

TECHNICAL REPORT
**ANALYSIS OF THE ECONOMIC
IMPACT OF THE
THERMAL DOME IN THE
EASTERN TROPICAL PACIFIC**



1

Introduction

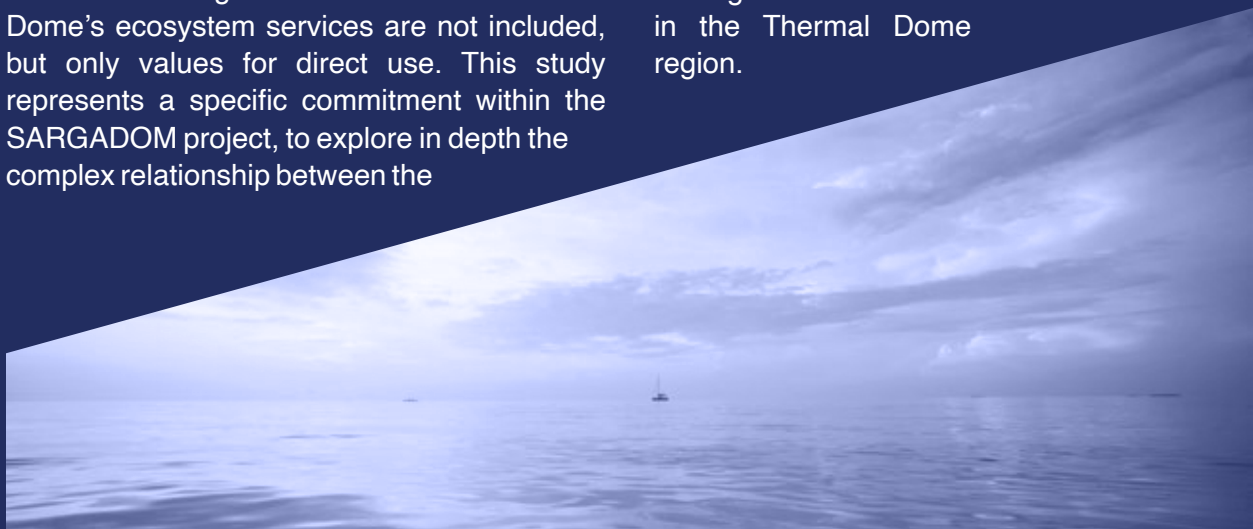
The Thermal Dome, also known as the Costa Rica Thermal Dome, located in the Eastern Tropical Pacific, is a unique marine phenomenon characterized by the interaction of winds and ocean currents. This interaction promotes the vertical ascent of deep, cold, nutrient-rich waters, which emerge towards the surface, giving rise to an upwelling area in the Eastern Tropical Pacific region. This phenomenon creates an environment conducive to marine biodiversity and supports a wide range of ecosystems and species. The presence of the Thermal Dome not only influences the oceanographic and climatic processes of the region but also plays a crucial role in the economic and social dynamics of the coastal communities that depend on its resources.

In partnership with MarViva Foundation, CINPE (International Center for Economic Policy) of the National University of Costa Rica has carried out research to comprehend the economic impact of the Thermal Dome in the Eastern Tropical Pacific and its influence on the national and local economies in the region, specifically those of Mexico, Costa Rica, Nicaragua, El Salvador, and Guatemala. Economic-ecological assessments of the Dome's ecosystem services are not included, but only values for direct use. This study represents a specific commitment within the SARGADOM project, to explore in depth the complex relationship between the

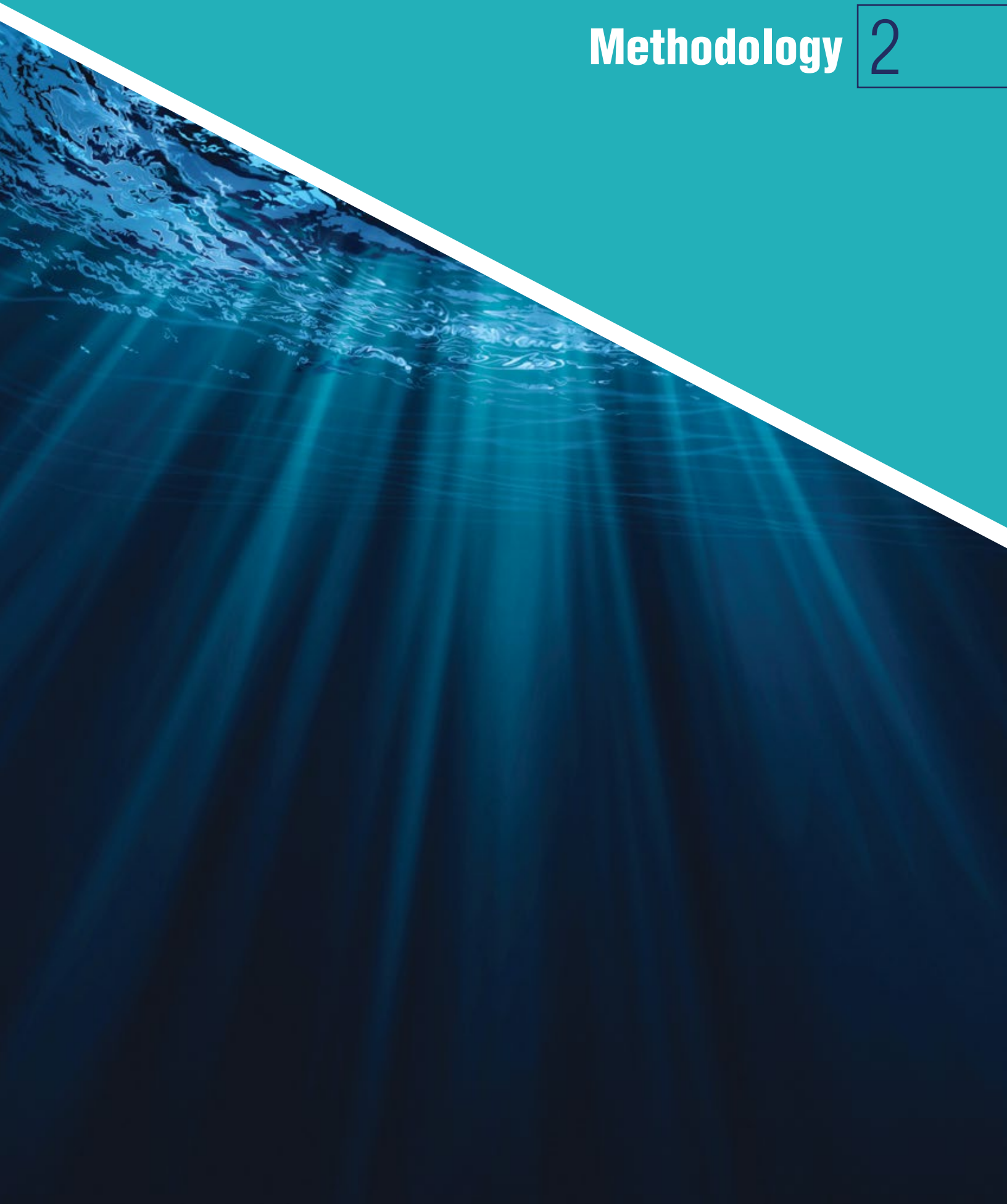
Thermal Dome and the associated economic activities in the region.

