing a functional definition of small-scale fisheries in support of marine capture fisheries management in Indonesia. Mar. Pol. https://doi.org/10.1016/j.marpol.2018.11.044.

Hicks, C., Cohen, P., Graham, A.J., Nash, K., Allison, E., MacNeil, M.A., et al., 2019. Harnessing global fisheries to tackle micronutrient deficiencies. Nature 574, 95–98.

Hilborn, R., Amoroso, R., Anderson, M.A., Baum, J.K., et al., 2020. Effective fisheries management instrumental in improving fish stock status. Proc. Natl. Acad. Sci. Unit. States Am. https://doi.org/10.1073/pnas.1909726116.

IPCC (Intergovernmental Panel on Climate Change), 2019. *Special Report on the Ocean and Cryosphere in a Changing Climate* (SROCC), Chapter 5, Changing Ocean, Marine Ecosystems and Dependent Communities. https://www.ipcc.ch/srocc/home/.

Jentoft, S., 2018. Governing change in small-scale fisheries: theories and assumptions. In: Chuenpagdee, R., Jentoft, S. (Eds.), Transdisciplinarity for Small-Scale Fisheries Governance: *Analysis And Practice*. Amsterdam and Wageningen. MARE Publication Series, Springer, pp. 305–320.

Jentoft, S., 2019. *Life above Water: Essays on Human Experiences of Small-Scale Fisheries, Too Big to Ignore* TBTI. Springer.

Jentoft, S., Chuenpagdee, R. (Eds.), 2015. Interactive Governance for Small-Scale Fisheries: Global Reflections. MARE Publication Series, Dordrecht, Springer.

Kawarazuka, N., Béné, C., 2010. Linking small-scale fisheries and aquaculture to household nutritional security: an overview. Food Security 2 (4), 343–357. https://doi.org/10.1007/s12571-010-0079-y.

Kolding, J., Béné, C., Bavinck, M., 2014. Small-scale fisheries – importance, vulnerability and deficient knowledge. In: Garcia, S., Rice, J., Charles, A. (Eds.), Governance for Marine Fisheries and Biodiversity Conservation. Interaction and Co-evolution. Wiley-Blackwell.

Kooiman, J., Bavinck, M., Chuenpagdee, R., Mahon, R., Pullin, R., 2008. Interactive governance and governability: an introduction. J. Transdiscipl. Environ. Stud. 7, 1–11.

LaTour, B., 2018. Down to Earth: Politics in the New Climatic Regime. Polity Press, Cambridge.

Lau, J., Cinner, J., Fabinyi, M., Gurney, G., Hicks, C., 2019. Access to Marine Ecosystem Services: Examining Entanglement and Legitimacy in Customary Institutions. World Development. https://doi.org/10.1016/j.worlddev.2019.104730.

Loneragan, N.R., Stacey, N., Warren, C., Gibson, E., Fitriana, R., Adhuri, C., Jaiteh, V., Mustika, P., Steenbergen, D., Wiryawan, B., 2018. Small-scale Fisheries in Indonesia: Benefits to Households, the Roles of Women, and Opportunities for Improving Livelihoods, Prepared for the ACIAR Small Research Activity. Project Number FIS/2014/104. https://www.aciar.gov.au/publication/Small-scale-fisheries-Indonesia.

Lucas, A., 2009. *Berjuang diatas perahu*: livelihood, contestation and declining marine resources on Java's north coast. In: Warren, C., McCarthy, J. (Eds.), Community, Environment and Local Governance in Indonesia: Locating the Commonweal. Routledge, London, pp. 59–88.

McCarthy, J.F., Sumarto, M., 2018. Distributional politics and social protection in Indonesia: dilemmas of layering, nesting and social fit in Jokowi's poverty policy. J. Southeast Asian Eco. 35 (2). https://www.jstor.org/stable/26539215.

Mellefont, J., 2015. Bali's secret fleet: a glittering armada. *Signals*. Quarterly Journal of the Australian National Maritime Museum 110, 25–31.

Nunan, F., 2020. The political economy of fisheries co-management: challenging the potential for success on Lake Victoria. Global Environ. Change 63. https://doi.org/10.1016/j.gloenvcha.2020.102101.

OECD, 2016. Economic Surveys - Indonesia: *Per capita GDP across Indonesia's Provinces*, (2015). https://doi.org/10.1787/eco_surveys-idn-2016-graph21-en.

Ortiz, M., 2020. Pre-image population indices for anchovy and sardine species in the Humboldt Current system of Peru and Chile: years of decaying productivity. Ecol. Indicat. 119 https://doi.org/10.1016/j.ecolind.2020.106844.

