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Growth and Instability of Small Pelagic Fisheries of the North Coast of Java, Indonesia: Lesson Learned for Fisheries Policy*

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The North Coast of the Java Sea is home of thousands of small-scale fishers harvesting small pelagic fish. Small pelagic fisheries make up the main economic and social activities for coastal communities where other alternatives are limited. However, these fisheries have experienced turbulence over the last 30 years due to various transitions in regulatory regimes. As early as 20 years ago, the fisheries were declared to be overfishing, and the livelihood of the fishers has continued to decline ever since. The government of Indonesia has initiated various policy schemes to save the fisheries, including the recent introduction of right-based coastal areas to address ill-defined property rights for fisheries. Nevertheless, the results of such policies are unclear. Poverty and resource degradation are still rampant in the area. This raises a critical question: Did growth policy solve the fisheries problem? This paper attempts to address the fate of the fisheries within different policy regimes, ranging from centralized policies to decentralized policies. Using instability assessment method, the results show that the instability in the fisheries was related to the growth oriented policy pursued by the fisheries authority since last two decades. The instability was also correlated with the fierce competition among vessels operating in the fishery targeting the same stock of fish. The study shows that the transition of the fishery from de facto open access to more regulated regimes designed to achieve responsible fishing has failed.

Keywords: small pelagic fisheries, the north coast of Java, instability index, decentralization, growth-oriented policy

Introduction

Small pelagic fisheries of the north coast of Java have played an important role in Indonesia. During the 1980s-1990s, the fisheries there contributed the largest share of small-pelagic landings in the country, and became the "engine of growth" for the coastal area of the north coast of Java. The fisheries have now undergone

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significant changes over last 20 years. The contribution of fish landings from the north coast of Java has declined. In 2006, the north coast contributed around 16% of the total fish landings, and in 2007 their contribution decreased to 15% of the total landings.

There are several factors that contribute to this declination. First, a massive influx of fishing vessels, particularly purse seiners, following the trawl ban in the 1980s put significant pressure on the fisheries. McElroy (1991a) described this period as the modern tragedy of the common. Second, massive developments in coastal areas along the north coast of Java caused severe environmental degradation, which in turn caused the loss of mangroves and coral reefs, as well as producing pollution. Third, climate variability and natural disasters have put significant pressure on fishing fleets, reducing their fishing operations and increasing the cost of fishing. All of these factors contribute to the considerable decline of small pelagic landings on the north coast of Java.

Recognizing the importance of these fisheries in the national economy has prompted us to further evaluate the development of the fisheries. This paper attempts to examine the development of the fisheries during the last three decades. Emphasis of the analysis was given to the evaluation of the growth pattern, variability of growth, and instability of production and level inputs exerted into the fishery. This analysis is not only important to establish a broader picture of the fisheries, but it is also important for policy makers who are repeatedly confronted with the problems of accurately addressing the fisheries' performance.

The structure of the paper is the following. It begins with description of the fisheries, followed by method of assessing the relationship between growth and instability of the fisheries. Results of assessment are discussed thereafter. The paper concludes with findings and concluding remarks.

Brief Description of Small Pelagic Fisheries of the N.C. of Java

The fishing area of central Java is part of the Java Sea, which falls within Fishing Area Management (Fishing Area 571) under the Indonesian Fisheries Management Area system (see Figure 1). The coastal area of central Java has been the main fishing hub for small pelagic fisheries along the north coast of the Java Sea contributing more than 50% of small pelagic landings out of the Java Sea. Even though the share of landings from central Java has shown a slight decline during the last five years, central Java still maintains its central role among the small pelagic fisheries of the Java Sea.

The majority of small pelagic fish was landed and sold in the main port of Pekalongan using two dominant fishing mechanisms: purse seine and gill nets. A catch of small pelagic fish was predominantly made up of four species: scads (*Decapterus macrosoma*), Indo-pacific mackerel (*Rastrelliger brachysoma*), trevallies (*Selar spp*), and sardines (*Sardinella spp*). Landings of these species have fluctuated considerably during the last thirty years as can be seen in Figure 2. All four species showed similar patterns in landing fluctuation, increasing dramatically prior to the mid-1980s, then decreasing significantly afterward. In part, the higher landings during the period of the 1970s to late 1980s were attributed to the increase in the number of vessels, particularly purse seiners and gill netters, whereby after the trawl ban in the 1980s, there was not only an increase in new fishing mechanisms operating in the Java Sea, but also due to an increase in the number of ex-trawlers, fishers who switched their gears to gill nets and purse seines.