During the research, the interrelationship between the Thermal Dome and the related economic aspects has been analyzed in detail, evaluating the impact of commercial fishing, sport fishing, and wildlife watching tourism. This executive summary will present the main findings and results obtained, as well as the socioeconomic implications derived from the presence of the Thermal Dome in the region. In addition, recommendations will be offered for more efficient management of these marine resources to ensure their preservation and maximize their positive and sustainable contribution to local communities and the economy.

Through a rigorous analysis of the data collected and the interactions between the Thermal Dome and associated economic activities, significant patterns and relevant trends have been identified that delineate the importance of this marine ecosystem to the regional economy. These findings will serve as a basis for the formulation of recommendations and strategies for more effective and sustainable management of marine resources in the Thermal Dome region.



Methodology 2



For this research, a descriptive and analytical methodology of the events that take place in the Dome was used, using as much quantitative information as it was possible to generate. The study focuses on the collection, transformation, analysis, and presentation of numerical data to describe and interpret both quantitatively and qualitatively the direct economic impacts linked to marine and fishing tourism activities in the Thermal Dome area. The temporary selection covered six years from 2017 to 2022.

The research focused specifically on the direct use values of economic activities that depend on the exploitation of the species present in the Thermal Dome, such as commercial fishing, sport fishing and, wildlife watching tourism. The economic impact of each of these activities was valued differently. In the case of commercial fishing, most of the data are geo-referenced and allow the exploitation of species on the high seas (in the same Dome) to be assessed. Other data comes from statistics or information that originates from the exploitation of species from the Dome that travel to the jurisdictional waters of the countries and their coasts in the Eastern Tropical Pacific, such as in sport fishing and wildlife watching.

In this research, all economic values were expressed in US dollars (USD). To ensure the accuracy of the data, currency conversions were performed using the exchange rates in effect for the year, thus ensuring an appropriate comparison of revenues and costs for the period analyzed. This research estimates the economic values of direct recreational products or uses by analyzing market prices, fees, licenses and permits in effect during the period of analysis. Approximations of the ecological economic value of the ecosystem services provided by the existence of the Thermal Dome will be left for future research.

2.1 Delimitation of the study area:

The Eastern Tropical Pacific Thermal Dome is an oceanographic phenomenon influenced by trade winds and the interaction of ocean currents with the Intertropical Convergence Zone. Its location and size vary seasonally, expanding or contracting off the Pacific coast of Central America throughout the year. This phenomenon covers thousands of square kilometers, with a diameter ranging from 200 to 1000 kilometers, and an area varying from 800 to 1,000,000 km², reaching its maximum expansion in November and December.

The location of the Thermal Dome is susceptible to variations due to climatic phenomena such as the Southern Oscillation (ENSO). Its negative phase can increase its extension, while the positive phase tends to reduce its area. Despite its mobility, research carried out by the MarViva Foundation has made it possible to delimit its area using the value of the thermocline and its constancy over 30 years.

In this research, we use the delimitation developed by the MarViva Foundation (2019), which places the core of the Dome at coordinates 9.56°N and 92.58°W, with maximum limits covering an area of 1 001 841 km². This delimitation includes portions of the maritime jurisdiction zones of all Central American countries.

In addition, the territorial study area is defined as a section of the Eastern Tropical Pacific coastline under the influence of the Dome during different months of the year, ranging from the southern Pacific coast of Mexico to the southern Pacific coast of Costa Rica. The distance between the coasts of these countries and the outer limit of the Thermal

Dome varies from 12 to 20 miles (19 – 32 km). This territorial delimitation includes 6 states in Mexico, 6 departments in Guatemala, 7 in El Salvador, 7 in Nicaragua, and 16 cantons in Costa Rica, for a total of five countries¹ of interest.

In general terms, the research is based on two delimitation criteria: the “MarViva persistence map” for the marine area and the coastal delimitation of the five countries located in the area under the influence of the Dome. Both delimitations are essential to obtain and analyze data related to productive activities in the Eastern Tropical Pacific.

MAP 1. Persistence of the Thermal Dome, 2018



Source: CINPE-UNA with data from MarViva, 2018.

¹ Honduras, although within the Dome’s zone of influence, does not participate in fishing or tourism activities in the Pacific, according to official communications. Therefore, it is excluded from the analysis because it has no relationship with the Dome.

