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ASSESSMENT OF THE FISHING TECHNIQUES IN BALI SARDINELLA FISHERY IN PENGAMBENGAN FISHING PORT, BALI, INDONESIA

KAJIAN TEKNIK PENANGKAPAN IKAN PADA PERIKANAN LEMURU DI PELABUHAN PERIKANAN NUSANTARA PENGAMBENGAN, BALI, INDONESIA

Made Mahendra Jaya[1*], Liya Tri Khikmawati[2], Rakhma Fitria Larasati[3], Bagus Sudananjaya[4]
[1]Capture Fisheries Study Program, Jembrana Marine and Fisheries Polytechnic, Pengambengan Village, Negara District, Jembrana Regency, Bali 82218, Indonesia
[2]Sidoarjo Marine and Fisheries Polytechnic, Jl. Raya Buncitan Post Box 1, Sedati District, Sidoarjo Regency, East Java, Indonesia
[3]Fishing Technique Study Program, Karawang Marine and Fisheries Polytechnic, Jl. Lingkar Tangjung Pura KM.3, Karangpawitan, Karawang, West Java 41315, Indonesia
[4]Pengambengan Nusantara Fishing Port, Pengambengan Village, Negara District, Jembrana Regency, Bali 82218, Indonesia
*Corresponding author: mademahendrajaya@gmail.com

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ABSTRACT

Fisheries management with an ecosystem approach is essential to implement. This approach aims to achieve sustainability and balance in socio-economic, ecological, and more effective fisheries governance dimensions. The aspect assessed in this study was fishing techniques. The assessment was divided into six indicators: fishing methods, fishing capacity, selectivity of fishing gear, modification of fishing gear, suitability of fishing boat size and function, and certified fishing boat crew. This study aims to assess the status of Bali sardinella fishery resources in Bali Strait Waters, especially related to fishing techniques. We conducted research activities at Nusantara Fishing Port (PPN) Pengambengan from March to July 2023. Data collection used several methods, including interviews, surveys, and fish size sampling. The study results showed that the indicator of illegal or destructive fishing techniques or methods obtained a score of 3, and modification of the fishing gear used also received a score of 3. Fishing capacity, selectivity of fishing gear, and suitability of function and size of fishing boat used, based on legal documents, received a score of 3, 3, and 1, respectively. In contrast, certified fishing crews received a score of 1. Overall, the composite assessment in the fishing technique domain reached 90%, indicating that the Ecosystem Approach to Fisheries Management (EAFM) principles have been implemented well.

Keywords: Bali sardinella, Bali Strait, EAFM, fishing technique

ABSTRAK

Pengelolaan perikanan dengan pendekatan ekosistem merupakan hal yang sangat penting untuk diterapkan. Pendekatan ini memiliki tujuan untuk mencapai keberlanjutan dan keseimbangan dimensi sosial ekonomi, ekologi, dan tata kelola perikanan yang lebih efektif. Aspek yang dinilai dalam penelitian ini adalah teknik penangkapan ikan. Penilaian tersebut terbagi menjadi enam indikator, yang mencakup metode penangkapan ikan, kapasitas perikanan, selektivitas alat tangkap, modifikasi alat penangkap ikan, kesesuaian ukuran dan fungsi kapal, serta awak kapal perikanan yang telah tersertifikasi. Penelitian ini bertujuan untuk menilai status sumber daya perikanan lemuru di Perairan Selat Bali, khususnya terkait teknik penangkapan ikan. Kegiatan penelitian berlangsung di Pelabuhan Perikanan Nusantara (PPN) Pengambengan dari bulan Maret hingga Juli 2023. Pengumpulan data menggunakan beberapa metode, meliputi wawancara, survei, dan pengambilan sampel ukuran ikan. Hasil penelitian menunjukkan bahwa indikator teknik atau metode penangkapan ikan yang bersifat ilegal atau dektruktif memperoleh skor 3, modifikasi dari alat penangkap ikan yang digunakan juga mendapatkan skor 3. Kapasitas perikanan, selektivitas alat tangkap, dan kesesuaian fungsi serta ukuran kapal perikanan yang digunakan berdasarkan dokumen legal masing-masing meraih skor 3, 3, dan 1, sedangkan awak kapal perikanan yang telah tersertifikasi mendapatkan skor 1. Secara keseluruhan, penilaian komposit pada domain teknik penangkapan ikan mencapai 90%, menandakan bahwa telah diterapkan dengan baik prinsip-prinsip *Ecosystem Approach to Fisheries Management* (EAFM).

