Characterization of the Operability, Catch, and Fishing Effort of a Hake Trawling Vessel in Peru

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Abstract

In this study, the operational characteristics of the industrial hake fishing vessel "Santa Monica II" were characterized for the years 2020 and 2021, focusing on its catch production and fishing effort. A total of 234 trips and 1087 hauls were analyzed, considering a working depth of 100 fathoms on the continental shelf. Fishing effort was assessed based on years, seasonal periods, and months, allowing for a comparison of its productivity with 33 other vessels in the industrial fleet. The results revealed that the vessel caught 18% of the total catch of the industrial fleet in 2020 and 17% in 2021. Subarea A was the most frequented in 2020, with 66 trips, while in 2021, Subarea B led with 78 trips. The Catch per Unit Effort (CPUE) was 6.24 tons per hour and 8.99 tons per haul in 2020, and increased to 8.20 tons per hour and 10.75 tons per haul in 2021, highlighting its performance. Additionally, a significant concentration of hake resources was observed in the upper part of the continental slope during the study years.

Keywords: Hake trawler; Fishing Operations; Fisheries Unit; Fishing effort.

1. Introduction

Historically, the oceans and their seas have provided food for humanity; thus, marine resources are extracted from their environment with the aid of fishing gear. However, when these resources are located outside the littoral area and/or at great distances from the coast, an adequately equipped fishing vessel (FV) is required for their operation. Likewise, these hydrobiological resources are classified according to their depth and the habitat in which they thrive; consequently, there are different types of vessels and fishing equipment for each of the fisheries developed. In Peru, the Peruvian hake is the most abundant and economically important species in the bottom trawl fishery. Under normal conditions, this species is distributed on the shelf and the upper part of the continental slope (Wosnitza-Mendo 2009). For the fishing of the Peruvian hake resource “Merluccius gayi peruanus”, the use of a bottom trawler with the appropriate means to extract the resource from the different demersal fishing zones in the Peruvian sea is required. The extractive activity of hydrobiological resources like this presents various problems that prevent their proper fishery management, which affects balanced biological, environmental, and economic management. One of the main problems is the reduction of the catch in fishing volumes, a problem that occurs worldwide and manifests in different types of fisheries. This resource was classified as overexploited or collapsed (Mendoza Ramirez 2018); however, since 2003 it has been cataloged as a resource in recovery (Bandín and Grandez 2021).

Hake and other demersal species are primarily captured using bottom trawl nets, although gillnets and longlines can also be used (Lloris, Matallanas, and Oliver 2003). The country's largest-scale hake fishery is carried out by the industrial trawl fleet, comprised of larger draught vessels equipped with bottom trawl nets and high technology. On the other hand, the artisanal or small-scale hake fishery uses fishing gear such as pinta, horizontal bottom longline, vertical bottom longline, and coastal bottom curtain. According to the classification of the General Fisheries Law, the large-scale fishery is regulated by the Fisheries Management Regulation (ROP) and is subject to annual quotas through Provisional Fishing Regimes (RPP), approved by ministerial resolutions

To thoroughly understand and know the operations of the vessel Santa Mónica II, data and information were directly gathered on the fishing catches from 1087 hauls in four fishing zones. These zones were determined using previous technological information about the location and behavior of the hake in northern Peru. This sui generis study, preliminary in its form of analysis, aims to contribute to the macro analysis of the management carried out for this resource through the operation of an industrial hake trawling fishing vessel, and which can be applicable to the present. It also seeks to establish indicators for future research related to the industrial trawl fleet, such as the statistical information on catches and landings of the industrial trawler fleet, published on the website of the Instituto del Mar del Perú (IMARPE). The objective of this study was to characterize the operations of an industrial trawler in the northern area of Peru during the years 2020 and 2021, through its catch production in the four fishing sub-areas, on a monthly basis, in seasonal times, observing the depth hauls and comparing the catch production and fishing effort with the rest of the industrial hake fleet.

2. Methodology

This study is based on a quantitative approach, adopting a methodological design that integrates descriptive, longitudinal, relational, and comparative elements (Hernández Sampieri and Mendoza Torres 2018; Hernández Sampieri, Fernández Collado, and Baptista Lucio 2014) for a holistic understanding of the operability, capture, and fishing effort of a hake trawling vessel in Peru.

The fishing unit was composed of the set of equipment and human potential that operated autonomously in the fishing industry. In the focus of the study, the fishing unit was a vessel dedicated to bottom trawling, classified according to the norms of the Fisheries Management Regulation (ROP) for hake (D.S. N° 016-2003-PRODUCE 2003), as indicated in table 1. Furthermore, this vessel was part of the 'Hake Fishery Unit,' defined as the set of vessels of a specific type with a common fishing regime for the species in question, thus grouping together vessels, men, and gear for the exploitation of a certain resource in a more or less defined area (Espino Barr et al. 2008).