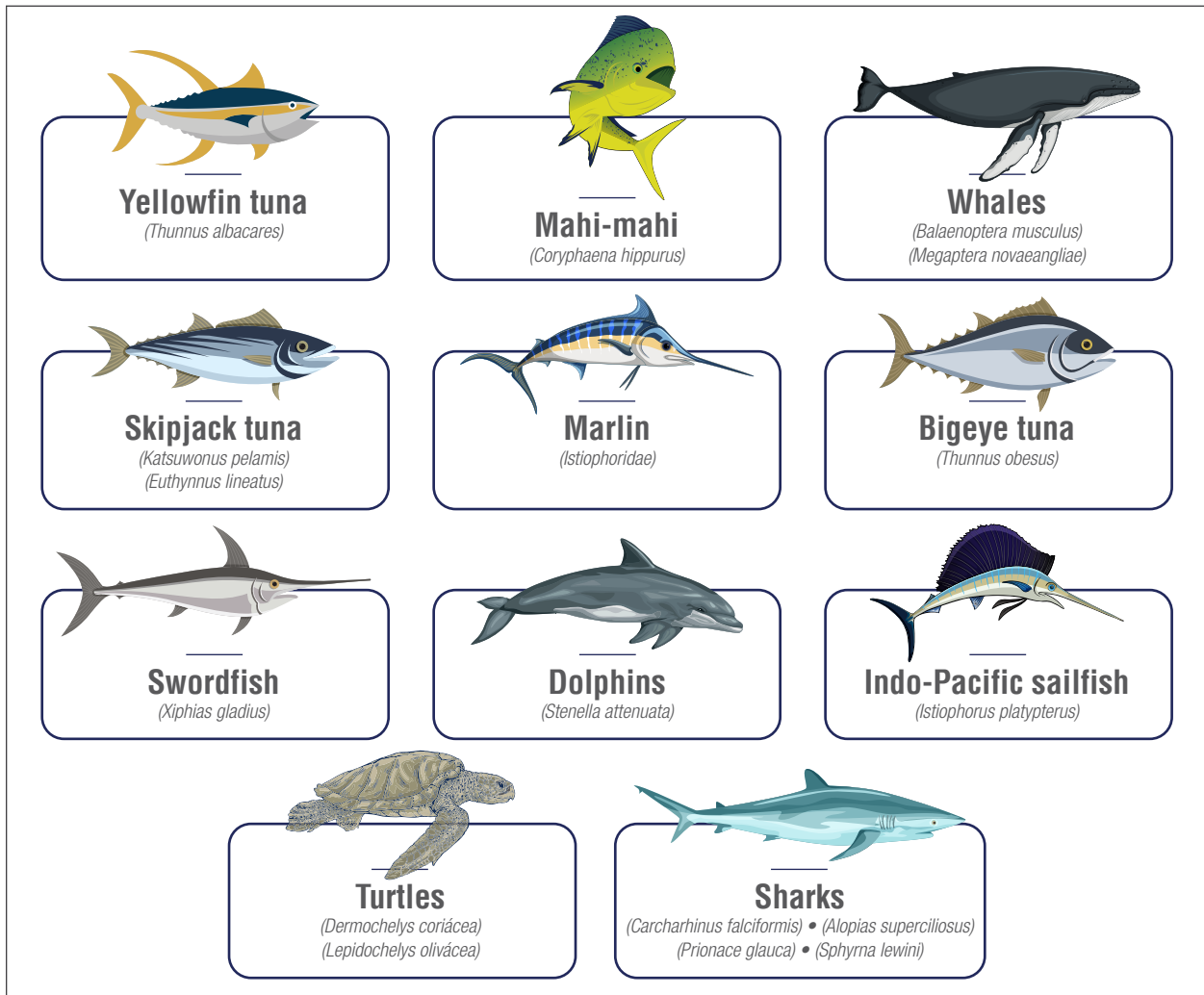
2.2 Species selection

In this research, the economic impacts of the Thermal Dome are analyzed through the relationship between human economic activities and the biodiversity of the Dome ecosystem. To this end, the groups of species present in this area were carefully selected, to explore how commercial fishing and tourism are influenced by the presence of these species, and how these interactions impact the local and regional economy.

Three key criteria for species selection were used to identify the economic values associated with the Thermal Dome: flagship species,

commercial value, and tourism value. Following discussions between the research team and MarViva experts, 12 species groups of species were carefully selected. These representative species were strategically chosen to provide a comprehensive understanding of the economic benefits of the Thermal Dome, addressing ecological aspects, fishing, and tourism activities. Flagship species reflect the health of the ecosystem, species of commercial value provide information on fisheries and their economic impact, and species of tourism value show the attractiveness of ecotourism and its economic contribution. The species groups selected for this research are presented in Figure 1.

FIGURE 1. Species selected for the identification of economic values related to the Thermal Dome.



2.3 Information, methods and calculations

To address the analysis of the economic impact of the Thermal Dome resulting from commercial fishing, data from three sources were applied: the Inter-American Tropical Tuna Commission (IATTC), Global Fishing Watch (GFW) and national fisheries institutions. Each source provides information that requires a different methodological treatment to generate an approximation of the value provided by commercial fishing on tuna catches, fishing efforts and local landings. However, data from GFW were selected for the presentation of this summary; although, data from all three sources were analyzed in the final document.

Data from Global Fishing Watch (GFW), a technology platform that uses satellite and positioning data to track and visualize fishing activity globally, were used. Two data sets related to fishing effort were explored within the polygon established for the Thermal Dome, focusing specifically on the fishing effort (in hours) carried out by vessels with Automatic Identification System (AIS) during the period from 2017 to 2022, with a particular focus on the type of purse seine fishing. These data were georeferenced only for the Thermal Dome area to ensure geographical precision in the analysis, to later convert them to the equivalent in tons and take them to the assessment of the activity.

About sport fishing, two methodological approaches were used to quantify income: a direct income approach that refers to the income that the State directly receives from payments of fees, licenses and permits processed by sport fishing enthusiasts; the other approach is indirect income received by people, businesses or local companies from the expenses of sport fishing tourists on transportation, lodging, food,

payment of salaries to boat workers, among other expenses related to the sport fishing activity, such as implements, equipment, and costs associated with boat maintenance. In both cases, information was collected from fisheries and tourism institutes in each country and the study area was delimited to ensure applicability and consistency with the research objectives. In addition, the findings of previous studies were taken in consideration, such as the detailed socioeconomic study conducted by Chaminade and Hernández (2020), which highlights that of the total number of groups of species captured in this activity, approximately half of them are also present in the Thermal Dome. Based on this premise, it was assumed that 50% of the estimated income from sport fishing is linked to the presence of the Thermal Dome, thus facilitating the understanding and quantification of its economic impact.

With respect to whale watching tourism, due to the lack of information from reliable sources, surveys were conducted between October 2023 and February 2024 directed at professionals involved in whale watching tour operating companies in the five countries. With the information obtained through these surveys, the total annual income per country was calculated by multiplying the average income by the total number of companies identified in the area delimited above. In Costa Rica, the interviews were carried out in person, facilitating in this manner the establishment of the exact number of companies. However, in other countries, surveys were conducted by e-mail and telephone due to the lack of government records and specialized literature. Despite the limitations, this approach made it possible to collect information on the number of whale-watching businesses in each country, providing an initial basis for understanding the revenues generated by this activity in the region.

2.4 Limitations

In the study on the economic contribution of the Thermal Dome, the quality and access to information represented significant challenges, affecting the collection and analysis of data from marine activities. The main limitations found in this investigative process are detailed below, including difficulties in updating and accessing data from recognized sources, as well as the poor response from public and private entities consulted. These obstacles highlight the challenges inherent in studying economic impacts in specific marine areas such as the Thermal Dome. The main limitations include:

