NOTE

First scenic assessment of the Coiba National Park's beaches (Panama)

Camilo M. Botero*, Sara C. Justo, Humberto A. Garcés B. and Edgardo Díaz-Ferguson*

Estación Científica Coiba (COIBA AIP), Calle Gustavo Lara, Edificio 145B, Ciudad del Saber, 0843-01853 - Clayton, Panamá.
ORCID *Camilo M. Botero* https://orcid.org/0000-0001-6886-8920, *Sara C. Justo* https://orcid.org/0000-0002-6677-3853,
Humberto A. Garcés B. https://orcid.org/0000-0001-7644-0860, *Edgardo Díaz-Ferguson* https://orcid.org/0000-0002-2314-5021

ABSTRACT. Coiba National Park (PNC) is one of the most important marine protected areas in the Americas, as an essential part of the Eastern Tropical Pacific Marine Corridor. As a marine protected area, its main objective is biodiversity conservation, although nature-based tourism and nautical activities are allowed. This research focused on the application of the Coastal Scenery Evaluation System (CSES) method along the entire PNC coastline. Based on two field visits, covering more than 200 km of coastline, 42 beaches were identified and evaluated, the vast majority in highly natural conditions. Similarly, five beaches were analyzed for biological data associated with the diversity of coastal fauna, as a preliminary inventory. The result of the CSES fuzzy logic calculation classified 64% of the beaches in the two highest scenery grades, with only 3 beaches in class IV, and none in class V. Regarding the biological data, macroinvertebrates were mostly represented by 13 mollusks, 1 echinoderm and 1 crustacean. In addition to scientific results, the research identified those beaches with the potential to be certified as coastal scenery of heritage value. In conclusion, this evaluation will help guide nature-based tourism actions within the PNC, and will serve as a baseline for future monitoring of the impact that tourism activity may have on beach fauna and natural attributes.

Key words: Coastal scenery, remote beaches, Eastern Tropical Pacific, beach biodiversity, nature-based tourism.

Primera evaluación escénica de las playas del Parque Nacional Coiba (Panamá)

RESUMEN. El Parque Nacional Coiba (PNC) es una de las áreas marinas protegidas más importantes de las Américas, como parte esencial del Corredor Marino del Pacífico Oriental Tropical. Como área marina protegida, su principal objetivo es la conservación de la biodiversidad, aunque se permite el eco-turismo y las actividades náuticas. Esta investigación se centró en la aplicación del Sistema de Evaluación de Paisajes Costeros (CSES) a lo largo de todo el litoral de la PNC. A partir de dos visitas de campo, cubriendo más de 200 km de costa, se identificaron y evaluaron 42 playas, la gran mayoría en condiciones altamente naturales. De igual forma, se analizaron cinco playas en busca de datos biológicos asociados a la diversidad de fauna costera, a manera de inventario preliminar. El resultado del cálculo de lógica difusa del CSES clasificó 64% de las playas en los dos grados más altos de paisaje, con solo 3 playas en clase IV y ninguna en clase V. En cuanto a los datos biológicos, los macroinvertebrados estuvieron representados principalmente por 13 moluscos, 1 equinodermo y 1 crustáceo. Además de los resultados científicos, la investigación identificó aquellas playas con potencial para ser certificadas como paisaje costero de valor patrimonial. En conclusión, esta evaluación ayudará a orientar las acciones del eco-turismo dentro de la PNC, y servirá como línea base para futuros controles del impacto que la actividad turística pueda tener sobre la fauna de playa y los atributos naturales.

Palabras clave: Escenario costero, playas remotas, Pacífico Tropical Oriental, biodiversidad de playas, eco-turismo.

*Correspondence:
playascol@gmail.com (CMB)
ediaz@coiba.org.pa (EDF)

Received: 6 June 2023
Accepted: 25 July 2023

ISSN 2683-7595 (print)
ISSN 2683-7951 (online)

https://ojs.inidep.edu.ar

Journal of the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP)

Beaches are ecosystems from the ecological perspective, but they are also considered socionatural systems in geographical studies (West 2018; Soto et al. 2021). Therefore, assessment of beaches as systems can be done with multiple methods and frameworks of analysis, such as the scenic evaluation. In fact, several authors have proposed techniques to assess the beauty of the coast, but perhaps one of the most well-known is the Coastal Scenic Evaluation System (CSES), proposed by Ergin et al. (2004). The relevance of this scenic perspective is based on the recognition of visible parameters as reliable indicators of coastal features (Williams et al. 2018).