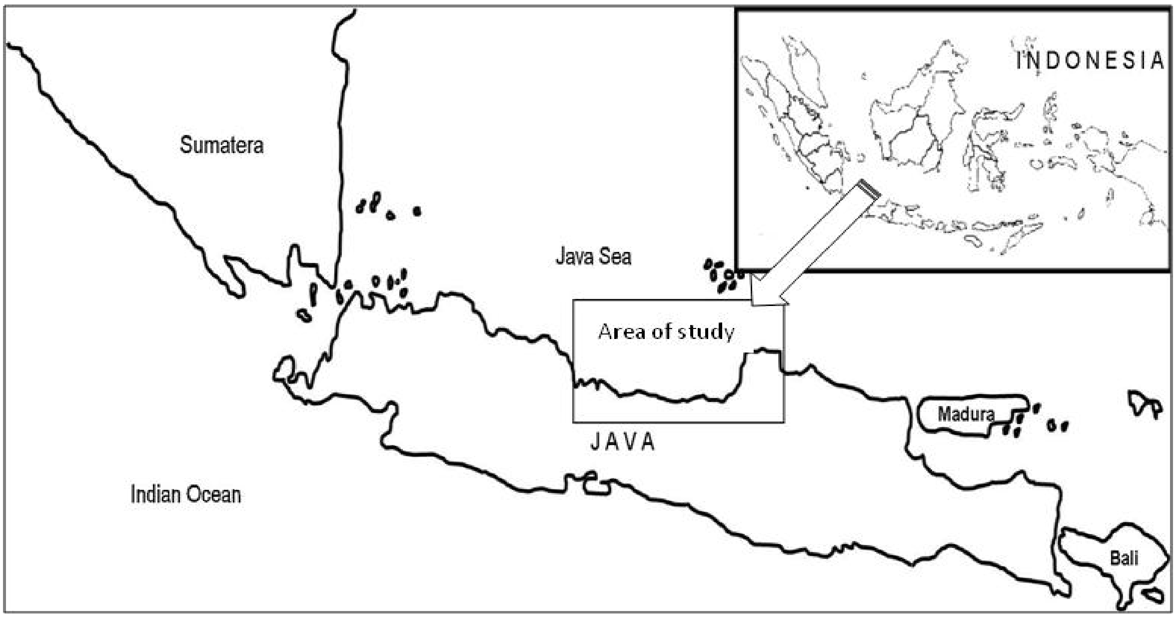

Figure 1. Fishing area of the north coast of central Java. Source: Fishing Area 571.

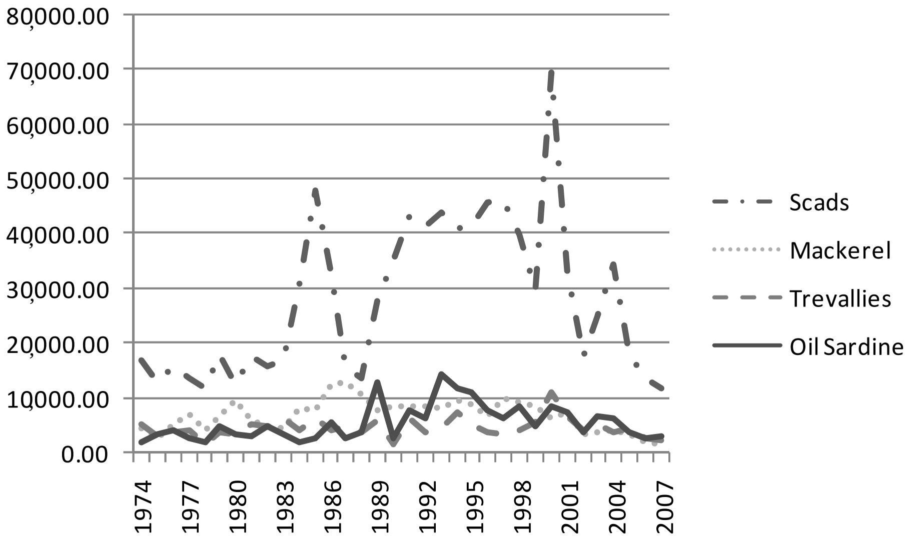

Figure 2. Landings of small pelagic fish in the north coast of central Java.