- | **Data Access and Update:** Information provided by entities such as GFW and IATTC, although publicly accessible, has significant restrictions. For example, the GFW fishing effort data is only available until 2020, and for subsequent years it was necessary to process georeferenced information through geographic information systems. On the IATTC side, the lack of disaggregated and updated data beyond 1985 for Costa Rica makes comparison with recent periods difficult. Additionally, they lack information on the groups of species captured.
- | **Longline Fishing:** The analysis excluded the contribution of longline fishing, since it is carried out by vessels from non-IATTC member countries, and therefore, their activities are not reported to this database.
- | **Limited IATTC Disclosure:** The IATTC groups the data into a general “other” category, without providing specific details by vessel or company, which limits the accuracy of the data for Guatemala and El Salvador in certain years.
- | **Response from Entities Consulted:** There was a low response to requests for information sent to various public and private entities. Despite attempts to involve these entities in focus groups and through forms, responses were scarce, except for a few isolated responses from organizations such as DIGEPESCA, FAO, FECOP and INCOPECA. El Salvador has no records on the number of sport fishing permits and their costs.
- | **Outdated information:** National fishing institutions do not have updated data since 2022 on sport fishing licenses issued, which leads to an underestimation of the contribution of the activity.
- | **Sport Fishing Tourism Registry:** Only El Salvador, Guatemala, and Costa Rica register data on sport fishing tourism, and not for all years, limiting estimates of indirect expenditures and generating underestimates.
- | **Vessel Registry:** Only Costa Rica has a complete registry of the number of vessels used to transport sport fishing tourists, resulting in underestimations of indirect income in other countries.
- | **The countries studied lack information on the number of companies offering whale watching services, as well as specific details on tour prices and the different types of services offered.**

These limitations underscore the challenges in data collection and analysis to accurately assess the economic impact of marine activities in the Thermal Dome.

Results

3



3.1 Commercial Fishing

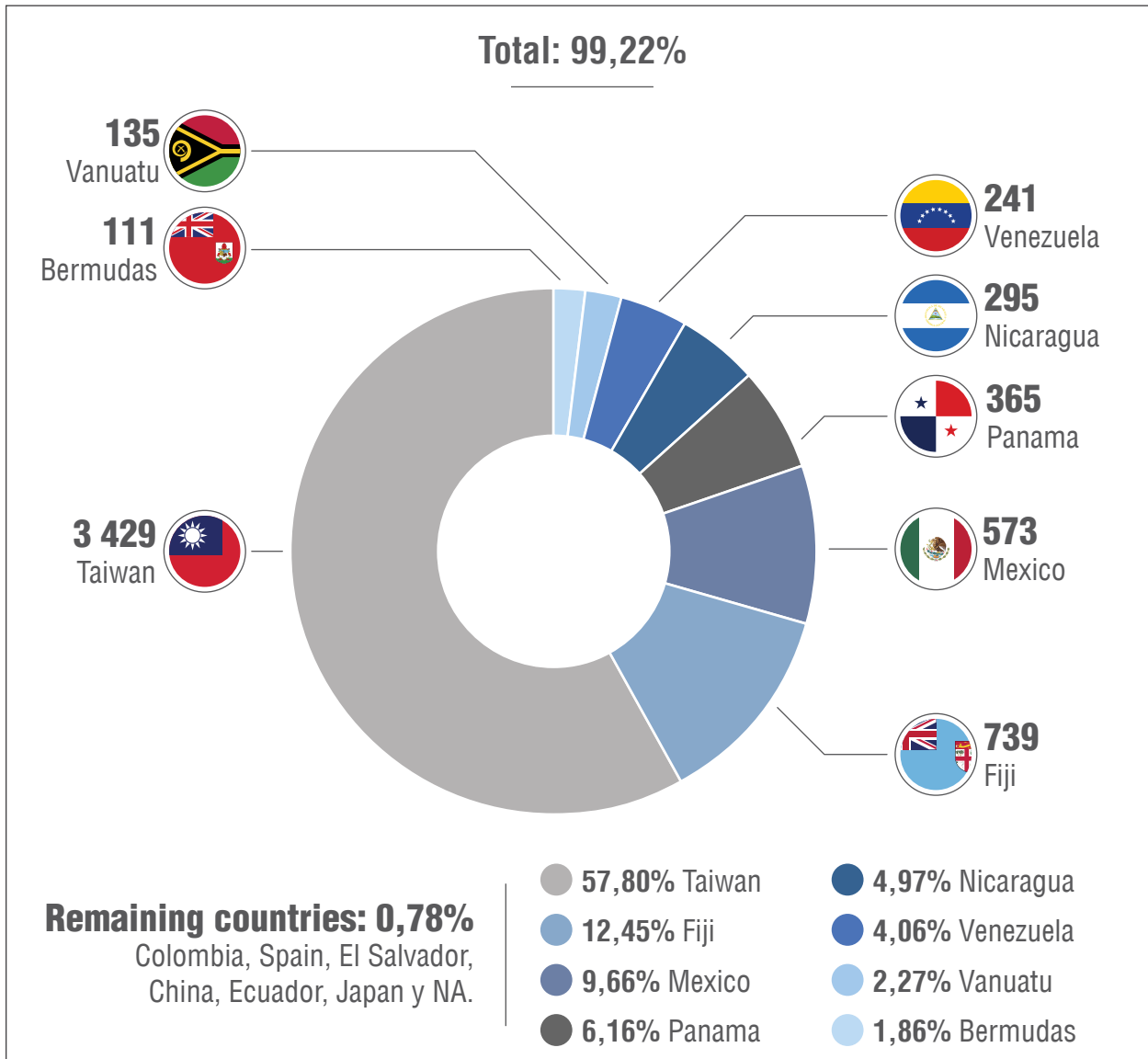
Analysis of the georeferenced Thermal Dome data obtained from GFW revealed significant results.

“Between 2017 and 2022, a total of 5933 days of both longline and purse seine fishing efforts were recorded in the Thermal Dome area.”

85% of this fishing effort was carried out by countries outside the region of interest, with Taiwan accounting for 57% of this effort. On the other hand, only the remaining 15% of the fishing effort was carried out by countries within the Central American region and Mexico, the latter together with Nicaragua represented 9.66% and 4.97% respectively (Graph 1).