Table 1. Classification of vessels in the industrial trawler fleet

Attribute	Small or Coastal (EAC)	Medium Scale (EAME)	Large or Factory (EAM/F)
Hold Capacity (m³)	< 142	142 – 425	>425 - 600
Length Overall (m)	< 25	25 – 40	>40 - 70
Main Engine Power (hp)	< 500	500 - 1000	>1000

Source: (Bandín and Grandez 2021).

For our study, the fishing unit was classified as a medium-scale Trawler Vessel (EAME) and belonged to Industrial Pesquera Santa Mónica S.A. The name of the vessel was FV Santa Mónica II (figure 1), and the main characteristics of the vessel were specified in table 2, being equipped with a bottom trawl net. Approximately 40% of global catches were made using bottom trawling or other gear that comes into contact with the ocean floor (FEDEPESCA 2013).

Figure 1. Santa Mónica II Fishing Vessel

Table 2. Specific Characteristics of the FV Santa Mónica II

Ship Name	Santa Mónica II
Owner or Shipowner	Industrial Pesquera Santa Mónica S.A.
Year of Manufacture	1983
Shipbuilding Yard	SIEMOLDV WERF
Registration	PT-12866-PM
Overall Length	28.11 meters
Beam	7.80 meters
Depth	3.80 meters
Gross Tonnage	186.08 tons
Net Tonnage	30.45 tons

Hold Capacity	125.83 m³
Hull Material	Naval Steel
Superstructure Material	Naval Steel
Type of Navigation	Coastal
Type of Vessel	Fishing
Navigation Area	Maritime
Cruising Speed	11 knots
Autonomy	10 days
Main Engine Power	886.42 hp
Fuel	Diesel 2
Bow Draft	3.5 meters
Midship Draft	2.1 meters
Stern Draft	2.3 meters

Operational Area of the Fishing Unit

The area where the vessel operated included the northern continental shelf of Peru and its surroundings, between the parallels 03º23'31” S, the border line with Ecuador, and the parallel 06º59'59” South latitude, an area in which the authorization for the industrial trawler fleet in the demersal fishery was delimited, in accordance with the establishment of the provisional fishing regime for the hake resource. This area was divided into 4 subareas: A, B, C, and D sequentially, for a comparative study and latitudinal analysis, as indicated:

- Subarea A: between the latitudes 03º23'31” and 03º59'59” S.
- Subarea B: between the latitudes 04º00'00” and 04º59'59” S.
- Subarea C: between the latitudes 05º00'00” and 05º59'59” S.
- Subarea D: between the latitudes 06º00'00” and 06º59'59” S.

To analyze the development of fishing effort according to fishing depth, fishing operations were grouped into two categories: hauls conducted on the continental shelf at depths less than 100 fathoms, towards the East or coastal area, and hauls conducted at depths greater than 100 fathoms (more than 183 meters) towards the West or high seas. It was considered that the continental shelf in Peru is well delimited by the 100 fathom isobath (Guevara-Carrasco, Castillo, and Gonzales 1996).

Fishing Operability and Catch of the Vessel

The frequency of the vessel's trips was determined by the company, which had five trawling vessels and maintained a set travel schedule. The determination of the fishing grounds and the different fishing subareas, as well as the fishing zones, were predetermined by the Fishing Captain, based on the information and/or fishing data from other vessels that had operated in that area in previous days. Generally, the most successful fishing operations were conducted during the early hours of the day, coinciding with the development of the first haul. This criterion was conceptualized because hake exhibits diel movement, especially in the evening hours, when the hake shoals begin to ascend (Guevara-Carrasco and Fernández 1996). Therefore, it was customary to carry out the first haul at 06:00 h in all fishing operations, and subsequent hauls were carried out according to the volume of catch obtained in the previous haul. The depth of fishing and the duration of trawling were subject to the indications of the electronic fishing detection equipment, such as the FURUNO FCV 1150 echo sounder with graphic and low frequency (Polvorín and Valle 2016).

Capture - Data Collection

The data analyzed came from the information recorded in the fishing logbook of the fishing vessel Santa Mónica II with registration PT-12866-PM, regarding the hake catch during the fishing years 2020 – 2021, and from the data on fishing catches by the industrial trawler fleet during the study period, as published on the website of the Instituto del Mar del Perú (IMARPE 2020), relating to the daily reports of the Hake fishery.