Despite their positive contribution to the landing of small pelagic fish, the increase in the number of vessels put added fishing pressure on pelagic resources. The productivity of fishing, measured by catch per unit effort (CPUE), tends to be declining after the late 1980s (see Figures 3, 4). This pressure was felt not only throughout the north coast of Java but also for the Java Sea as a whole. McElroy (1991a, 1991b) even noted that the increased pressure on the pelagic stock, indicated by a large fluctuation in the catch scads and mackerel, might in the future lead to the stock collapse of these species.

The decline in small pelagic landings will undoubtedly affect the socio-economic conditions of the fishing communities as well. A recent study by Fauzi and Anna (2010) shows that the decline in small pelagic landings on the north coast of Java has disrupted the socio-economic livelihood of fishermen and coastal communities as a whole. Income from fishing has been declining and fishers have to seek alternative sources for their livelihood, including exploiting terrestrial resources in order to survive the changing and uncertain situation in the fisheries.

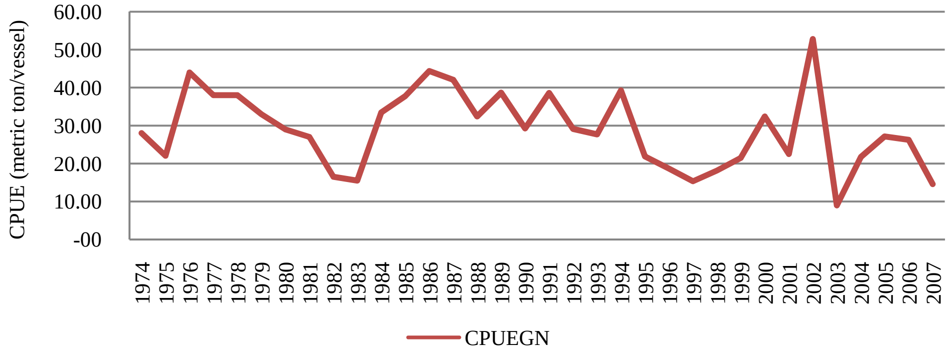

Figure 3. CPUE of gill net vessel.

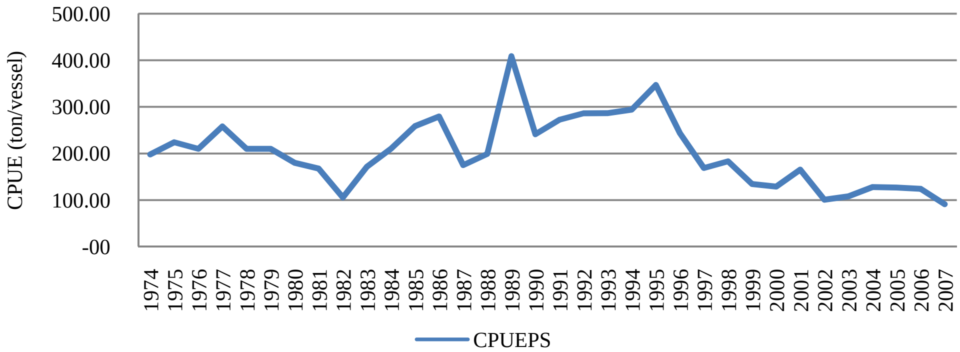

Figure 4. CPUE of purse seines vessel.

Assessment Method

In order to gain insight into and understand what had happened with the fishery during the last 30 years, an evaluation based on observable data was carried out.

There are various methods available to evaluate the state of fisheries. Among these are the non-parametric technique introduced by Pitcher and Preikshot (2001), growth analysis as done by Squires (1994), Squires and Reid (2004), and Jin, Thunberg, Kite-Powell, and Blake (2004), econometric modeling (Agnarson & Arnarson, 2007), and many others. Pitcher and Preikshot (2001) developed a method to evaluate the sustainability of fisheries using their so-called Rapfish (rapid appraisal for fisheries) technique. The method can be used to assess the sustainability of fisheries based on the FAO Code of conduct. Growth analyses, such as those on which Squires (1994) and Jin et al. (2004) focus, evaluated the sources of growth and input and output factors that contribute to total factor productivity (TFP). In the meantime, Agnarson and Arnason (2007) used the error correction model (ECM) to assess the fishing industry in Iceland. All aforementioned techniques can be beneficial to evaluate fluctuation and change in fisheries over a long period of time. The results may be extremely meaningful to understand both the fisheries and the policies that have been applied to them.