Kata kunci: EAFM, lemuru, Selat Bali, teknik penangkapan ikan

INTRODUCTION

The ecosystem approach to fisheries management (EAFM) is about balancing socio-economic objectives in fisheries management. The ecosystem approach management model also considers several aspects, like knowledge and information, as well as the dynamics of abiotic and biotic components and interactions between fisheries actors in waters through fisheries management. Fishery management activities through sustainable utilization must be carried out so that fisheries' resources can provide optimal social and economic impacts and benefits to the community.

Bali sardinella fisheries are an economically important resource in the Bali Strait. This commodity has high economic value and contributes to the local economy. This can be seen from the catch, which is mainly dominated by the Bali sardinella (Susilo 2015). Bali sardinella production is significant for the communities around the Bali Strait. For them, fish is the main source of income, where 76% of the income comes from fisheries (Tanjov *et al.* 2024). In addition, this production also supports the local fishing industry and helps expand employment opportunities in the area (Purwaningsih 2015). The high demand for Bali sardinella in Indonesia has led to high levels of fishing, especially in the Bali Strait. The fluctuating number of fish caught in Bali Strait waters requires proper fisheries management in this community (Hendiari *et al.* 2020).

Applying the EAFM concept in managing Bali sardinella fisheries in the Bali Strait waters is critical, especially regarding the fish caught and landed at PPN (Nusantara Fishing Port) Pengambengan. The aim is to balance ecological sustainability, socio-economic benefits, and good governance. The implementation of EAFM in managing Bali sardinella fisheries landed at PPN (Nusantara Fishing Port) Pengambengan requires several indicators used as a tool for monitoring and evaluating fisheries management. One of the domains observed is the role of the fishing gear's operating technique. The purse seine at PPN Pengambengan differs from that operated in Indonesian waters. The purse seine fishing gear is operated by two paired boats. The results of the study conducted by Arip *et al.* (2023) in 2022 stated that the composite value of Bali sardinella fisheries management reached 73.33. Although the fisheries are in good condition, several indicators scored 1. These indicators include illegal or destructive fishing methods, the suitability of the size and function of the fishing boat with legal documents, and certified fishing boat crews. This study aimed to assess the condition of Bali sardinella fishery resources in the Bali Strait Waters, especially in terms of fishing techniques. The assessment included fishing methods, fishing gear modifications, fishing capacity, selectivity of fishing gear used, suitability of size and function of the fishing boat based on its legal documents, and the number of certified fishing crew. Several assessment factors show the role or influence of fishing technique indicators on EAFM management in Bali sardinella fisheries landed at PPN Pengambengan.

METHODS

The research was conducted from March to July 2023 at PPN (Nusantara Fishing Boat) Pengambengan. Data was collected through observation and surveys, including primary and secondary data. This research activity focused on fishing techniques, with six indicators to assess (NWG EAFM 2014). Some materials used as objects of observation were purse seine fishing gear, "slerek" (purse seine) boats, and fish catches (Table 1).

The composite aggregate values obtained were then grouped into three criteria and then displayed using the flag model, as shown in Tables 2 and 3. The assessment was carried out using several criteria determined based on the scores and weights of each indicator. Furthermore, the status of EAFM implementation was assessed by accumulating the values obtained from each criterion and then dividing them by the number of indicators in this domain. The values obtained were then plotted, which were the values obtained from the flag model.

Indicators of modification of fishing gear and supporting equipment: A comparison was made between the average size of the target fish and the first size of gonad maturity (Lm) of the target fish (Bali Sardinella). Data on the average size of the target fish was obtained by measuring the total length of the fish. The calculation of Lm was analyzed using the Spearman-Karber method (Udupa 1986 *in* Kasmi *et al.* 2017).

$$\log M = Xk + \frac{X}{2} - (X\sum pi)$$

Description:
Log M = Logarithm of fish length at first gonad maturity.
Xk = Logarithm of the last mean value when the fish is gonad mature (100%).
X = Logarithmic difference of class means

$$pi = ri/ni$$

ri = Difference in logarithms of class mean values.
ni = Number of fish in class i

Fishing capacity indicators, or fisheries' capacity and fishing efforts, can be obtained by comparing the previous year's fishing capacity with the last year's. Fishing capacity was determined through calculations involving calculations between the number of fishing boats (units) against the maximum catch (tons), and the amount of fishing effort carried out each year for the last ten years (NWG EAFM 2014).