GRAPH 1.
Thermal Dome: fishing effort in days according to flag, 2017-2022

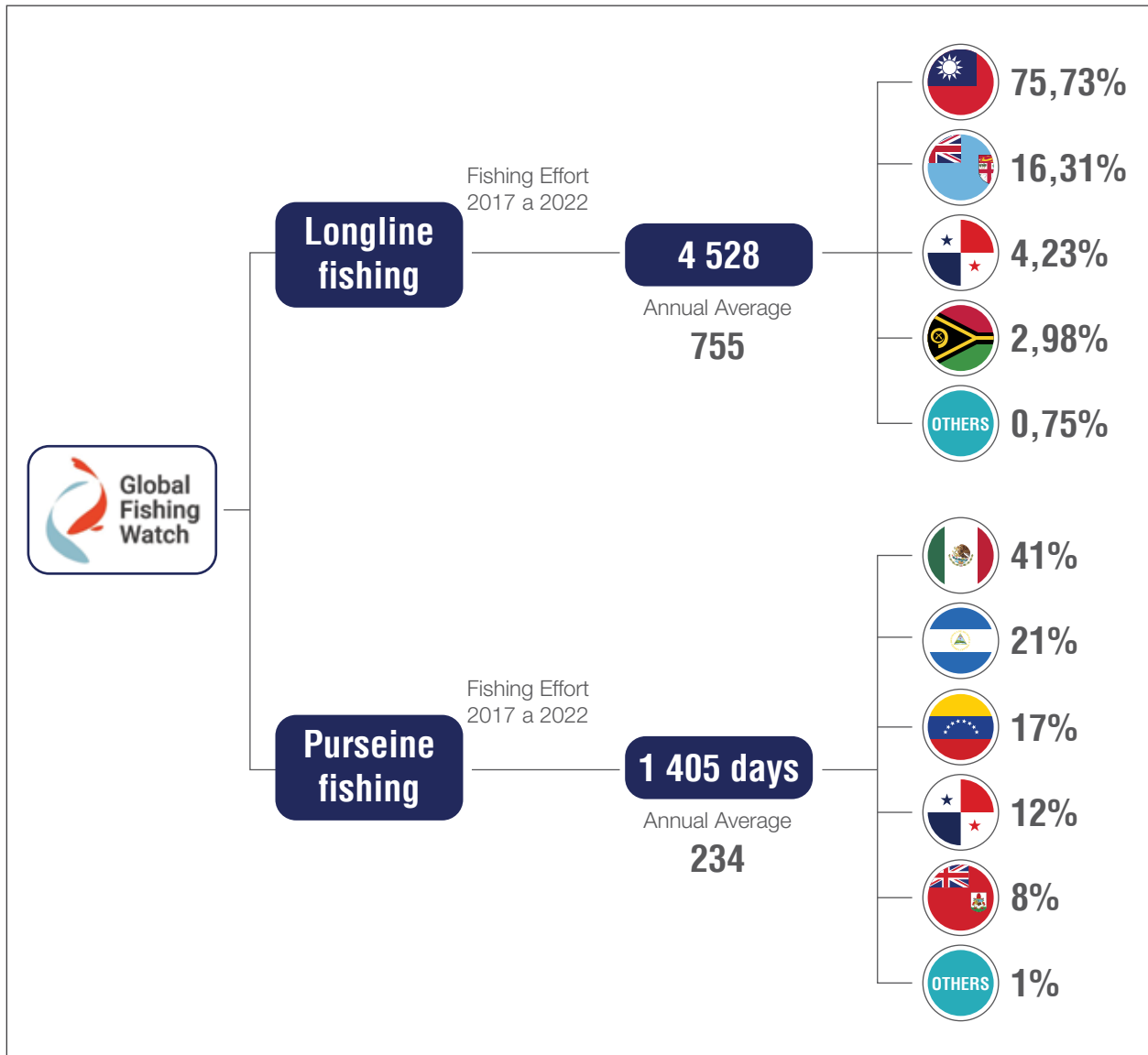


Source: prepared by CINPE-UNA with data from GFW, 2023.

The above reveals a high disparity regarding the distribution and participation of the countries in fishing activity within the Dome area. Likewise, the International Commission for the Conservation of Atlantic Tunas (ICCAT) revealed a clear disparity in the distribution of fishing effort between longline and purse seine vessels within the Thermal Dome area.

While 76% of the effort is attributed to longline vessels, representing a total of 4,528 days, the remaining 24% corresponds to purse seiners, with a total of 1,405 days (Graph 2). On the other hand, the estimated fishing effort for vessels flying the flag of the countries of interest is mostly purse seiners and less than 1% comes from longline vessels.

FIGURE 2. Thermal Dome: Fishing effort in days, by fishing gear, 2017-2022



Source: prepared by CINPE-UNA with data from GFW, 2023.

Of the total 1,405 days of purse seine fishing effort in the Thermal Dome area, 62% came from the countries under study. Specifically, and as shown in table 1, a total of 573 days from Mexico, 295 days from Nicaragua and 1 day from El Salvador were recorded in the Dome area, which highlights the importance of these Central American countries in the

fishing activity within this area. This finding emphasizes the relevance of analyzing the economic impact of purse seining in the region, highlighting the significant participation of Mexico and Nicaragua in this fishing activity in the Eastern Tropical Pacific Thermal Dome environment.

TABLE 1.

Thermal Dome: Fishing effort of purse seine vessels in days by country, 2017-2022

FLAG	2017	2018	2019	2020	2021	2022	TOTAL
Bermudas	0	0	45	20	34	12	111
Colombia	1	0	0	1	0	0	2
Ecuador	0	0	0	0	12	0	12
Mexico	153	194	76	89	54	7	573
Nicaragua	31	60	33	70	41	60	295
Panama	14	0	147	4	0	5	170
El Salvador	0	1	0	0	0	0	1
Venezuela	60	39	44	46	26	26	241
TOTAL	259	294	345	230	167	110	1 405

Source: prepared by CINPE-UNA with data from GFW, 2023.

By transforming the fishing effort into tons using the information provided by the International Commission for the Conservation of Atlantic Tunas (ICCAT) (2008), which establishes that purse seine vessels have a storage capacity ranging between 200 and 400 tons per day, it was possible to estimate the total tonnage. Multiplying the average value of this range,

i.e. 300 tons, by the total days of purse seine fishing effort, which was 1 405 days, gives an approximate tonnage for the period 2017 to 2022 of 421 500 tons (Table 2). Of this amount, 260,700 tons corresponded to the catch made by the countries under study, which includes Mexico, Nicaragua and El Salvador.

TABLE 2.

Thermal Dome: Estimated tonnage caught by purse seiners by country, 2017-2022

FLAG	2017	2018	2019	2020	2021	2022	TOTAL
Bermudas	0	0	13 500	6 000	10 200	3 600	33 300
Colombia	300	0	0	300	0	0	600
Ecuador	0	0	0	0	3 600	0	3 600
Mexico	45 900	58 200	22 800	26 700	16 200	2 100	171 900
Nicaragua	9 300	18 000	9 900	21 000	12 300	18 000	88 500
Panama	4 200	0	44 100	1 200	0	1 500	51 000
El Salvador	0	300	0	0	0	0	300
Venezuela	18 000	11 700	13 200	13 800	7 800	7 800	72 300
TOTAL	77 700	88 200	103 500	69 000	50 100	33 000	421 500

Source: prepared by CINPE-UNA with data from GFW, 2023.

Thus, over the period 2017 to 2020, the value of the commercial fishing of the countries registered by the GFW in the Thermal Dome is estimated at \$792 708 600, multiplying the tons of fish obtained by the average prices per ton. Within these, the countries under study registered by GFW (Mexico, Nicaragua, and El Salvador) represented 62% of the total catches

in the Dome area, equivalent to an amount of \$499 444 007 (table 3).