Data Analysis

For the respective analysis, all data obtained on catch, fishing zone, trip number, haul number, trawling time, and geographical location were processed using Microsoft Excel, where these data were standardized to the same units of measurement and converted to decimal degrees. For the evaluation and graphical representation of the hauls, Geographic Information System (GIS) software was used, which integrates computer technology, people, and geographic information, with the main function of capturing, analyzing, storing, editing, and representing georeferenced data (Olaya 2014). The location data where the vessel operated were georeferenced in the ArcGIS online software, mapping the positions (latitude – longitude) under a code and relating them to the bathymetry of the area. The 15,218 data points were grouped and presented according to depth (in relation to the 100 fathom isobath) and the defined subareas, as well as operation times and catches. To visualize and edit the spatial data, ArcGIS Pro was used.

3. Resultados

Fishing Operability - Frequency of Trips

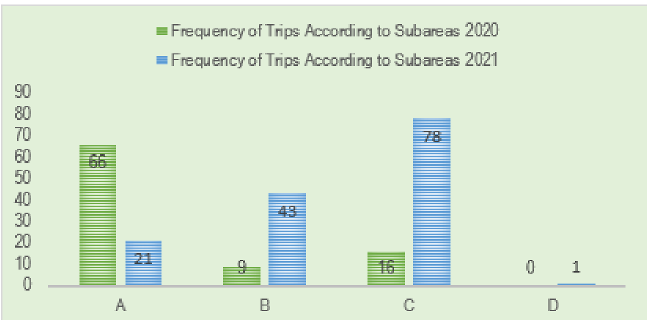

Figure 3. Frequency of Trips According to Subareas

The vessel operated in the four established subareas A, B, C, and D. The number of trips made was determined according to the existing fishing density in those months and seasonal times, as shown in figure 3. In 2020, a total of 91 fishing trips were carried out, while in 2021, 143 trips were made. The subarea with the highest incidence of trips was subarea 'A' with 66 trips in 2020, and for 2021, subarea 'C' was the most frequented for fishing, with 78 trips. The subarea where the vessel made the fewest trips was subarea 'D', located further to the south (06°S – 07°S), where no trips were made in 2020, and only one trip with minimal catch was recorded in 2021.

Annual Fish Catches

Table 3. Hake Catch for the Years 2020, 2021

Period	FV Santa Mónica II	Peruvian Industrial Fishing Fleet
2020	3,984.31 tn.	18,773.69 tn.
2021	6,922.23 tn.	34,190.67 tn.

Source: (PRODUCE 2021, 2020a, 2020b)

In 2020, 22,758 tons were fished. Of this amount, 18% of the total catch corresponded to the F/V Santa Mónica II (3,984.31 tons), and the rest of the catch was obtained by other industrial trawler vessels (18,773.69 tons), as shown in table 3. It can be asserted that the efficacy of the vessel was acceptable, representing approximately one-fifth of the total fishing volume achieved for the year 2020. In 2021, the total hake catch reached was 41,112.90 tons. Of this amount, 17% (6,922.23 tons) was fished by the Santa Mónica II vessel, and the rest of the fishing catches, corresponding to 83%, was obtained by different industrial trawler vessels. The vessel's efficacy in terms of catch remained constant during the study period, fluctuating between 17% and 18% of the total global catch.

Catches by Month

Table 4. Monthly Distribution of Hake Catch for the Years 2020, 2021

2020	FV Santa Mónica II	Peruvian Industrial Fishing Fleet	2021	FV Santa Mónica II	Peruvian Industrial Fishing Fleet
Jan	98.10	643.80	Jan	516.07	2,768.53
Feb	201.12	1121.68	Feb	828.65	2,115.85
Mar	0.00	160.70	Mar	847.55	2,708.95
Apr	91.06	1114.24	Apr	359.58	3,241.32
May	499.95	1755.05	May	438.92	3,640.68
Jun	533.47	2370.33	Jun	798.89	3,687.81
Jul	671.19	2423.11	Jul	502.56	2,996.24
Aug	730.14	3042.16	Aug	955.34	4,357.96
Sep	151.31	751.99	Sep	63.87	103.53
Oct	175.80	771.90	Oct	208.29	989.52
Nov	400.64	2176.06	Nov	684.52	3,448.48
Dec	431.54	2442.66	Dec	717.99	4,131.81
Total	3,984.31 tons	18,773.69 tons		6,922.23 tons	34,190.67 tons

Source: (PRODUCE 2021, 2020a, 2020b)