Purwaningsih, R., Widjaja, S., Partiwi, S., 2011. The effect of marine fish stock reduction to Fishers' revenue (A case study of *Sardinella lemuru* fisheries on Bali Strait). IPTEK Journal of Technology and Science 22 (3), 166–176.

Saputra, C., Arthana, I.W., Hendrawan, I.G., 2017. Studi ancaman sumber daya ikan *lemuru* (*Sardinella lemuru*) di Selat Bali hubungannya dengan enso dan IOD [the vulnerability study of *lemuru* (*Sardinella lemuru*) fish resources sustainability in Bali Strait in correlation with ENSO and IOD]. Ecotrophic 11 (No. 2), 140–147. https://ojs.unud.ac.id/index.php/ECOTROPHIC/article/view/32910.

Schreiber, M., Ñiquen, M., Bouchon, M., 2011. Coping strategies to deal with environmental variability and extreme climatic events in the Peruvian anchovy fishery. Sustainability 3 (6), 823–846. https://doi.org/10.3390/su3060823.

Simbolon, D., Nurfaqih, L., Sala, R., 2017. Analysis of oil sardine (*Sardinella lemuru*) fishing grounds in the Bali Strait waters, Indonesia. AACL Bioflux 10 (4), 830–843.

Smith, H., Basurto, X., 2019. Defining small-scale fisheries and examining the role of science in shaping perceptions of who and what counts: a systematic review. Frontiers in Marine Science 6. https://doi.org/10.3389/fmars.2019.00236.

Stacey, N., Gibson, E., Loneragan, N., Warren, C., Wirawan, B., Adhuri, D., Fitriana, R., 2019. Enhancing Coastal Livelihoods in Indonesia: an Evaluation of Recent Initiatives on Gender, Women and Sustainable Livelihoods in Small-Scale Fisheries. Maritime Studies. https://doi.org/10.1007/s40152-019-00142-5.

Steenbergen, D., 2016. Strategic customary village leadership in the context of marine conservation and development in southeast Maluku, Indonesia. Hum. Ecol. 44, 311–327. https://doi.org/10.1007/s10745-016-9829-6.

Steenbergen, D., Warren, C., 2018. Implementing strategies to overcome social-ecological traps: the role of community brokers and institutional bricolage in a locally managed marine area. Ecol. Soc. 21 (3), 10. https://doi.org/10.5751/ES-10256-230310.

Teh, L.C.L., Pauly, D., 2018. Who brings in the fish? The relative contribution of small-scale and industrial fisheries to food security in Southeast Asia. Frontiers in Marine Science 5 (44). https://doi.org/10.3389/fmars.2018.00044.

Teitelbaum, S., Montpetit, A., Bissonnette, J.-F., Chion, C., Chiasson, G., Doyon, F., Dupras, J., Fortin, M.-J., Leclerc, E., St-Amour, C., Tardif, J., 2018. Studying resource-dependent communities through a social-ecological lens? Examining complementarity with existing research traditions in Canada. Soc. Nat. Resour. https://doi.org/10.1080/08941920.2018.1517913.

Thurstan, R.H., McClenachan, L., Crowder, L.B., Drew, J.A., Kittinger, J.N., et al., 2015. Filling historical data gaps to foster solutions in marine conservation. Ocean Coast Manag. 115, 31–40.

TPI [Tempat Pelelangan Ikan] reportPengambengan– Fish Auction Reports for Pengambengan TPI 1993-1998 and 2003 – 2016. (unpublished).

Warren, C. forthcoming. Between the sea and a hard place, In McCarthy, J. & McWilliam, A., eds. Social Protection Policy in Indonesia. National University of Singapore Press.

Warren, C., 1993. Adat and Dinas: Balinese Communities in the Indonesian State. Oxford University Press, Kuala Lumpur.

Warren, C., 2016. Leadership, social capital and coastal community resource governance: the case of the destructive seaweed harvest in West Bali. Hum. Ecol. 44 (3), 329–339. https://doi: 10.1007/s10745-016-9832-y.

Warren, C., Visser, L., 2016. The local turn: revisiting leadership, elite capture and good governance in Indonesian conservation and development programs. Hum. Ecol. 44 (3), 277–286. https://doi.org/10.1007/s10745-016-9831-z.

Ye, Y., Gutierrez, N., 2017. Ending Fisher overexploitation by expanding from local successes to globalized solutions. Nature, Ecology and Evolution. https://doi.org/10.1038/s41559-017-0179.