Scenic assessment could be used for any kind of coastal area, from urban to remote sites (Williams et al. 2018), but have been more common in the former than in the latter. Some authors have included national parks within their assessments, as the case of Mooser et al. (2018) in Spain, Mestanza et al. (2020) in Ecuador, Cristiano et al. (2020) in Brazil, and Williams et al. (2023) in France. Nevertheless, these studies have been focused only on the scenic assessment, without adding information on the biological assets, nature-based tourism management, and the importance of ecosystem protection.

This scientific note shows for the first time in the history of the Coiba National Park (PNC) a comprehensive inventory and assessment of the whole coastline, from the scenic perspective. This research also includes a preliminary approximation of the benthic fauna (infauna and epifauna) sampling granulometric features of the sediment and species richness in five representative beaches. This discovery arises from the current challenges that tourism is generating for the ecosystem conservation of beaches, rocky shores, and other intertidal systems of Coiba National Park.

The PNC is the largest marine protected area in Panama Pacific. The area encompasses 216.000 Ha (82.5%) of marine area out of 270,000 Ha of the national park (Guzmán et al. 2021; Brugnoli Olivera et al. 2023). PNC includes the island of Coiba (503 km^2) and a group of 38 small islands. It is an essential part of the Eastern Tropical Pacific Marine Corridor which comprises other marine protected areas from four countries: Coco Island in Costa Rica, Malpelo and Gorgona in Colombia, and the archipelago of the Galapagos in Ecuador.

The methodology used in this research is based on the CSES, which started as a checklist obtained by enquiring > 1,000 beach users chosen by random number tables in Europe (Ergin et al. 2004). The checklist has 26 parameters (18 physical and 8 human), which are evaluated from a low score (1) to a high score (5). Further, for limiting errors by subjective uncertainties inherited in assessment parameters, a fuzzy logic approach was used to represent mathematically the complexity of the evaluation as a non-linear process and to eliminate the possibility of the scenic value assessor (who ticks one box for each parameter) ticking the wrong attribute box due to uncertainty in the values (Rangel-Buitrago 2019).

The CSES was applied to the whole coastline of the PNC through two field visits (March and July 2022), summing up nine days of boat trips. The final list of beaches (n = 42) agreed with their ease of access and a previous virtual inventory made with Google Earth images. In addition, when weather conditions were safe, photomosaics were obtained on beaches (n = 22) with a Mavic 2 Pro drone, with the purpose of complementing the scenery evaluation. Following the CSES methodology, fuzzy logic calculations were applied with the DProLitore application (Gómez Zuluaga 2021), obtaining values of the D index for each beach. Due to the extensive coastline of the PNC, the area was divided into four segments according to their extension and the total number of beaches evaluated. The numbering of beaches was also carried out, so that their organization in the project products would be simpler. Finally, beaches were grouped in scenic classes, and those within classes I and II were proposed for their certification with the EIC-PPP award (Botero et al. 2022).

To have an overall representation of the beach ecosystem, a preliminary inventory of epifaunal

biota was made with a transect of 18 m in five of the beaches with easiest access and highest tourism activity: Granito de Oro, Machete, Juncal, Canales de Afuera, and Rancheria. The samples covered the intertidal zone from the highest part of the beach to the lowest part, making a visual census of the organisms found in the intertidal and supralittoral zones and quantifying the collected organisms. In the case of the infauna, sand samples from beaches were fixed with formaldehyde, for the granulometry analysis and organic content.

From each sample of approximately 4 l, 350 g weighed with an electronic balance were extracted and then dried in an electric oven at 75 °C from 24 to 72 h (Garcés and Grimaldo 2005). Two replicates of each 100 g dry sample were sieved by passing them through a standard battery of sieves (0.063 mm, 0.125 mm, 0.250 mm, 0.500 mm, 1.00 mm and 2.00 mm), recovering 90% or more (Holme and McIntyre 1984). The organic matter was determined with subsamples of 25 g of dry samples incinerated in an electric muffle at 500 °C and for 1 h. All analyses were performed at the Marine Biology Laboratory of the School of Marine Sciences at the Panama International Maritime University.