$$FC = V \times C \times E$$

Description:
V = Number of fishing boats (units)
C = Number of catches (tons)
E = Number of efforts (trips)

The index value was obtained by multiplying the score value by the weight and density of each indicator. The weight of each indicator was determined and set based on the level of influence of the indicator on the domain or aspect of fishing techniques. The indicator with the most significant influence in a domain certainly had considerable weight in that domain (Sulistyowati *et al.* 2018; Roni *et al.* 2021).

$$C_{at-I} = S_{at-I} \times W_{at-I} \times D_{at-I}$$

Description:
C_{at-I} = Index value of attribute/indicator i
S_{at-I} = Score of attribute/indicator i
W_{at-I} = Weight of attribute/indicator i
D_{at-I} = Density of attribute/indicator i

The indicators in the Ecosystem-Based Fisheries Management Framework (EAFM) were assessed using a multi-criteria system related to the level of achievement of fisheries management. This assessment aims to describe the condition of fisheries management in an area, regarding its suitability to the principles of fisheries management that prioritize the ecosystem approach. The total index values obtained were analyzed through a simple composite analysis based on the arithmetic average. The analysis results were displayed in a flag model with appropriate criteria, which reflects the conversion of the total value of all existing indicators.

$$C_{at-I} = (C_{at} : C_{at-max}) \times 100\%$$

Description:
C_{at} = Total index value of all attributes/ indicators
C_{at-max} = Maximum total index value

Table 1. Data collection from the fishing technique domain at PPN Pengambengan.

Indicator	Data Requirements	Data Collection Methods
Fishing methods	Several of violations related to the operation of fishing gear and supporting fishing gear.	Interviews were conducted with 30 fishermen who were moored, as well as stakeholders (Harbor Master and boat owners).
Modification of fishing gear and supporting fishing gear.	Size of fish caught.	Conducting sampling of the length of fish caught (January-July 2023).
Fishing capacity and fishing effort.	Large capacity and fishing activity based on fisheries production data at the port for 10 years.	Interviews with 30 fishermen and stakeholders (Harbor Master).
Selectivity of the fishing gear used.	Number of target fish caught.	Interviews, sampling of main and by-catch fish (January-July 2023).
Suitability of the function and size of the fishing boat.	The suitability of the function and size of the sampled fishing boat was matched with existing documents.	Survey of ship documents at the Harbor Master.
Certification of the fishing boat crew.	Number of ownership of fishing boat crew qualification certificates.	Survey of 30 fishermen, interviews with the Harbor Master.

Table 2. Criteria and weighting of the fishing techniques domain (NWG EAFM 2014).

Indicator	Score/Criteria	Weight
Fishing methods	1 = Frequency of violations > 10 cases per year. 2 = Frequency of violations between 5 to 10 cases per year. 3 = Frequency of violations < 5 cases per year.	30
Modification of fishing gear and supporting fishing gear.	1 = >50% of fish size caught <Lm. 2 = 25% to 50% of fish size caught <Lm. 3 = <25% of fish size caught <Lm.	25
Fishing capacity and fishing effort.	1 = <1 2 = =1 3 = >1	15
Selectivity of fishing gear used.	1 = <75% means low. 2 = 50-75% means medium. 3 = high (<50%, fishing gear is not selective	15
Suitability of the function and size of the fishing boat.	1 = >50% of ship samples do not comply with legal documents. 2 = 30-50% of ship samples do not comply with legal documents. 3 = <30% of ship samples do not comply with legal documents.	10
Certification of the fishing boat crew.	1 = <50% of certified crew members. 2 = 50-75% of certified crew members. 3 = >75% of certified crew members.	5

Table 3. Classification of composite index values and flag models (NWG EAFM 2014).

Score Value	Range Composite Value		Flag Model	Description
	Low	High		
1.0 – 1.50	33.3	55.5		Implementation of EAFM is still lacking.
1.51 – 2.50	55.56	77.77		The implementation of EAFM is moderate.
2.51 – 3.00	77.78	100		The implementation of EAFM is exemplary.

RESULTS AND DISCUSSION

The Bali Strait and its surroundings have an enormous potential for pelagic fish catches, including Bali sardinella (Sihombing *et al.* 2018). Bali sardinella fish is the most widely caught fish commodity in the Bali Strait and has a high economic value (Ridha *et al.* 2013). For local people, Bali sardinella is a source of income, especially for fishermen, as one of the supporting factors for local industrial activities in the field of fish processing, and can expand employment opportunities in the area (Purwaningsih 2015). Bali sardinella fish-catching operations in these waters usually use purse seine fishing gear.