In 2020, the hake fishery did not operate at full capacity, affected by external factors that restricted the fleet's operability. One of these factors was COVID-19, which imposed limitations on the number of trips per vessel due to the absence of an adequate health protocol. During the first months, January, February, and April, the catches were minimal, with 100 tons, 200 tons, and 90 tons respectively. In the months of May, June, July, and August, the catches increased, fluctuating between 500 tons and 730 tons. In September (150 tons) and October (180 tons), catches decreased, coinciding with the hake's reproductive closure, to then show an upward trend in November (400 tons) and December (430 tons), as shown in figure 6. Similarly, catches made by other vessels of the industrial fleet were also reduced in the first months of 2020: January (640 tons), February (1,120 tons), March (160 tons), and April (1,110 tons). In 2021, the catch of the hake resource varied over the months. Catches corresponding to the vessel under study increased from the beginning of the year, with 520 tons in January, and reached a peak of 960 tons in August. Subsequently, catches decreased in September (60 tons) and October (210 tons). However, in the last two months, November (680 tons) and December (720 tons), catches progressively increased, as illustrated in table 4. Catches made by other industrial vessels also showed high values, following a similar proportion to that of the vessel under study, with their highest catch recorded in August, with 4,360 tons.

Seasonal Catch Variation

Table 5. Hake Catch Distribution by Seasonal Periods (Years 2020, 2021)

2020	FV Santa Mónica II	Peruvian Industrial Fishing Fleet	2021	FV Santa Mónica II	Peruvian Industrial Fishing Fleet
Verano	400.94	2,345.76	Verano	1,983.04	8,819.26
Otoño	989.04	4,400.36	Otoño	1,737.39	10,196.71
Invierno	1,688.07	6,945.23	Invierno	1,773.74	8,809.86
Primavera	906.26	4,702.34	Primavera	1,428.06	7,714.24

Source: (PRODUCE 2021, 2020a, 2020b)

In the 2020 fishing season, the vessel Santa Mónica II recorded the highest catches in the winter, reaching 1,688 tons. In the same period, the rest of the fleet achieved a total catch of 6,945 tons. In the autumn and spring seasons, the catches of the vessel were similar, with 989.04 tons and 906.26 tons respectively. This catch trend was similar for the rest of the industrial vessels, with 4,400 tons in autumn and 4,702.34 tons in spring. The lowest catch for the Santa Mónica II was recorded in summer, with 400.94 tons, as shown in Figure 8. For the 2021 fishing days, the catch volumes obtained by the Santa Mónica II were relatively close in value and in some cases similar throughout the four seasons: summer (1,983.04 tons), autumn (1,737.39 tons), winter (1,773.74 tons), and spring (1,428.06 tons), with a catch range fluctuating between 1,428 and 1,983 tons, as illustrated in Figure 9. On the other hand, the rest of the vessels in the industrial fleet recorded catch ranges that varied between 7,714 tons in spring and 10,196 tons in autumn. For the summer and winter seasons, the productions were close in volume, with 8,819 tons and 8,809 tons respectively.

Operational Efficiency by Depth

Table 5. Frequency of Fishing Operations by Depth in Fathoms (años 2020, 2021)

2020	< 100 Fathoms	> 100 Fathoms	2021	< 100 Fathoms	> 100 Fathoms
Summer	8	52	Summer	80	99
Autumn	15	111	Autumn	38	148
Winter	23	118	Winter	16	155
Spring	18	98	Spring	26	82

The vessel conducted trawling fishing operations at various depths, in response to the movement of hake schools over the continental shelf, which are located at different depth strata under the influence of oceanographic factors. Commonly, demersal species move over the continental shelf at depths less than 100 fathoms, although dense schools were also detected in the initial area of the continental slope, corresponding to greater depths. Of the 443 trawls carried out in 2020, as shown in Figure 10, 85.55% were conducted at depths greater than 100 fathoms, with a higher frequency of trawls during the winter (118 trawls), autumn (111 trawls), and spring (98 trawls), followed by summer (55 trawls), the latter being the season with the fewest trawls and shallower depths. In 2021, out of 644 trawls conducted, a total of 484, representing 75%, were carried out in depth strata greater than 100 fathoms, as shown in Figure 12. There were 160 trawls in depth ranges less than 100 fathoms. In the summer of 2021, the trawls at greater and lesser depths than 100 fathoms were evenly distributed, with 99 and 80 trawls respectively. In the other seasons, trawls at greater depths were predominant: 148 in autumn, 155 in winter, and 82 in spring. On the other hand, trawls at shallower depths were also less frequent: 38 in autumn, 16 in winter, and 26 in spring.