On the other hand, the analysis revealed an upward trend in catches or landings until 2019, which marked the highest point, followed by a decline during the pandemic, which failed to fully recover in subsequent years.

TABLE 3. Thermal Dome: Monetary value obtained by tons of total catch obtained by year, 2017 to 2022

YEAR	TONNAGE	AVERAGE PRICES ²	AMOUNT FROM ALL COUNTRIES RECORDED	NUMBER OF REGISTERED COUNTRIES UNDER STUDY
2017	77 700	\$ 2 152	\$ 167 210 400	\$ 118 526 207
2018	88 200	\$ 2 158	\$ 190 335 600	\$ 165 087 000
2019	103 500	\$ 1 821	\$ 188 473 500	\$ 59 546 700
2020	69 000	\$ 1 635	\$ 112 815 000	\$ 77 989 500
2021	50 100	\$ 1 611	\$ 80 711 100	\$ 45 913 500
2022	33 000	\$ 1 611	\$ 53 163 000	\$ 32 381 100
TOTAL	421 500		\$ 792 708 600	\$ 499 444 007

Source: prepared by CINPE-UNA with data from GFW, 2023.

In general terms, although most of the total catches in the Dome, according to GFW records, are made by countries outside the region, Mexico, Nicaragua, and El Salvador stand out with 62% of the purse seine catches in this scenario. This finding highlights the significant contribution of these countries in the Central American region to the fishing effort in the Dome area, suggesting a crucial role in fishing activity in this area. However, the presence of extra-regional countries is also notable, underscoring the importance of international cooperation and shared

management of marine resources in this area of interest. These results highlight the need for collaborative policies and strategies that promote the sustainability and conservation of fishing resources in and around the Thermal Dome.

The lack of information about the storage capacity of longline vessels that would allow estimating approximate averages to convert the fishing effort of these vessels, led the present economic analysis to concentrate on purse seine fishing.

² The average prices per ton of fish were obtained through a research process using information from the fisheries institutes of each of the countries analyzed in this study. The methodology and original information are detailed in the corresponding research document.

3.2 Sport fishing

According to Chaminade and Hernández (2020) the main species caught in sport fishing are red snapper (*Lutjanus purpureus*), crevalle jack (*Caranx hippos*), roosterfish (*Nematistius pectoralis*), wahoo (*Acanthocybium solandri*), yellowfin tuna (*Thunnus albacares*), mahi-mahi (*Coryphaena hippurus*), Indo-Pacific sailfish (*Istiophorus platypterus*), and marlin (family *Istiophoridae*).

“Of these species, tuna, mahi-mahi, sailfish, and marlin are characteristic of the Dome; and assuming they have equal weight in the total catch, an estimated 50% of the income from sport fishing is related to the Dome.”

The lack of adequate records in some countries and the significant differences in the requirements and valuation of sport fishing permits, licenses, cards, and tournaments made it difficult to obtain and analyze the information. Despite these difficulties, it was possible to identify, as shown in Table 4, that during the period from 2017 to 2022 a total of at least \$1 022 134 in direct income was generated from the Dome.

TABLE 4. Direct income from sport fishing permits, cards, licenses, and tournaments by country, 2017-2022

	2017	2018	2019	2020	2021	2022	TOTAL
Mexico	\$ 216 730	\$ 213 150	\$ 0	\$ 0	\$ 193 896	ND	\$ 623 776
Guatemala	\$ 980	\$ 1 277	\$ 1 351	\$ 2 590	\$ 2 586	ND	\$ 8 784
El Salvador	ND	ND	ND	ND	ND	ND	ND
Nicaragua	ND	ND	\$ 37 625	\$ 136 831	\$ 81 995	ND	\$ 256 451
Costa Rica	\$ 288 183	\$ 308 622	\$ 378 199	\$ 158 202	\$ 7 528	\$ 14 524	\$ 1 155 258
TOTAL	\$ 505 893	\$ 523 049	\$ 417 175	\$ 297 623	\$ 286 005	\$ 14 524	\$ 2 044 269
TOTAL OF THE THERMAL DOME	\$ 252 946	\$ 261 525	\$ 208 587	\$ 148 812	\$ 143 002	\$ 7 263	\$ 1 022 134

Note 1: The notation “ND” is used to indicate the lack of publicly available data, while “0” indicates the absence of income in a specific year.
 Note 2: Data in the table are raw, since the percentage associated to the Thermal Dome has not been deducted.
 Source: CINPE-UNA with data from the national fishing institutions of each country, 2023.

Direct revenues exhibit an overall downward trend from 2017 to 2022, with a notable peak in 2018 followed by a gradual decline in subsequent years, attributed in part to the COVID-19 pandemic, but mainly to the lack of updated permits and licenses data issued by many countries. In terms of income by country, Costa Rica presents the highest amounts and the most complete and updated records during the period analyzed, standing out in its position as an important destination for sport fishing in the region. Mexico also generates significant amounts, although not for all the years of the period. The other countries have data that allows estimating a part of these incomes, but the information is incomplete or non-existent, as in El Salvador, due to the lack of available statistics.

Regarding indirect income, which includes tourist expenditure on sport fishing, salaries, boat maintenance and equipment, information

was only available for three countries: Costa Rica, El Salvador, and Guatemala. In the case of Costa Rica, information was available on the average expenditure of sport fishing tourists (food, transportation, etc.), as well as information on expenditures on salaries and equipment maintenance. In El Salvador, only information on average tourist expenditure was available, while in Guatemala similar information was available, but only for the year 2023 (the same value was assumed for all years).

In general, as in other analyses, a clear negative impact is observed during the pandemic, and no recovery is evident in the following years. It was determined by applying the 50% estimation factor, that a total of US\$ 957 718 618 was generated from indirect income during the period from 2017 to 2022, as shown in table 5.

TABLE 5. _____

Indirect income from sport fishing in Guatemala, El Salvador, and Costa Rica, associated with species characteristic of the Dome. 2017-2022

	GUATEMALA	EL SALVADOR	COSTA RICA	TOTAL	TOTAL THERMAL DOME
2017	\$ 915 752	0	\$ 431 728 403	\$ 432 644 155	\$ 216 322 078
2018	\$ 915 752	0	\$ 438 842 012	\$ 439 757 764	\$ 219 878 882
2019	\$ 915 752	\$ 267 960	\$ 454 164 488	\$ 455 348 200	\$ 227 674 100
2020	0	\$ 130 152	0	\$ 130 152	\$ 65 076
2021	\$ 915 752	\$ 191 400	\$ 229 733 126	\$ 230 840 278	\$ 115 420 139
2022	\$ 915 752	\$512 952	\$ 355 287 982	\$ 356 716 686	\$ 178 358 343
TOTAL	\$4 578 760	\$1 102 464	\$1 909 756 011	\$1 915 437 235	\$ 957 718 618
TOTAL THERMAL DOME	\$2 289 380	\$ 551 232	\$ 954 878 006	\$ 957 718 618	

Note: El Salvador records tourism data for sport fishing purposes as of 2019, for this reason the years 2017 and 2018 appear with US\$ 0. The year 2020 has been disregarded in the scenario of Guatemala and Costa Rica primarily due to the suspension of tourism during the pandemic.