Regarding the scenic assessment, a total of 42 beaches were evaluated in the four sectors of the PNC (Appendix, Table A1). Most of the accessible beaches are in the north-east part of the main island (Figure 1). The hotspot area of most scenic beaches was found in the area between the station of National Park Service (Gambute beach) and the Scientific Station of COIBA AIP (Tigron beach), complemented by the small cays close to the main island. On the contrary, the southwest part of the island was almost inaccessible due to high waves and strong winds. This sector has only one Class I beach (Jicarita) and three Class II (Playa Blanca, Periquitos, and Punta David).

In total, half of the beaches were categorized as Class I, which is unusual. In fact, the CSES method has been applied on more than 20 countries, but a proportion of very attractive beaches as high as PNC has been recorded only in natural parks (Mooser et al. 2018; Mestanza-Ramón et al. 2020; Williams et al. 2023). Those beaches with lower scenic values were affected by their human parameters (Campamento Central, D = 0.24), or because several natural parameters were in medium to low values (Dolly, D = 0.38), or both reasons together (Manila, D = 0.36). Figure 2 shows the distribution of the 42 beaches according to their scenic class and their geographical sector.

Regarding the biological information, granulometry of the five beaches analyzed for epifaunal biota had average sand grain size between 0.125 and 0.250 mm (Machete and Granito), 0.25 to 0.50 mm (Rancheria), and 0.062 to 0.125 mm (Juncal), the latter highly influenced by the mouth of Juncal River. The taxonomic identification showed similar community structure domain by mollusk. Macroinvertebrates were mostly represented by 13 mollusks, one echinoderm and one crustacean (Table 1). Of these only the mole crab *Emerita rathbunae* was found complete at the Machete station. The rest of the organisms were representative samples of shells and a sea dollar *Encope pacifica* at Juncal station. In general, the benthic fauna was very poorly represented with a few isopods found only at the Rhincodoon station (1 *Exosphaeroma diminitum* and 1 *Excirolana braziliensis*). A great variety of empty shells of gastropod mollusks and bivalves were also found in the samples, as well as some other macrofaunal samples collected directly from the beaches.

The relevance of these findings turns around the new data obtained for scientific purposes and management actions. Initially, the PNC showed a high level of conservation of the natural attributes of CSES method, and virtually no impact of human activities with exception of two beaches with constructions (Campamento and Rancheria). This is consistent with other studies in protected areas (Mooser et al. 2018; Mestanza-Ramón et al. 2020; Williams et al. 2023). Additionally, unlike any other study published in coastal scenery, this study incorporated a preliminary inventory of both