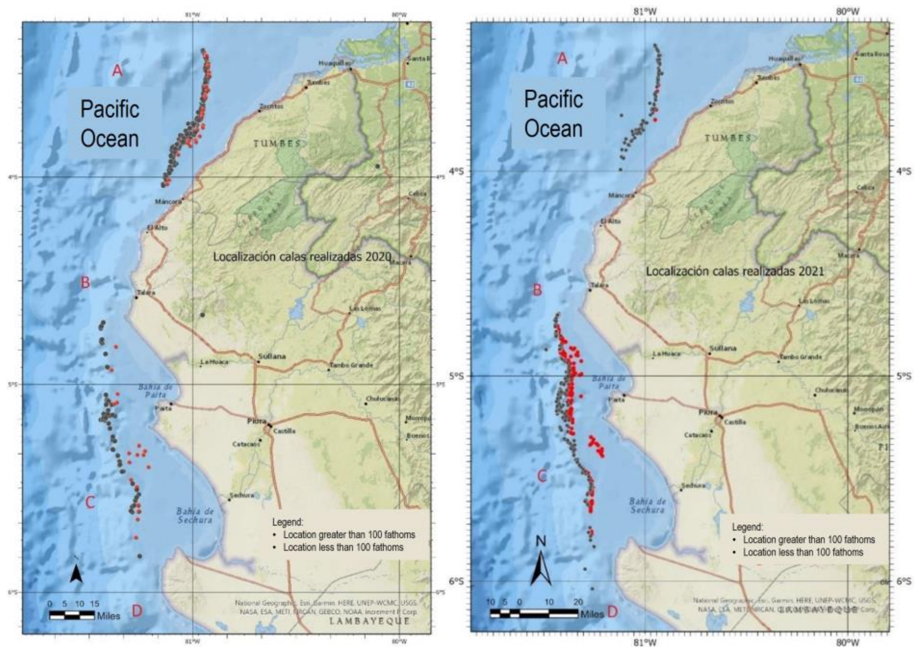

Figure 4. Spatial Distribution of Trawls by Depth, 2020, 2021

During 2020, in the trawls conducted at depths greater than 100 fathoms, subarea A stood out for its effectiveness, followed by subarea C. In subarea A, fishing operations were carried out around the 100-fathom isobath, as indicated in Figure 11, where trawls conducted at greater and lesser depths are seen very close to each other, indicating that the trawls were initiated in a range close to 100 fathoms. On the other hand, in subarea C, trawls at greater and lesser depths show a greater distance between them, suggesting that trawls were carried out over a wider range of depths, as documented in the geographic information system. The total catch obtained at depths greater than 100 fathoms was 3,568.41 tons, while in shallower strata, 415.90 tons were achieved, totaling 3,984.31 tons of fish for the year 2020. During the fishing operations of 2021, it was noted that the frequency of trawls covered a wider range of depths, as illustrated in Figure 13. In the four designated subareas, trawls were conducted at greater depths, with subarea "A" standing out for having the highest frequency of trawls at deeper levels. Subareas "B" and "C" also showed significant activity in this depth range, while in subarea "D" only a minimal value was recorded. The catches obtained in deeper strata totaled 5,089.69 tons, and the catches in shallower depths (less than 100 fathoms) reached 1,832.54 tons, totaling 6,922.23 tons of fish caught by the vessel during the 2021 fishing campaign.

Fishing Effort of the Vessel

The catch per unit effort (CPUE) achieved by the vessel Santa Mónica II was proportional to the number of hauls conducted in the years 2020 and 2021 (443 and 644, respectively) and to the fishing time spent in each operation. Thus, the catches obtained in the year 2020: summer (400.94 tons), autumn (989.04 tons), winter (1,688.07 tons), and spring (906.26 tons), total a catch of 3,984.31 tons, achieved in 638.95 hours of effective fishing, resulting in an annual CPUE for 2020 of 6.24 tons/h. The CPUE achieved in summer was 4.58 tons/h, in autumn 5.81 tons/h, in winter 3.36 tons/h, and in spring 5.41 tons/h. According to IMARPE (2022), the estimated CPUE for medium-sized trawling vessels (EAME) varied from 3.3 to 9.0 tons/h. Therefore, the vessel was positioned at central CPUE values with 6.24 tons/h (IMARPE 2022). For the year 2021, the fishing effort of the vessel was 8.20 tons/h, defined by the ratio of 6,922.23 tons of catch achieved in 843.87 hours of fishing. Furthermore, the highest effort was achieved in spring with 10.18 tons/h, followed by the fishing operations in winter with 8.03 tons/h, summer with 8.20 tons/h, and autumn with 7.63 tons/h.

Regarding the 2020 CPUE by month, the vessel's monthly CPUE was determined by dividing the total catches of each month by the number of fishing hours. The CPUE values ranged from 2.77 tons/h to 8.81 tons/h. The vessel was not operational in March. The highest CPUE was recorded in August at 8.81 tons/h, and the lowest in January at 2.77 tons/h. The vessel's CPUE showed an increasing trend, with a linear monthly increment of 0.0059 tons/h.