Note 2: Data in the table are raw, since the percentage associated to the Thermal Dome has not been deducted.

Source: prepared by CINPE-UNA with data from tourism institutions in each country, Villalobos (2021), Fecop (2018), Fecop (2019) and López, 2024 and calculation assumptions.

During the study period between 2017 and 2022, total income, which includes both direct and indirect income associated with the Thermal Dome, reaches the considerable sum of US\$ 958 740 752. Most of this amount corresponds to indirect income, which represents the average expenditure per tourist and other related disbursements, totaling US\$

957 718 617. On the other hand, direct income from sport fishing permits, licenses, cards, and tournaments during the same period amounted to US\$ 1 022 134. For a more detailed understanding of these revenues, annual and country breakdowns are provided in Tables 6 and 7.

TABLE 6. Total income received per year in sport fishing and tourism in Mexico and Central America, 2017-2022

	2017	2018	2019	2020	2021	2022	TOTAL
Ingresos directos	\$ 505 893	\$ 523 049	\$ 417 175	\$ 297 623	\$ 286 005	\$ 14 524	\$ 2 044 269
Ingresos Indirectos	\$ 432 644 155	\$ 439 757 764	\$ 455 348 200	\$ 130 152	\$ 230 840 278	\$ 356 716 68	\$ 1 915 437 235
TOTAL	\$ 433 150 048	\$ 440 280 813	\$ 455 765 375	\$ 427 775	\$ 231 126 283	\$ 356 731 210	\$ 1 917 481 504
TOTAL OF THE THERMAL DOME	\$ 216 575 024	\$ 220 140 407	\$ 227 882 688	\$ 213 888	\$ 1115 563 142	\$ 178 365 605	\$ 958 745 252

Source: CINPE-UNA with data from fisheries and tourism institutions in each country, 2023.

TABLE 7. Total income received by country in sport fishing and tourism in Mexico and Central America, 2017-2022

	MEXICO	GUATEMALA	EL SALVADOR	NICARAGUA	COSTA RICA	TOTAL
Direct income direct	\$ 623 776	\$ 8 784	ND	\$ 265 451	\$ 1 155 258	\$ 2 053 269
Indirect income	ND	\$ 4 578 760	\$ 1 102 464	ND	\$ 1 909 756 011	\$ 1 915 437 235
TOTAL	\$ 623 776	\$ 4 578 760	\$1 102 464	\$ 265 451	\$ 1 910 911 269	\$ 1 917 490 504
TOTAL THERMAL DOME	\$ 311 888	\$ 2 293 773	\$ 551 232	\$ 132 726	\$ 955 455 635	\$ 958 745 252

Note: N.D. - Data for these countries was not available.

Source: CINPE-UNA with data from fisheries and tourism institutions in each country, 2023.

The economic impact of the Thermal Dome through sport fishing stands out as the most economically relevant activity among the three analyzed, although complete information was

not available. The sustainability of this activity and more than half of the estimated income for the region depend on the protection and management of the Thermal Dome.

3.3 Whale watching

“Whale watching has become a very important tourist activity in the waters influenced by the Thermal Dome.”

This oceanic phenomenon, where nutrient-rich currents rise to the surface, creates an ideal habitat for a variety of marine species, including the majestic humpback whale (*Megaptera novaeangliae*) and the agile spotted dolphin (*Stenella attenuata*).

In-depth interviews with tour operators and whale watching experts in the Central American region and Mexico provided crucial information on watching frequency, tourism demand, tour prices, and other relevant aspects to estimate the economic impact of this activity in the Dome area. These findings are summarized in Table 8.



TABLE 8. Average whale watching tour data in the study area, 2023

COUNTRY	AVERAGE NUMBER OF DAILY DEPARTURES	AVERAGE QUANTITY OF SERVICE DAYS PER YEAR	AVERAGE NUMBER OF PARTICIPANTS PER TRIP	AVERAGE PRICE PER PERSON (IN US DOLLARS)	AVERAGE ESTIMATED INCOME BY COMPANY
Costa Rica	2	239	21	63	\$ 632 394
Mexico	4	118	20	72	\$ 679 680
El Salvador	2	104	7	53	\$ 77 168
Nicaragua	1	133	35	60	\$ 279 300
Guatemala	1	148	5	29	\$ 21 460

Source: CINPE-UNA with data from interviews with whale watching tour operators, 2023.

In general terms, it was found that companies carry out an average of two tours per day, although this figure may vary depending on the season. 60% of companies offer tours all year round, although they warn clients about the lack of guarantees for whale watching outside of peak whale watching seasons. Sighting seasons were mainly identified in two periods: from January to March and from July to October, with an annual average of approximately 128 days in which the service is offered. The number of participants per tour varies considerably, ranging from 2 to 65 people per outing. In terms of prices, it was found that the cost per person for sighting tours varies between US\$ 60 and US\$ 290³.

Average annual income per company shows significant disparities among the countries analyzed. Mexico and Costa Rica stand out with the highest annual revenues, exceeding US\$600 thousand on average per company. They are followed by Nicaragua, with an

average annual income of close to US\$ 280,000 per company. On the other hand, El Salvador and Guatemala show much lower average annual income per company, being less than US\$ 77 thousand and US\$ 21 thousand respectively. These last two countries are also characterized by charging lower rates per tour compared to the other countries in the region.

The total estimated revenue per watching in the countries of the region during the peak whale watching season in 2023 reached US\$ 24 509 178, where the estimated revenue is presented according to the number of tour operators. Considering that this income remained constant annually during the analysis period from 2017 to 2022, except for the year of the pandemic where the service was stopped, it is estimated that the total income per watching in the countries of the region under the influence of the Thermal Dome for the period from 2017 to 2022 would be US\$ 122 545 890.

3 The instrument applied and the list of companies can be reviewed in the annexes of the document.

4

Conclusions and recommendations



This document summarizes the main results obtained from the analysis of the economic relevance of the Thermal Dome, exploring its economic impact through commercial fishing, sport fishing and wildlife watching tourism. From 2017-2022 the three together totaled an economic value of US\$ 1580 million in the countries of the Central American region and southern Mexico. A detailed evaluation of economic activities has identified significant trends, as well as a marked vulnerability to external events such as the COVID-19 pandemic or phenomena such as ENSO in the case of commercial fishing. These findings highlight the importance of understanding the environmental dynamics that also translate into economic changes in the activities surrounding the Dome and the need to implement appropriate management measures to ensure its sustainability and maximize its contribution to the economic development of the region.