The operation of purse seine nets in PPN (Nusantara Fishing Port) Pengambengan is carried out with two paired boats, commonly called "slerek" (purse seine) boats. Each boat has its function. One boat is tasked with carrying fishing gear and operating it, while the other boat functions to transport the catch. During the fishing operation, it will be led by a fishing master. This fishing master plays an important role in the success of the Bali sardinella fishing operation. The fishing master can also determine the fishing ground and the time the net is lowered (Susilo and Wibawa 2016). The Bali sardinella fishing season usually occurs throughout the year. The potential of the Bali sardinella fishery, which is so large and abundant, has an important meaning for the communities around the Bali Strait that utilize the fishery resources. Managing fisheries' activities with an ecosystem

approach to the technical aspects of fishing is implemented by considering various relevant aspects. These aspects include the fishing methods applied, whether they have met the principles of being environmentally friendly, modifications to fishing gear and supporting fishing gear, fisheries' capacity in the area concerned, and the fishing efforts made. In addition, an assessment of the level of selectivity, the suitability of the size and function of the fishing boat to the applicable legal documents, and the fishing boat crew certified by the regulations stipulated in Indonesia.

Destructive/illegal fishing methods

Fishing methods that are not environmentally friendly or destructive can certainly cause damage to the habitat where the fish live, and the fish resources themselves (Jaya *et al.* 2016). Illegal fishing methods are fishing methods that conflict with or violate local, national, and international regulations. Destructive and illegal fishing activities, such as using dangerous tools or materials, such as electricity, bombs, and fish poison, as well as using fishing gear that does not comply with applicable regulations (for example, the use of fishing gear that is not in the permitted fishing lane or area). Based on observations, the level of violations that have occurred is no more than 5 cases per year.

More details, the number of violations related to illegal or destructive fishing methods in the Pengambengan State Training Center of Nusantara Fishing Port (PPN) area during 2023 was zero. Fishermen use purse seines to catch Bali sardinella, following applicable regulations. The Harbor Master also supports this at the PPN Pengambengan. In carrying out fishing activities, fishermen use tools in the form of lamps to help collect fish. Regarding the fishing area, fishermen catch the fish no more than 12 miles from the coast. The fishing method score is 3.

Modification of fishing gear and supporting fishing gear

This indicator was assessed by measuring the average length of Bali sardinella caught using the fishing gear used, in this case, the purse seine fishing gear (Tables 4 and 5). Furthermore, the average is compared with the size of the target fish (Bali sardinella) Lm. Based on the results of the Lm calculation that was carried out with a sample of 817 fish. It was obtained that the male Lm was 14.93 cm, and the female Lm was 15.73 cm. A total of 230 female fish samples were obtained from fish that had reached a size suitable for catching. While, for the male fish samples, 344 individuals also met the criteria for being suitable for catching. If added up, it was obtained that 70% of the total fish caught were fish that met the requirements for being suitable for catching (>Lm). Furthermore, the score for this indicator is 3.

Table 4. Distribution of the length of female Bali sardinella caught using a purse seine at PPN Pengambengan.

Lower Class Limit	Upper Class Limit	Class Range	Maturing Gonad	Mature Gonad	Number of Maturing and Mature Gonads	Number of Fish (ni)	Percentage of Maturing and Mature Gonads (%)
105	114	105-114	0	0	0	5	
115	124	115-124	0	0	0	15	14.21
125	134	125-134	0	0	0	31	
135	144	135-144	0	1	1	17	
145	154	145-154	4	0	4	61	
155	164	155-164	11	2	13	62	
165	174	165-174	15	2	17	31	85.79
175	184	175-184	32	6	38	45	
185	194	185-194	53	7	60	69	
195	204	195-204	12	4	16	23	
205	214	205-214	-	-	-	-	

Table 5. Distribution of the length of male Bali sardinella caught using a purse seine at PPN Pengambengan.