Despite the advantages, these methods require extensive data sets, both at macro and micro levels. This could be difficult for fisheries in developing countries where data are sometimes incomplete. A less elegant but powerful method measures growth and instability indices to evaluate the fisheries. The Coppock Instability Index (CII) (Coppock, 1962), for example, has been used in various assessments of the fisheries in developing countries by Shah (2007), and Wasim (2007). This technique has also been used to evaluate other agricultural products such as found in Reddy (2009), and Karjogi, Namaker, and Kunnal (2009). This method requires a less extensive data set and is suitable for evaluating the fisheries policies in developing countries. This paper will use such a method to evaluate the fisheries harvesting small pelagic fish off the north coast of Java, which has been subjected to various policy initiatives to manage their practices.

Growth of small pelagic landings during a given time period *t* was evaluated using the following formula:

$$Log(h_{it}) = \log \alpha + t \log \beta \tag{1}$$

where h_{it} is the landing (catch) of species i at time t, α is constant, β is a coefficient containing the rowth rate (i.e., $\beta = 1 + r$ where *r* is the growth rate) and t is time variable (in years). This compound growth rate (CGR) was chosen because it fits well with the data as compared to a linear model.

The instability index was calculated using the Coppock Instability Index, i.e.:

$$CII = \left| anti\log \sqrt{\log V} - 1 \right| \times 100 \tag{2}$$

where:

$$\log V = \frac{1}{n-1}\left[\sum \left(\log x_{t+1} - \log x_t \right) - \frac{1}{n-1} \sum \left(\log x_{t+1} - \log x_t \right) \right] \tag{3}$$

n is the number of years, x is the value of the variable being observed, and t is the year.

Results and Discussion

Growth and Instability of the Fisheries

Table 1 presents the growth rate and instability index of small pelagic landings. Both the growth rate and instability index are divided into four phases: Phase 1 (1974-1983), Phase 2 (1984-1993), Phase 3 (1995-2007), and Overall Period (1974-2007). As can be seen from Table 1 and Figure 5, in general, instability is higher during phase 2, while the Overall Period shows a modest instability index. Species wise, production instability for scads is higher during Phase 1 and Phase 3, while mackerel instability is higher during Phase 3, and the Overall Period. Sardines show the highest instability in production during Phase 2, while trevallies show the highest instability during Phase 3. Higher instability is also shown for sardines during periods of Phase 3 with a CII of more than 40. Higher levels of instability during Phase 3 may perhaps be attributed to negative production growth during Phase 3, as indicated in Table 1 and Figure 5. As for sardines, the case is different. Higher growth in Phase 2 is related to a higher instability index in the same period. These findings are, to some extent, similar to those found in other fisheries studies, such as Shah (2007) and Wasim (2007), who found that for some fisheries, a higher growth rate was related to higher instability, while for others the situation was the opposite.

Table 1

CGR and CII for Small Pelagic Landing

Fish	CII-P1	CII-P2	CII-P3	CII-Overall	CGR-P1	CGR-P2	CGR-P3	CGR-All
Scads	19.09	1.97	38.83	6.32	1.35	4.11	-9.08	1.95
Mackerel	17.94	4.75	56.73	18.36	3.50	-1.78	-11.76	-1.19
Trevallie	6.70	19.87	37.92	15.12	4.33	-2.05	-4.57	0.47
Sardines	2.69	71.56	42.49	6.98	4.69	17.90	-8.80	2.35