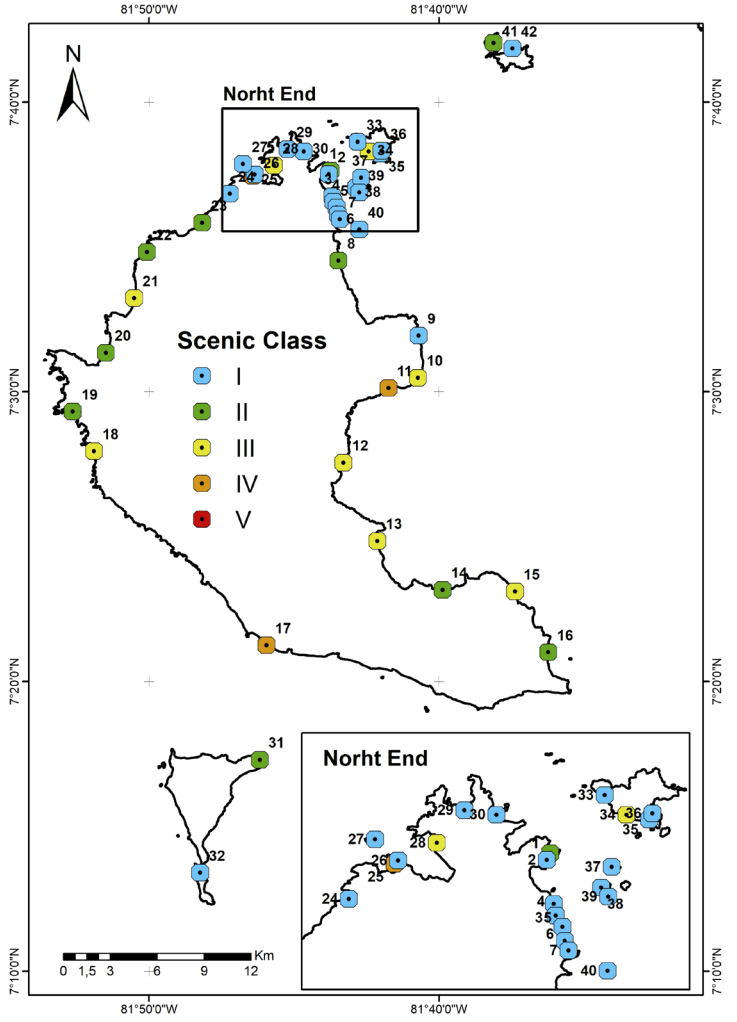

Figure 1. Map of beaches classified by their scenic value in the Coiba National Park (PNC).

epifauna and infauna. Although the data related to epifaunal biota was only 11%, which is considered a limitation of this research, it is the first step for further biological studies. Moreover, this data will enable the creation of the first catalogue of beaches in the PNC in over 30 years since the park's establishment, featuring high-resolution photomosaics of 22 selected beaches. Lastly, although the data obtained with the CSES is only visual, it can be used as a starting point for other research projects on the coastal process influencing the high scenic value of the beaches within the PNC.

From the managerial perspective, the classification of beaches could be used as an input for tourism planning within the PNC, reducing the current pressure to the northern beaches, and improving the quality of tourists' experiences allowed in this marine protected area. Biological data is also an important contribution of this paper and despite no relationship was found between biota composition (total number of species) and beach category; understanding the community structure of some of these sand beaches will be essential for education, community outreach, conservation

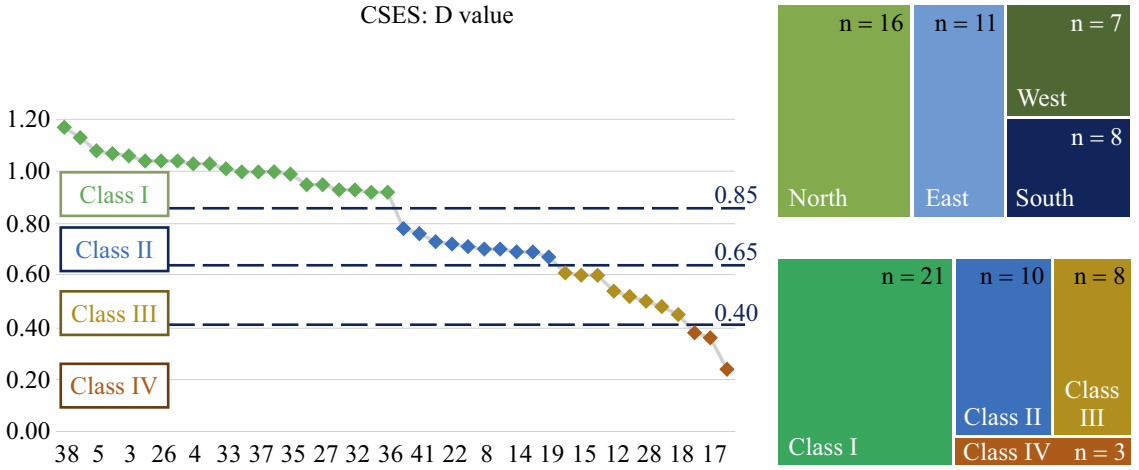

Figure 2. Geographical and scenic distribution of beaches in the Coiba National Park (PNC). CSES: Coastal Scenery Evaluation System.

Table 1. Biota distribution in analyzed beaches. N.I.: no information.

Beach name	Class	Phylum	Epifaunal	Infaunal
Machete	I	Arthropod	*Emerita rathbunae*	N.I.
		Mollusk	*Pinna rugosa*	N.I.
			Isognomon recognitus	N.I.
Granito de Oro	I	Mollusk	*Fissurella virescens*	N.I.
			Strombus granulatus	N.I.
			Bulla punctata	N.I.
Juncal	II	Echinodermata	*Encope pacifica*	N.I.
		Mollusk	*Cardita affinis*	N.I.
			Trachycardium procerum	N.I.
			Macoma grandis	N.I.
			Donax carinatus	N.I.
			Tagelus peruanus	N.I.
			Turritella leucostoma	N.I.
			Cerithium uncinatum	N.I.
			Conus brunneus	N.I.
Canales de Afuera	I	Arthropod	*Balanidae**	N.I.
			*Coenobitidae**	N.I.
			*Murisidae**	N.I.
Rhincodon	II		N.I.	*Exosphaeroma diminitum*
			N.I.	*Excirolana braziliensis*

*Samples that could not be identified to species level were identified to family level.

activities and research purposes. Indeed, at the time of the publication of this article, the Management Plan of the PNC is being updated by a consultancy hired by the Ministry of Environment; what better opportunity to use the outcomes of this research?