It was determined that approximately 85% of the fishing effort in this area comes from countries outside the region, with Taiwan standing out as one of the main stakeholders, with a participation that exceeds 50%. In contrast, Central American countries and Mexico contribute about 15% of the total fishing effort in this area. This finding highlights the need to deepen our understanding of the international economic interests in the Thermal Dome and its importance for commercial fishing in the region, as well as the need to strengthen the participation and capacity of local stakeholders in Central American countries.

Between 2017 and 2022 commercial fishing by vessels flagged to Mexico, Nicaragua and El Salvador in the Thermal Dome was estimated at around US\$500 million. From

the information provided by GFW it is not possible to extract information on the groups of species caught, however, the review of other complementary sources indicates that 97% of the commercial fishery in the Thermal Dome corresponds to the yellowfin tuna species, while the remaining 3% is distributed among species such as skipjack and black skipjack (IATTC, 2023).

Sport fishing associated with the main species of the Dome during the period from 2017 to 2022 contributed a total of \$959 million to the regional economy. This figure includes both direct income from permits and licenses issued by governments for sport fishing, as well as indirect income derived from spending by tourists who participate in this activity and other associated costs. These revenues highlight the economic importance of sport fishing in the region, underlining its role as a key driver of tourism and sustainable economic development in coastal communities. The analysis of the data suggests that the Thermal Dome is a source of food for half of the main catch species groups, which not only attract sport fishing enthusiasts in search of characteristic species, but also creates opportunities for tourist activities related to marine life observation.

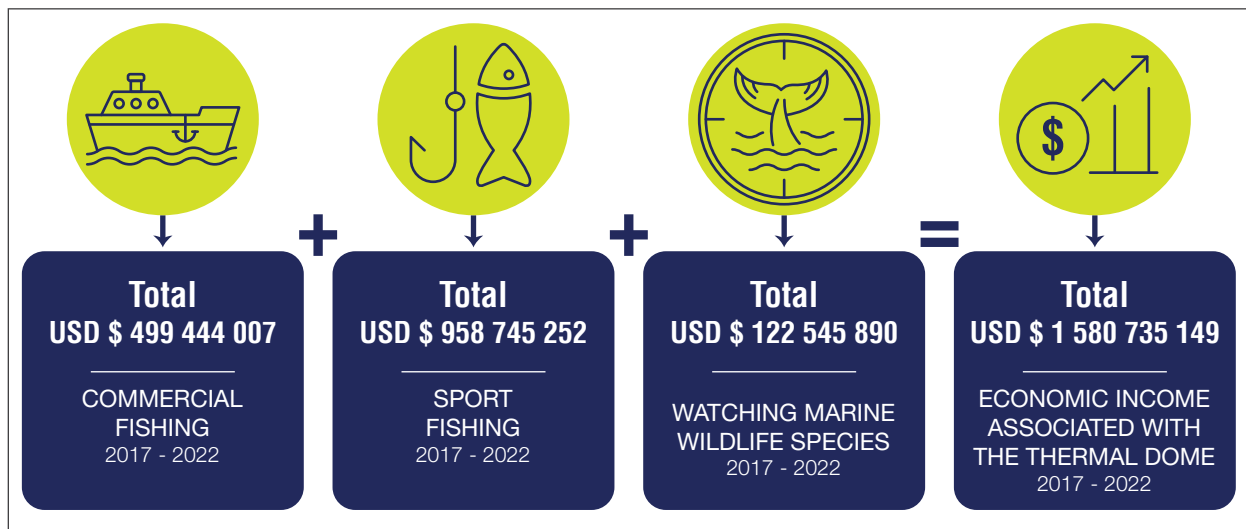
Likewise, wildlife watching tourism of species such as the humpback whale and the spotted dolphin, also present in the Thermal Dome, is emerging as an economic activity in the Central American region and Mexico with a significant impact for local companies such as tour operators and other tourist services related to the sighting. During the 2017-2022 period, revenue was estimated at approximately \$122 million.

Graph 3 summarizes the previous information considering the three activities analyzed: commercial fishing, sport fishing and wildlife sighting tourism. These results underscore the important economic contribution of the Thermal Dome in the region, highlighting its relevance as a source of national and local income. In

addition, they show the close interrelationship between the Dome phenomenon and the groups of species present there with these economic activities, which underlines the imperative need for an adequate and sustainable management of this resource to ensure its conservation and maximize its long-term economic benefit.

GRAPH 3.

Estimated total monetary value of the Thermal Dome, between 2017-2022



Source: Prepared by CINPE-UNA.

As a recommendation, the analysis also reveals the critical importance of deepening the knowledge and management of commercial relationships within the fishing and tourism value chain in the Thermal Dome and in the zone of influence that includes the countries of the region. This implies improving the coordination and governance structure by the competent institutions and other stakeholders at the regional and global levels. It also highlights the need to establish new protection and control mechanisms to guarantee the conservation and sustainable use of this valuable marine resource.

Regarding strategic planning, it is recommended to strengthen risk management policies and the creation of rapid response mechanisms to mitigate the economic impacts of crises such as the COVID-19 pandemic and climate change. This includes training programs and

financial support for workers in the fishing and tourism sector, as well as alternative forms of financing to foster innovation and improve the long-term resilience of the sector.

On the other hand, it is crucial to improve the quality and availability of information in the fishing and tourism sector in general. More effective information management will allow for better allocation of resources and the design of more effective policies to benefit the sector and society.

Finally, the need to generate more comprehensive knowledge on the economic, cultural, and ecological impacts of the Thermal Dome on local communities is highlighted. This will require future research that analyzes these dynamics and outcomes in detail, allowing for a better understanding of their interrelationship.

References

5

Chaminade, C. y Hernández, N. (2020). Informe Socioeconómico Expansión Área Marina Protegida Corcovado. Conservación Osa.

International Commission for the Conservation of Atlantic Tuna, 2008. Descripción de las pesquerías con redes de cerco. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.iccat.int/Documents/SCRS/Manual/CH3/CHAP%203_1_1_PS_SPA.pdf

Global Fishing Watch. (2023). Ocean Governance through Transparency | Global Fishing Watch. <https://globalfishingwatch.org/about-us/>

MarViva (2019). Atlas Domo Térmico de Costa Rica. Fundación MarViva, San José. 108 pp.





CONTACT US:
COSTA RICA +506 4052-2500
PANAMA +507 317-4350
COLOMBIA +571 743-5207



To collaborate with our efforts:
donaciones@marviva.net
www.marviva.net