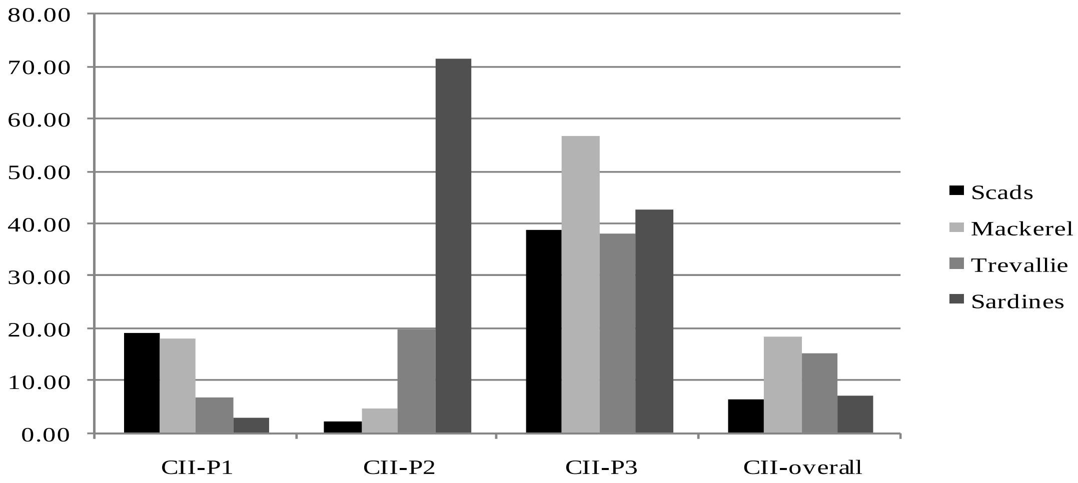

Figure 5. CII for small pelagic fish.

The tradeoff between growth and instability of these small pelagic landings can be categorized into four types following Reddy and Mishra (2007): high growth/low risk (low CII), high growth/high risk, low growth/low risk, and low growth/high risk. These patterns are depicted in Figure 6. Looking closely at Figure 6, one can see that only three patterns emerge. The first one is a cluster of low growth/low risk landings, as indicated by the bottom left corner of Figure 6. This pattern is undesirable from an economic point of view, since it indicates that landings must be restrained. However, this might be preferable from an ecological perspective. It also signifies to policy makers and fisheries managers that the state of the fisheries indeed calls for strict management and control of the catch of each species. The second cluster is attributed to low growth and medium to high risk. This can be seen from landings of sardine, mackerel and trevallies during the period of Phase 3. This pattern is also undesirable. It confirms the fact that Phase 3 of the fisheries study on the north coast of Java was indeed a phase during which overfishing was rampant and control of the fisheries was lacking.

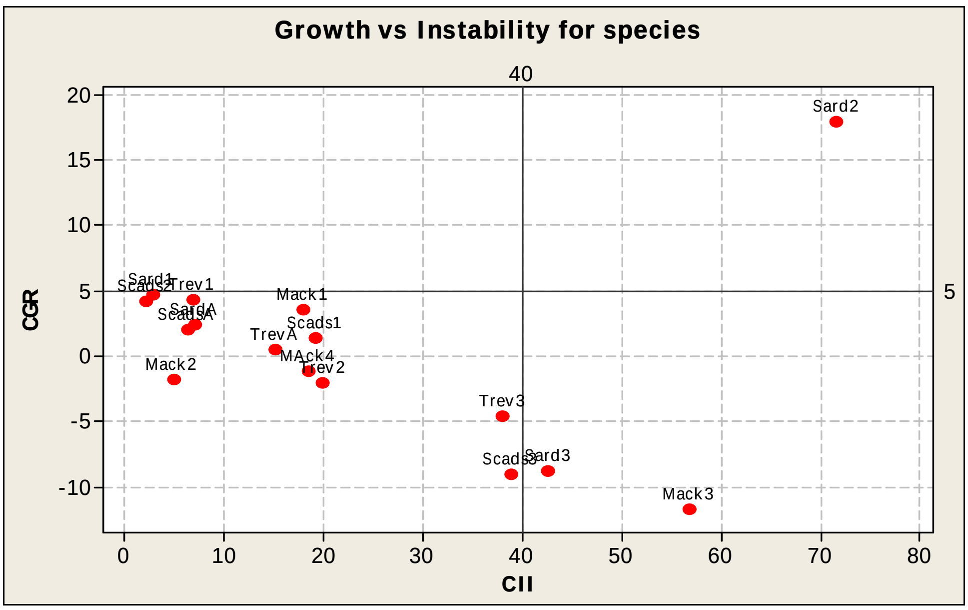

Figure 6. Matrix graph of growth vs. instability for small pelagic landing.