Lastly, but crucial for the long-term conservation of the high-scenery beaches of PNC, this selection of beaches is proposed as a roadmap for international certification of those 31 beaches in classes I and II. Initially, seven beaches were selected, based on their scenic quality and ease of access from the PNC influence area in the Santa Catalina and Pixvae sectors (El Ermitaño, Isla Coco, Canales de Afuera, Tortuga, Machete, Tigron, Granito de Oro). Then, and following the regulations of the International Certification Scheme for Coastal Landscapes (Botero et al. 2022), the first beaches to be certified must be chosen by the Steering Committee of the PNC. Once this decision is made, a set of documentation must be developed on each beach to guarantee that landscapes remain preserved, while generating a segmentation of tourists within the PNC, and increasing the valuation of its ecosystem services.

ACKNOWLEDGEMENTS

Authors thank the exceptional scientific support provided by Dr Cristina I. Pereira, Dr Juan Alfredo Cabrera, and Eng. Juan Guillermo Torres. In the same way, a warm recognition to the technical personnel of PNC, including Manuel Flores, Alvis Chong, Alex Robles, Samuel Sánchez and Edgar González, as well as to the Environmental Policy of Panama represented by Lieutenant 15234 Reynaldo Castillo and Second Corporal 16097 Ezequiel Abrego. Finally, they extend their appreciation to the great administrative personnel of COIBA AIP namely Ruby Polo de Egea, Marta Vigna and Melissa Quintero. This research would not have been possible without their contribution. The first and third authors are proud members of Proplayas Network.

Author contributions

Camilo M. Botero: conceptualization, data curation, formal analysis, investigation, methodology, project administration, roles/writing-original draft, writing-review and editing. Sara C. Justo: data curation, investigation. Humberto A. Garcés B.: investigation, methodology, writing-review and editing. Edgardo Díaz-Ferguson: conceptualization, formal analysis, funding acquisition, investigation, methodology, writing-review and editing.

REFERENCES

Botero CM, Cabrera JA, Cervantes OD, Pérez G. 2022. Certificação da paisagem de praias: o caso do EIC-PPP. In: Bombana B, Turra A, Polette M, editors. Gestão de praias: do conceito à prática. São Paulo: Instituto de Estudos Avançados da Universidade de São Paulo. p. 396-410. DOI: https://doi.org/10.11606/9786587773360

Brugnoli Olivera E, Molina L, Till I, Camarena M, Morales-Ramírez A, Díaz-Ferguson E. 2023. Mesozooplankton and oceanographic conditions in the North zone of Coiba National Park (Panamá, Central America). Reg Stud Mar Sci. 66: 103136.

Cristiano S, Rockett G, Portz LC, Rodrigues JL. 2020. Beach landscape management as a sustainable tourism resource in Fernando de Noronha Island (Brazil). Mar Pollut Bull. 150: 110621. DOI: https://doi.org/10.1016/j.marpolbul.2019.110621

Ergin A, Karaesmen E, Micallef A, Williams AT. 2004. A new methodology for evaluating coastal scenery: fuzzy logic systems. Area. 36: 367-386.

Garcés HA, Grimaldo M. 2005. Guía de laboratorio. Bio 330. Limnología general: parte biológica. Panamá: Departamento de Biología Marina y Limnología, Universidad de Panamá. 150 p.

Gómez Zuluaga CD. 2021. Evaluación paisa-

jística de las playas en la Unidad Ambiental Costera (UAC) Urabá-Darién con el método CSES, mediante el diseño del ejecutable Dpro-Litore en AppDesigner de MATLAB [thesis]. Turbo: Facultad de Ingeniería, Universidad de Antioquia. 100 p.