Regarding the 2021 CPUE by month, the vessel achieved higher CPUE values compared to the previous year, due to an increased frequency of trips, totaling 143 voyages. In the early months of the year (summer), CPUE values were: January (5.72 tons/h), February (9.23 tons/h), and March (8.77 tons/h). For the autumn months, the values were: April (5.86 tons/h), May (6.35 tons/h), and June (8.60 tons/h). During the winter months, the values recorded were: July (7.50 tons/h), August (7.87 tons/h), and September (17.74 tons/h); and finally, for the spring months: October (7.74 tons/h), November (9.01 tons/h), and December (14.64 tons/h). When evaluating

CPUE according to seasonal periods, it is observed that the first month of each season has a lower value compared to the following months, indicating that CPUE values tend to increase over time. The CPUE for 2021 shows a positive linear relationship, with CPUE values increasing towards the end of the year, reaching 14.64 tons/h in December. The linear regression line of the CPUE for 2021 shows an upward trend, as the monthly catches present increasing values, with an increment of 0.0175 tons/h for the year 2021.

In relation to the annual CPUE based on catch per trawl, the CPUE in relation to the number of trawls during the annual campaigns of 2020 and 2021, in which 443 and 644 trawls were conducted respectively, and 638.95 and 843.87 hours of fishing were employed, resulted in the vessel achieving a CPUE of 8.99 and 10.75 tons per trawl for each year respectively (as shown in Figure 17). The CPUEs for both years are relatively close, with a difference of 1.76 tons per trawl, indicating that the vessel has been effective in its fishing operations, achieving consistent and comparable catch volumes per trawl over the two years.

4. Discussion

The discussion of the results obtained in this study reveals interesting patterns in fishing operations and trip frequency, as well as in annual, monthly, and seasonal catches, which deserve to be contrasted with the existing scientific literature for a deeper and more critical interpretation.

The variability in trip frequency and the preference for certain subareas observed in this study could reflect the adaptability of fishing practices to environmental conditions and resource availability, as suggested in studies linking hake catches to environmental factors such as oxygen and depth (Kainge et al. 2017). However, this study considered the influence of geographical position on resource availability, a factor that has been shown to be significant in the variability of catches in previous studies (Kainge, Wieland, and Feekings 2015; Kainge et al. 2017). The lack of trips to subarea D, for example, could indicate unfavorable environmental conditions or lower resource abundance, which would require more detailed investigation to understand the underlying causes

The consistency in the efficiency of the Santa Mónica II vessel, maintaining a capture percentage of the total annual catch between 17% and 18%, could be interpreted as efficient management. However, this interpretation might be premature without a more rigorous analysis that considers the interannual variability of oceanographic conditions and the potential overexploitation of hake, as observed in previous research (Marengo et al. 2016; Ocampo Reinaldo et al. 2013). In the same vein, the reduction of operations during the reproductive ban and the COVID-19 pandemic are examples of factors that significantly altered fishing patterns. While these factors are critical, the study does not discuss in depth how these interruptions might affect abundance estimates and long-term management strategies, a crucial aspect in fishery management (Marks et al. 2015).

The CPUE of the Santa Mónica II, although within the average range estimated by IMARPE, shows an upward trend that could indicate increased fishing efficiency or changes in hake abundance. However, this study does not address whether this trend is sustainable or if it could be indicating a depletion of the resource, which is a topic of great relevance in the scientific literature (Yang et al. 2017). Additionally, the relationship between CPUE and the characteristics of the thermocline observed in the study of bigeye tuna suggests that variability in the thermocline could have a significant impact on the distribution of fishing grounds, an aspect not explored in the present study but which could have important implications for the management of the hake fishery.

Finally, cross-sector collaboration and ecosystem-based management are fundamental for the long-term sustainability of fisheries (Field et al. 2013). However, the present study does not discuss how collaboration among scientists, NGOs, and industry could improve the management of the fishery under study, an aspect that could significantly enrich the interpretation of the results. In summary, while the study's findings provide valuable information about the operation of the hake fishery, a more critical and detailed discussion that contrasts these findings with existing literature is essential for a deeper understanding of the fishery's dynamics and to inform more effective and sustainable management strategies.

5. Conclusions

This study reveals significant patterns in fishing operations, trip frequency, and annual, monthly, and seasonal catches, offering valuable insight into the dynamics of the hake fishery. The variability in trip frequency and the preference for certain subareas suggest an adaptability of fishing practices to environmental conditions and resource availability. The absence of trips to certain subareas could indicate unfavorable environmental conditions or a lower abundance of resources, warranting further detailed investigation.