Fluctuations in production that lead to instability are not standalone phenomena. They are attributed to other indicators, such as inputs that were exerted into the fisheries. In Table 2, the instability index as well as compound growth rates, were measured for other indicators related to the landing of small pelagic fish. This includes the number of vessels operating during the period in question, disaggregation of catch per vessel, and total catch by vessels (i.e., purse seine and gill net). As can be seen from Table 2 and Figure 7, the number of purse seine and landing of small pelagic fish by this vessel shows the highest instability index during the first phase. This conforms to some analyses (McElroy, 1991a, 1991b) that found that higher influxes of this vessel during the early 1980s caused a massive increase in growth production. This can be seen from the CGR during Phase 1 (CGR-P1) where purse seine enjoyed the highest growth rate in production. In terms of productivity measured by CPUE, Table 2 indicates that productivity of purse seine shows the highest instability during Phase 3 (CII-P3 = 51.68). This is perhaps attributed to the fact that there is a lag between production growth and instability in CPUE. Higher growth of vessels and production affected instability in CPUE in later periods. The higher instability of CPUE during this period perhaps affected the higher instability of small pelagic landings for the same period, as indicated in Table 1.

Table 2

Scores of CII and CGR for Inputs Indicators

	CII-P1	CII-P2	CII-P3	CII-Overall	CGR-P1	CGR-P2	CGR-P3	CGR-All
CPUEGN	5.42	4.86	30.08	11.88	-6.40	-3.07	-1.38	-1.39
CPUEPS	1.81	10.43	36.31	14.20	-5.18	3.11	-7.93	-1.66
ProdGN	57.56	14.19	7.64	33.89	12.40	6.6	3.28	2.80
ProdPS	133.48	21.08	51.68	39.24	25.08	4.54	-8.98	3.35
NVGN	49.47	8.90	20.85	49.80	19.97	9.97	4.72	4.25
NVPS	129.34	9.64	11.28	59.00	31.91	1.38	-1.15	5.10

Notes. CPUEGN = catch per unit effort gill net, CPUEPS = catch per unit effort purse seine, ProdGN = production of gill net, ProdPS = production purse seine, NVGN = number of vessel gill net, NVPS = number of vessel purse seine.

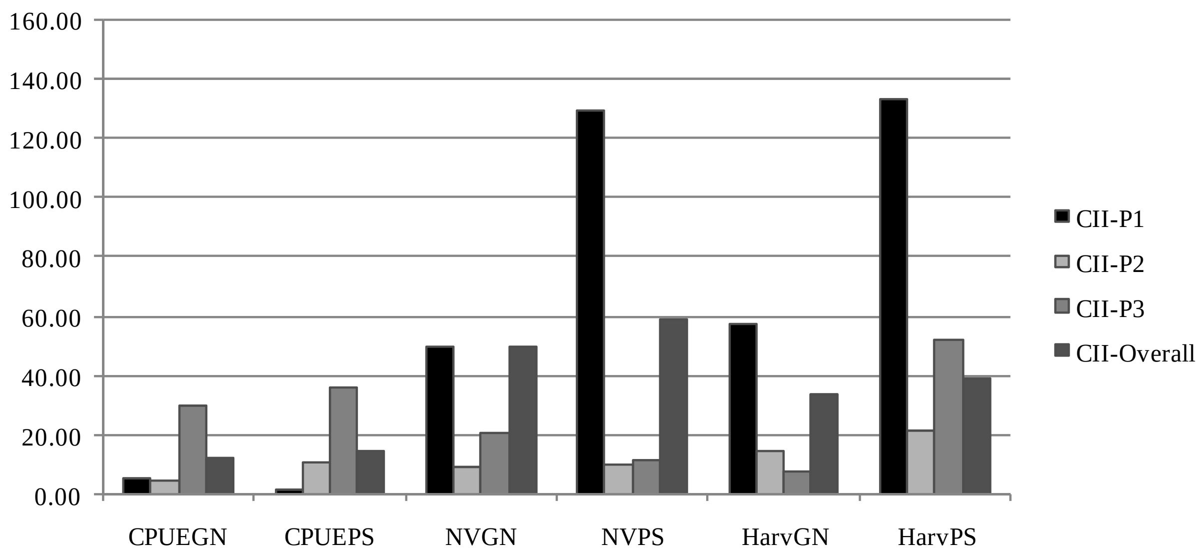

Figure 7. Coppock instability index for input and output wise.