Guzmán HM, Beaver CE, Díaz-Ferguson E. 2021. Novel insights into the genetic population connectivity of transient whale sharks (*Rhincodon typus*) in Pacific Panama Provide crucial data for conservation efforts. Front Mar Sci. 8: 744109. DOI: https://doi.org/10.3389/fmars.2021.744109

Holme NA, McIntyre AD. 1984. Methods for the study of marine benthos. 2nd ed. IBP Handbook 16. Oxford: Blackwell Scientific Publications. 399 p.

Mestanza-Ramón C, Chica-Ruiz JA, Anfuso G, Mooser A, Botero CM, Pranzini E. 2020. Tourism in Continental Ecuador and the Galapagos Islands: an integrated coastal zone management (ICZM) perspective. Water. 12: 1647. DOI: https://doi.org/10.3390/w12061647

Mooser A, Anfuso G, Mestanza, C, Williams AT. 2018. Management implications for the most attractive scenic sites along the Andalusia coast (SW Spain). Sustainability. 10: 1328.

Rangel-Buitrago N, editor. 2019. Coastal scenery: evaluation and management. Dordrecht: Springer. 247 p.

Soto EH, Botero CM, Milanés CB, Rodríguez-Santiago A, Palacios-Moreno M, Díaz-Ferguson E, Velázquez YR, Abbehusen A, Guerra-Castro E, Simoes N, et al. 2021. How does the beach ecosystem change without tourists during COVID-19 lockdown? Biol Conserv. 255: 108972. DOI: https://doi.org/10.1016/j.biocon.2021.108972

West N. 2018. Beach use and behaviors. In: Finkl C, Makowski C, editors. Encyclopedia of Coastal Science. Encyclopedia of Earth Sciences Series. Cham: Springer. DOI: https://doi.org/10.1007/978-3-319-48657-4_43-2

Williams AT, Mooser A, Anfuso G, Herbert V, Aucelli P. 2023. Coastal scenic assessment in northern France: an attempt to quantify scenic beauty and analyse the role played by the Conservatoire du littoral. Ocean Coast Manage. 236: 106446. DOI: https://doi.org/10.1016/j.ocecoaman.2022.106446

Williams AT, Rangel-Buitrago NG, Pranzini E, Anfuso G, Botero C. 2018. Coastal scenery. In: Finkl C, Makowski C, editors. Encyclopedia of Coastal Science. Encyclopedia of Earth Sciences Series. Cham: Springer. DOI: https://doi.org/10.1007/978-3-319-48657-4_387-1

APPENDIX

Table A1. List of beaches assessed and scenery classification. CSES: Coastal Scenery Evaluation System.

Cod	Beach	Sector	Class	CSES
1	El Gambute (MINAM)	North	II	0,78
2	Tito	North	I	0,92
3	Roca en medio	East	I	1,06
4	Arroyo rocoso	East	I	1,03
5	Equis	East	I	1,08
6	Pelicano	East	I	1,04
7	Tigron	East	I	1,07
8	Juncal	East	II	0,70
9	Punta Esquina	East	I	0,93
10	Micrurus	East	III	0,52
11	Campamento Central	East	IV	0,24
12	Rio San Juan	East	III	0,54
13	El Maria	South	III	0,48
14	Playa Blanca	South	II	0,69
15	Rio Amarillo	South	III	0,60
16	Periquitos	South	II	0,70
17	Manila	South	IV	0,36
18	Rio Santa Clara	West	III	0,45
19	Leukas	West	II	0,67
20	Playa Hermosa	West	II	0,73
21	Playa Brava	West	III	0,61
22	Caracoles	West	II	0,72
23	Majaguillo	West	II	0,69
24	El Ermitaño	West	I	0,95
25	Doli	West	IV	0,38
26	Nispero	North	I	1,04
27	Mogote Coral	North	I	0,95
28	Limosa	North	III	0,50
29	Rosario	North	I	1,00
30	Machete	North	I	1,03
31	Punta David	South	II	0,71
32	Jicarita	South	I	0,93
33	Jabillo	North	I	1,01
34	Rancheria	North	III	0,60

Table A1. Continued.

Cod	Beach	Sector	Class	CSES
35	Tortuga	North	I	0,99
36	Lagarto	North	I	0,92
37	Palma Crisis	North	I	1,00
38	Isla Coco	North	I	1,17
39	Isla Coquito	North	I	1,00
40	Granito de Oro	East	I	1,13
41	Rhincodon	North	II	0,76
42	Canales de Afuera	North	I	1,04