Lower Class Limit	Upper Class Limit	Class Range	Maturing Gonad	Mature Gonad	Number of Maturing and Mature Gonads	Number of Fish (ni)	Percentage of Maturing and Mature Gonads (%)
105	114	105-114	0	0	0	13	
115	124	115-124	0	0	0	33	17.69
125	134	125-134	0	0	0	35	
135	144	135-144	1	4	5	33	
145	154	145-154	16	1	17	75	
155	164	155-164	29	5	34	89	
165	174	165-174	21	6	27	52	82.31
175	184	175-184	30	26	56	60	
185	194	185-194	28	23	51	59	
195	204	195-204	6	1	7	7	
205	214	205-214	2	0	2	2	

Fisheries capacity and fishing effort

This indicator was assessed and measured by comparing the value of fishing capacity in the previous year with the value of fishing capacity in the last year at PPN Pengambengan. The value of fishing capacity and effort was obtained from the catch, the number of fishing boats, and the number of trips obtained within a specific period. The data collected during this study spanned 10 years, from 2013 to 2022. Data related to fishing capacity in the waters of the Bali Strait can be seen in Table 6.

The ratio value obtained in the last 10 years is 9.93 (>1). Table 4 also shows that the Bali sardinella fishing capacity in the Bali Strait is not always consistent at more than 1, which indicates the fluctuation of the Bali sardinella catch in the Bali Strait. In the past few years, there has been a shortage of Bali sardinella, especially those that landed at the port from 2018 to 2020, and then increased again from 2021 to 2022. The increase in the number of catches was due to the increasing fishing efforts carried out, which were supported by the fact that this year was the peak season for Bali sardinella fishing in the Bali Strait. If fishery inputs such as fishing gear, fishing boats, and trips are too high, it can cause excess capacity, resulting in overfishing (Pradnya *et al.* 2020; Atmaja and Nugroho 2017).

Capture selectivity

Assessment of the level of selectivity of fishing based on the catch of the main target fish compared to the bycatch. Based on the production data of PPN Pengambengan for 10 years (2013-2022), the main catch data from "slerek" (purse seine) in Pengambengan is Bali sardinela, while the by-catch is in the form of scad, squid, and ribbon fish, with the percentages shown in Figure 1.

The selectivity of fishing is related to the characteristics of the fishing gear, which must be environmentally friendly (Prayitno *et al.* 2017; Elvany 2019). Environmentally friendly means that the fishing gear can catch fish that are the target catch effectively and efficiently, and minimize bycatch. The results will be compared later in the form of a percentage. Based on data and observations in the field, the results of the assessment of this indicator are 3. These results indicate that the target fish, Bali sardinella, dominates the fish caught. The average results of observations in the field were that 98% of the catches of fishermen in PPN Pengambengan were dominated by Bali sardinella. According to Idzhar *et al.* (2019), if a fishing gear can catch more than 60% of the main target fish, then the fishing gear is stated to be selective and environmentally friendly.

Table 6. Fishing capacity of Bali sardinella fisheries in the Bali Strait 2013-2022.

Year	Fishing Capacity (ton/tahun)	Ratio
2013	5,720.00	0.00
2014	14,146.15	0.40
2015	16,038.00	0.88
2016	7,150.00	2.24
2017	76.50	93.46
2018	1,154.05	0.07
2019	16,002.90	0.07
2020	18,101.00	0.88
2021	13,747,616.00	0.00
2022	11,009,997.00	1.25
Average	**2,483,600.16**	**9.93**

Source: Annual report of PPN Pengambengan.

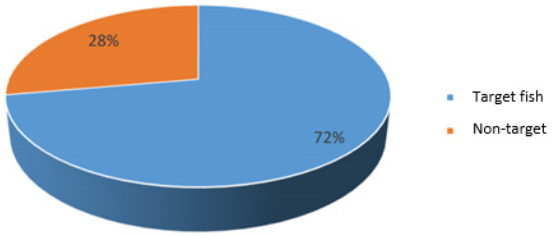

Figure 1. Composition of target catches (Bali sardinella) and non-targets caught using "slerek" (purse seine) at PPN Pengambengan.

Compliance of the function and size of the fishing boat with the legal document

The assessment of this indicator has a very significant influence. If the comparison of the number of existing official boat documents is very low, this can indicate that there are many illegal fishing activities in the area. This can certainly cause damage to environmental sustainability and fish resources themselves (Wahyudin *et al.* 2019). The results of random checks of existing ships and interviews with port officials showed that four fishing boats had valid documents (licensed). The total number of boats at PPN Pengambengan is 101, meaning almost all do not have permits. Most fishermen in PPN (Nusantara Fishing Port) Pengambengan, especially those who have "slerek" (purse seine) boats, assume that their fishing activities are still traditional and do not exceed the 12 nautical mile limit for catching Bali sardinella. This makes fishermen reluctant to take care of the boat documents. In addition, fishermen assume that taking care of permits will be more difficult because taking care of a boat above 30 GT will make it difficult for them. So, the results of the assessment of this indicator are 1.