The consistency in the efficiency of the Santa Mónica II vessel, maintaining a capture percentage of the annual total between 17% and 18%, suggests efficient management. However, a more rigorous analysis is needed that considers the interannual variability of oceanographic conditions and the possible overexploitation of hake. In addition, the influence of external factors such as the reproductive closure and the COVID-19 pandemic on fishing patterns requires deeper consideration to understand their impact on abundance estimates and long-term management strategies.

The upward trend in the CPUE of the Santa Mónica II could indicate increased fishing efficiency or changes in the abundance of hake. It is crucial to investigate whether this trend is sustainable or if it could be indicating a depletion of the resource. Finally, cross-sector collaboration and ecosystem-based management are essential for the long-term sustainability of fisheries. This study underscores the importance of a more critical and detailed discussion that integrates these findings with a deeper understanding of the fishery dynamics to inform more effective and sustainable management strategies.

Acknowledgements

The researchers would like to thank Industrial Pesquera Santa Mónica S.A., especially the fishing unit under study, for their support, logistics, and information provided for the development of this research.

Conflict of Interests

The authors of this research paper declare that they have no potential personal or economic conflicts of interest with other individuals or organizations that could unduly influence the content of this manuscript.

WORKS CITED

Bandín, Ricardo, and Percy Grandez. 2021. “Hacia Un Mejor Ordenamiento de La Pesquería de La Merluza Peruana.” Sociedad Peruana de Derecho Ambiental (SPDA).

D.S. N° 016-2003-PRODUCE, DECRETO SUPREMO No. 2003. Reglamento Del Ordenamiento Pesquero Del Recurso Merluza. https://cdn.www.gob.pe/uploads/document/file/3155190/D.S. No 006-2022-PRODUCE.pdf.pdf.

Espino Barr, Elaine, Álvaro González Vega, Heriberto Santana Hernández, and Humbero González Vega. 2008. “Manual de Biología Pesquera.” Instituo Nacional de Pesca, Universidad Autónoma de Nayarit. Nayarit. https://www.inapesca.gob.mx/portal/Publicaciones/Manuales/2008-Espino-Barr-etal-Manual-de-BIOLOGIA-PESQUERA.pdf?download.

FEDEPESCA. 2013. “Guía Técnica Sobre Artes de Pesca.” Fondo Europeo De Pesca. https://fedepesca.org/wp-content/uploads/2014/12/GUIA-ARTES-DE-PESCA.pdf.

Field, J. G., C. G. Attwood, A. Jarre, K. Sink, L. J. Atkinson, and S. Petersen. 2013. “Cooperation between Scientists, NGOs and Industry in Support of Sustainable Fisheries: The South African Hake Merluccius Spp. Trawl Fishery Experiencea.” Journal of Fish Biology 83 (4): 1019–34. https://doi.org/10.1111/JFB.12118.

Guevara-Carrasco, Renato, Raúl Castillo, and Alberto Gonzales. 1996. “Aspectos Metodológicos de La Evaluación Directa de La Merluza Merluccius Gayi Peruanus Con El Método Del Área Barrida (Cr. BIC SNP-1, 9505-06).” Informe Instituto Del Mar Del Peru 117: 8–15. https://repositorio.imarpe.gob.pe/bitstream/20.500.12958/464/1/INF 117-2.pdf.

Guevara-Carrasco, Renato, and Flor Fernández. 1996. “Comentario General Del Crucero de Evaluación Del Recurso Merluza Ejecutado En Otoño de 1995 (Cr. BIC SNP-1, 9505-06).” Informe Instituto Del Mar Del Peru, no. 117. https://repositorio.imarpe.gob.pe/bitstream/20.500.12958/462/1/INF 117-1.pdf.

Hernández Sampieri, Roberto, Carlos Fernández Collado, and María del Pilar Baptista Lucio. 2014. Metodología de La Investigación. 5. 6th ed. México: McGRAW-HILL / INTERAMERICANA EDITORES, S.A. DE C.V.

Hernández Sampieri, Roberto, and Christian Mendoza Torres. 2018. Metodología de La Investigación: Las Rutas de La Investigación Cuantitativa, Cualitativa y Mixta. México: McGRAW-HILL INTERAMERICANA EDITORES (Ed.), Mc Graw Hill. http://highered.mheducation.com/sites/1456260960/information_center_view0/index.html.

IMARPE. 2020. “Reportes de La Actividad Pesquera.” Instituto Del Mar Del Perú. 2020. https://www.imarpe.gob.pe/imarpe/calendario_reportes.php?id_seccion=I0131020201150000000000.

———. 2022. “Análisis de La Pesquería, Estado Poblacional y Proyecciones de Pesca de La Merluza Peruana Merluccius Gayi Peruanus.” Instituto Del Mar Del Perú. https://cdn.www.gob.pe/uploads/document/file/3497401/Informe Cuota merluza julio 2022 - junio 2023.pdf.