The tradeoff between CII and CGR using these indicators is somewhat different from that for individual species. As indicated in Figure 8, three clusters emerged which illustrate the CII-CGR tradeoff. The first cluster is similar to the species cluster whereby a low growth/low risk pattern is dominant, as shown in the bottom left corner of Figure 6. This pattern again shows that the fisheries are suffering, since this pattern is an undesirable one. Figure 8 also reveals a desirable situation, higher growth with low risk, as indicated by the upper left quadrant. This is shown by the number of gill net during Phase 1 (NGN1) and Phase 2. This implies that stabilizing the fisheries would call for reducing the level of effort (gill net scale) to at least the same level as the period from 1974 to the late 1980s. The opposite is indicated by the upper right corner, in which reflects a higher growth/higher risk tradeoff. Again, this tradeoff is attributed to the growth of purse seine during the first phase, which induced instability in the fisheries during that period and periods afterward.

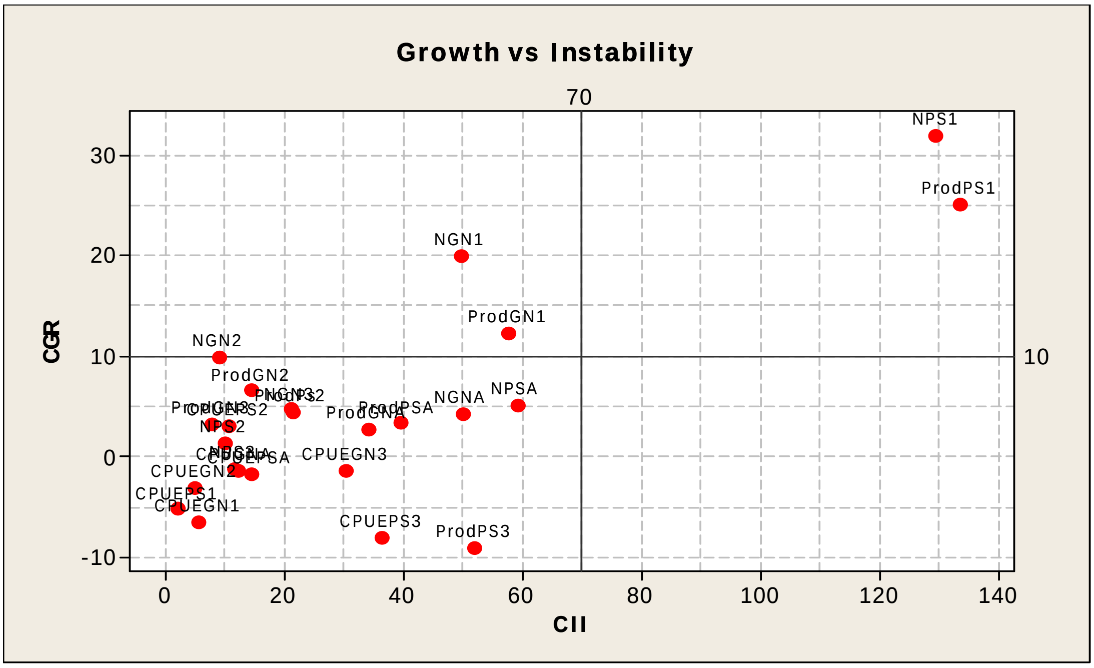

Figure 8. Matrix graph for CII and CGR (input and output wise).

Correlation Between Growth and Instability: Input-Output Wise

In order to capture the overall interaction between instability and the growth rate, a correlation analysis was carried out. Table 3 presents the correlation matrix between input variables and output variables for both purse seine and gill net. As indicated by Table 3, in general, there is a strong correlation between the growth rate and instability index both positively and negatively. On average, the coefficient is relatively higher than 50%. Looking closely at Table 3, it shows that there are strong correlations between the growth in purse seine and the instability index of this vessel. For example, growth in production by purse seine is negatively correlated with the instability of CPUE of this vessel (r = -0.90). Similar signs of correlation are also found for gill net. One interesting finding is in terms of cross-correlation between these two vessels. For example, growth in production by purse seine is highly correlated with higher production instability for other vessels, in this case, gill net (r = 0.92). It indicates that since these two vessels compete for the same type of fish, an increase in production of one vessel will likely induce perturbation on the other.