Certification of fishing the boat crew

The certificate reflects the competence possessed by fishermen and is officially recognized. This is very important in implementing the principles of responsible and sustainable fisheries (Amin *et al.* 2018). The issuance of the Regulation of the Minister of Marine Affairs and Fisheries Number 33 of 2021 mandates that the crew of a fishing boat, including fishermen who will go to sea, must have a safety training certificate. Examples of the certificates in question are Basic Safety Training for Fisheries (BST-F) or other expertise certificates, so the crew must have these certificates. The results of observations in the field showed that most ABK (fishing boat crews) did not have certificates, while fishing boat captains had SKK (certificate of competence) 60 miles. This is because most fishermen in

PPN Pengambengan still think that having the certificate is not too important and will interfere with the fishermen's working time. In addition, the cost issue is also a consideration for fishermen looking for the required certificate. The value obtained from this indicator is 1, where certificate ownership is less than 50%.

Index value and composite value of the fishing technique domain

Bali sardinella fisheries management in the Bali Strait in this domain has a composite value of 90%. The green flag model includes the values obtained (Table 7). Overall, fisheries management, especially in the fishing technique domain, has been considered good in implementing EAFM.

Sustainable fisheries management is a planning and regulation process through control over fishermen, stakeholders, fishing gear operations, seasons and times, fishing grounds, and the permitted fishing capacity in water (Kurniawan *et al.* 2019; Baihaqi and Hufiad 2013). The sustainability of fish resources, especially Bali sardinella in the Bali Strait, will significantly impact fishing activities in the area. Therefore, efforts are needed to maintain the sustainability of Bali sardinella resources, which need to be carried out continuously to avoid excessive utilization (Wujdi *et al.* 2013). The same thing was also expressed by Muliawan (2015), who stated that the management of fisheries' activities aims to ensure the number of fish that can be caught and regulate the fishing effort to ensure the sustainability of these fish resources. Existing fisheries management should also involve various institutions and communities to prevent overfishing (Ninef *et al.* 2019).

Analysis of the composite values listed in the table above shows that two indicators still get low scores, namely, in the aspect of the suitability of the size and function of the fishing boat according to legal documents and certification for the fishing boat crew. The other four indicators show good results. Fishermen at PPN Pengambengan have a high level of compliance with regulations related to fishing methods. Bali sardinella caught by "slerek" (purse seine) boats have a size that meets the requirements for being caught. According to Aprianti *et al.* (2022), Bali sardinella fish caught and landed at PPN Pengambengan have sizes between 18.15 and 19.6 cm.

Although the fishing boats at PPN Pengambengan follow their designation to catch Bali sardinella using purse seines, the boats' documents must be completed. Managing the boat's documents is ongoing, so it is hoped that in the next few years, the fleet of boats at PPN Pengambengan will have valid documents. Regarding crew certification, by the mandate in the Regulation of the Minister of Marine Affairs and Fisheries Number 33 of 2021, all crew members are gradually expected to have a minimum Basic Safety Training (BST) certificate. According to Marasabessy *et al.* (2022), the certification of fishing boat crews needs to be carried out to standardize the professional expertise of fishermen. This will be related to the licensing process for a boat to carry out fishing activities. It is hoped that certification ownership for fishing boat crews will increase yearly in the next few years. Both indicators are expected to be green or have good scores in the next few years to support responsible fishing activities and eradicate illegal fishing activities.

Table 7. Composite values in fishing techniques in managing Bali sardinella fisheries in the Bali Strait.

Indicator	Score	Weight	Index Value
Fishing methods	3	30	90
Modification of fishing gear and supporting fishing gear.	3	25	75
Fishing capacity and fishing effort.	3	15	45
Selectivity of fishing gear used.	3	15	45
Suitability of the function and size of the fishing boat.	1	10	10
Certification of the fishing boat crew.	1	5	5
Assessment of Fishing Technique Domain.	**Composite Score = 270**		**Composite Score = 90**

CONCLUSION

Bali sardinella fishery resources in the Bali Strait waters, especially in fishing techniques, are in good condition with a composite value of 90%. This shows that Bali sardinella fishing activities in the Bali Strait waters have been well managed through a sustainable fisheries management approach (EAFM).

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