Kainge, P., A. K. van der Plas, C. H. Bartholomae, and K. Wieland. 2017. “Effects of Environmental Variables on Survey Catch Rates and Distribution by Size of Shallow- and Deep-Water Cape Hakes, Merluccius Capensis and Merluccius Paradoxus off Namibia.” Fisheries Oceanography 26 (6): 680–92. https://doi.org/10.1111/FOG.12227.

Kainge, P, K Wieland, and J Feekings. 2015. “Diel Effects on Bottom-Trawl Survey Catch Rates of Shallow- and Deep-Water Cape Hakes Merluccius Capensis and M. Paradoxus off Namibia, Using Solar Zenith Angle,” December. https://doi.org/10.6084/M9.FIGSHARE.1626663.V1.

Lloris, D., J. Matallanas, and P. Oliver. 2003. “Merluzas Del Mundo (Familia Merlucciidae). Catálogo Comentado e Ilustrado de Las Merluzas Conocidas.” FAO Catálogo de Especies Para Los Fines de La Pesca, no. 2: 1–6. https://www.fao.org/3/y4876s/y4876s.pdf.

Marengo, Michel, Anthony Pere, Bernard Marchand, Pierre Lejeune, and Eric D.H. Durieux. 2016. “Catch Variation and Demographic Structure of Common Dentex (Sparidae) Exploited by Mediterranean Artisanal Fisheries.” Bulletin of Marine Science 92 (2): 191–206. https://doi.org/10.5343/BMS.2015.1041.

Marks, Corina I., Ryan T. Fields, Richard M. Starr, John C. Field, Rebecca R. Miller, Sabrina G. Beyer, Susan M. Sogard, Deb Wilson-Vandenberg, Dan Howard, and Richard M. Starr. 2015. “Changes in Size Composition and Relative Abundance of Fishes in Central California after a Decade of Spatial Fishing Closures.” California Cooperative Oceanic Fisheries Investigations Reports 56 (October). https://www.researchgate.net/publication/282818244_Changes_in_size_composition_and_relative_abundance_of_fishes_in_central_California_after_a_decade_of_spatial_fishing_closures.

Mendoza Ramirez, David Humberto. 2018. “Conflicts in Productive Development in Hake Fisheries (Merluccius Gayi Peruanus) in Peru.” https://www.fao.org/fishery/static/tenure-user-rights/root/volume6/C64.pdf.

Ocampo Reinaldo, Matías, Raúl González, Gabriela Williams, Lorena Pía Storero, María Alejandra Romero, Maite Narvarte, and Domingo Antonio Gagliardini. 2013. “Spatial Patterns of the Argentine Hake Merluccius Hubbsi and Oceanographic Processes in a Semi-Enclosed Patagonian Ecosystem.” Marine Biology Research 9 (4): 394–406. https://doi.org/10.1080/17451000.2012.739700.

Olaya, Víctor. 2014. Sistemas de Información Geográfica. Sistemas de Información Geográfic. https://www.icog.es/TyT/files/Libro_SIG.pdf.

Polvorín, Gonzalo, and Víctor Valle. 2016. “Ecosonda Android.” http://rinfi.fi.mdp.edu.ar/xmlui/bitstream/handle/123456789/325/GAPolvorin%2BVMValle-TFG-IEe-2016.pdf?sequence=1&isAllowed=y.

PRODUCE. 2020a. Resolución Directoral N.° 00299-2020-PRODUCE/DS-PA. https://www.gob.pe/institucion/produce/normas-legales/1247814-00299-2020-produce-ds-pa.

———. 2020b. Resolución Ministerial N.° 188-2020-PRODUCE. https://cdn.www.gob.pe/uploads/document/file/898390/RM_188-2020-PRODUCE.pdf?v=1593524055.

———. 2021. Resolución Ministerial N.° 266-2021-PRODUCE. https://www.gob.pe/institucion/produce/normas-legales/2130397-266-2021-produce.

Wosnitza-Mendo, C. 2009. “Presentación Del Informe Del Tercer Panel Internacional de La Merluza Peruana.” Boletín Del Instituto Del Mar Del Perú 24 (1y2): 7–8.

Yang, Sheng Long, Yu Mei Wu, Bian Bian Zhang, Yu Zhang, Wei Fan, Shao Fei Jin, and Yang Dai. 2017. “[Relationship between Fishing Grounds Temporal-Spatial Distribution of Thunnus Obesus and Thermocline Characteristics in the Western and Central Pacific Ocean].” Ying Yong Sheng Tai Xue Bao = The Journal of Applied Ecology 28 (1): 281–90. https://doi.org/10.13287/J.1001-9332.201701.013.