Table 3

Correlation Matrix Between CGR and CII for Input and Output

	CIICPUEGN	CIIPRODGN	CIINVGN	CIICPUEPS	CIIPRODPS	CIINVPS
CGRCPUGN	0.63	-0.77	-0.21	0.75	-0.83	-0.79
CGRPRODGN	-0.62	0.73	0.26	-0.74	0.81	0.75
CGRNVGN	-0.62	0.75	0.29	-0.74	0.83	0.77
CGRCPUPS	-0.71	-0.13	-0.34	-0.50	-0.54	-0.27
CGRPRODPS	-0.77	0.92	0.56	-0.90	0.78	0.89
CGRNVPS	-0.52	0.94	0.65	-0.72	0.78	0.96

Notes. CGR = compound growth rate, CPUE = catch per unit effort, Prod = production, NV = number of vessel, GN = gill net, and PS = purse seine.

Findings and Concluding Remarks

The small pelagic fisheries of the north coast of Java have undergone significant transformation driven by various factors. One key factor is inconsistent policy directed toward managing the fisheries. The policies for managing the fisheries have been subjected to a widely changing governance environment during the last 30 years. To understand these policy changes, we need to refer to what happened during Indonesia’s 1999 political transformation. The fishery policy can then be viewed within two major periods: pre-1999 and post-1999 (Syarif, 2009). Before 1999, the central government had full authority to manage the fisheries throughout the country. The main mantra during this period was “growth”. It was a growth-oriented policy that eventually drove the Indonesian fisheries into their current state of overfishing. The Java Sea pelagic fisheries were no exception. Following the ban on trawl fishing, the fisheries were subjected to several policies designed to stimulate growth, including providing loans and massive subsidies for the expansion of fishing fleets, as well as for ex-trawl fishers to convert to purse seiners and gill netters. It is not surprising, therefore, that landing growth was higher before 1999, causing higher instability in the fisheries in the years following. The impact of this “growth-oriented policy” eventually became visible in later periods.

After 1999, Indonesia embarked on a new era of decentralization. This new governance system affected the fisheries policy. Under the so-called autonomy law (Law No. 32/2004), 35 of 41 management authorities, including authority to manage natural resources such as fisheries which were previously under the central government, were delegated into regional governments. Under this decentralization system, it became more difficult to manage the fisheries, since various levels of government were now involved in managing the fisheries. Delegating the right to manage the fisheries to the local level would indeed lead to better fisheries management, much like that practiced in developed countries. This, unfortunately, is not the case for the small pelagic fisheries of the north coast of Java.

As stated in the annual report of the Regional Fisheries Agency of Central Java (DFO, 2007), one major factor that contributed to the decline of small pelagic landings was conflict over access to small pelagic fishing grounds between fishers of the north coast of Java and those from South Kalimantan. Under the Autonomy Law, the fishing grounds were claimed by various provinces bordering the Java Sea. This unresolved dispute caused a significant reduction in the number of trips taken by Java Sea fishers. This conflict, driven by the decentralization process, caused another domino effect. Fishers had to fish further out. With increasing fuel prices, which led to double jeopardy for fishers, leading to declining income and increasing incidence of poverty.

In addition to changing policies towards fisheries management, post-1999 was also marked by the new system of managing coastal areas. Under Law Number 27/2007 on Coastal Zone and Small Islands Management, a new coastal right-based system was introduced. This system was intended to better manage coastal areas and their resources, including the fisheries. Nevertheless, the policy failed to be implemented. Resistance from fishing communities as well as potential conflicts with other regulatory instruments, such as the Law on Spatial Planning, constrained the implementation of Law 27/2007.

Small pelagic fisheries of the north coast of Java are constantly challenged by various regulatory measures. Yet, none of these is succeeding developing them into well-managed fisheries. The declining trend in small pelagic landings and high degree of instability are certainly disturbing features of fisheries management on the north coast of Java. This calls for serious attention by policy makers to bring the fisheries into healthy sectors which could bring prosperity to coastal communities as well as maintain a healthy ecosystem. Current regulatory measures need to be reviewed, especially with regards to the regional Autonomy Law. Similarly, a stabilization policy could be introduced to reduce instability through controlling input costs such as fuel prices, improving socioeconomic conditions, and strengthening the capacity building of local fisheries authorities.

It is also important to note that the government of Indonesia needs “blue print” strategies to manage small pelagic fisheries, and for all fisheries in Indonesia. This includes a thorough review of both past and current management, as well as direction toward future management. Results of this study could be used as a benchmark for policy makers to understand how fisheries behaved in the past. Future direction can then be drawn upon to develop existing fisheries into well-managed fisheries.

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