PLAN OF OPERATIONS
INDIVIDUAL PROJECT OF THE FACILITY RG-O1676
LINE OF ACTIVITY FOR INNOVATION PROTOTYPES
"TC PROTOTYPES"

DELEGATION OF AUTHORITY TO COUNTRY OFFICES[1]

PANAMA
(PN-T1265)

I. GENERAL INFORMATION

Title	Sustainable Sea Cucumber Hatchery		
Executing Agency:	PanaSea Global, S.A.		
Focus Area:	Climate Smart Agriculture		
Project Beneficiaries:	The **direct** beneficiaries are 64 individuals from the communities that will be trained and hired. The indirect beneficiaries will be the public institutions (ARAP, MiAmbiente) receiving new knowledge of both species behavior and details related to their feeding, reproduction and production in scale. The project seeks to protect the marine ecosystem and related natural capital.		
Financing:	Non-Reimbursable Technical Cooperation (PN-T1265-001):	US$ 50,000	21%
	Contingent Recovery Technical Cooperation (PN-T1265-002):	US$ 100,000	42%
	Counterpart:	US$87,000	37%
	TOTAL PROJECT BUDGET:	US$ 237,000	100%
Execution and Disbursement Period:	18 months of execution and 24 months of disbursement.		
Objective:	To pilot an inclusive aquaculture model of sea cucumber on the Panamanian Caribbean Coast to demonstrate the adaptability of the species in that geographical marine ecosystem and determine its technical, environmental, and economic viability at a scale production.		
Environmental and Social Impact Review	This operation was screened and classified as required by the IDB's safeguard policy (OP-703) on August 25, 2020. Given the limited impacts and risks, the proposed category for the project is C.		
Project Team	Nicole Orillac (DIS/LAB CPN) and Lorena Mejicanos (DIS/LAB), team leaders, Santiago Bucaram (RND), Fermín Vivanco (DIS/LAB), Camilo Santa Pena (CSD/CSD), Gabriela Flores (INV/LAB), Nicolás Avilan (DSP/CPN) and Juan Pedeflous (FML/LAB).		
Unit responsible for disbursements	IDB Lab/CPN		

[1] Delegation of authority for approval of TC Prototype operations up to US$150,000 is established under MIF-GN-123

II. BACKGROUND AND JUSTIFICATION

A. Problem Description

2.1. Nearly 60 million people globally work in fisheries and aquaculture, and an estimated 200 million jobs are directly or indirectly connected with the fisheries sector according to a 2018 report from the World Economic Forum. Fishing remains one of the most traded food commodities worldwide, and 54% of this trade comes from developing countries[2]. Protein consumption is increasing worldwide, and fish is becoming one the healthier sources. The sustainability of fisheries is therefore essential to the livelihoods of billions of people in coastal communities around the world, especially in developing countries, where 97% of fishers live[2]. This entire economy relies on the healthy functioning of localized marine eco-systems.

2.2. The decline of the coastal corals and fisheries has an oversized impact on some of the most vulnerable people in Panama. Like with many rural coastal towns in Caribbean coast of Panama, the economy of the communities of the Portobelo district in the Colón province has relied mainly on tourism and fishing, which has been in decline over the past decade. The COVID-19 crisis has made a barely tenable situation even worse. The communities of the district of Portobelo (10,000 population) and the province of Colón need an alternative economic activity that can provide them with a higher, sustainable family income as well as allow for the regeneration of the local marine ecosystem they depend on.

2.3. Panama has a significant potential in fisheries and aquaculture as sources of food and employment. It also has species that are almost extinct but that have great market potential coupled with the challenge of creating local conditions for their biological recovery and sustainable cultivation. Sea Cucumbers, the "earthworms of the sea" is one of them. Sea Cucumbers are essential nutrient recyclers that release calcium carbonate needed for coral growth into the sea water and increase the water's pH, counteracting acidification[3]. Unfortunately, severe overfishing fueled by unbridled market demand in China has led to the near extinction of these crucial species throughout the world. Specifically, the market prices of local Panamanian sea cucumber species (I. Badionotus and H. Mexicana) have reached new highs as demand far exceeds supply[4]. In one 2018 study[5], market value ranged 132–358 US$ kg for I. badionotus, and 16–209 US$ kg for H. Mexicana. As a comparison, typical market prices for prime seafood such as Tuna and Halibut are around $4.50/ Kilo. Even prime lobster tail and knuckle meat does not typically exceed $30/ kilo.

2.4. Like many governments throughout Latin America and the Caribbean (LAC), Panama implemented a preventive measure to protect the remaining sea cucumber populations banning since 2003 the extraction, possession, or commercialization of all sea cucumber species. The *Autoridad de los Recursos Acuáticos de Panamá* (ARAP) conducted a study in 2016 on the state of sea cucumber populations on the Caribbean coast and confirmed that the fisheries

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[2] 90% of fish stocks are used up, July 2018, https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/

[3] Sea Cucumbers Counter Negative Effects of Ocean Acidification, February 2012, https://scitechdaily.com/sea-cucumbers-counter-negative-effects-of-ocean-acidification/

[4] These Bizarre Sea Creatures May Help Save Coral Reefs—If They Survive, February 2018, https://news.nationalgeographic.com/2018/02/wildlife-watch-sea-cucumbers-illegal-wildlife-trade-coral-reefs

[5] https://fishmanmkt.com/pages/market-prices

were too depleted to bounce back without proactive repopulation and regeneration measures[6].

2.5. At the same time, the current Panamanian government strategy recognizes the need to strengthen fisheries and aquaculture research, and to improve and evolve experimental stations as well as to promote auxiliary maritime industries in the central provinces and in the west of the country[7] where the province of Colón is located. In line with this plan, the ARAP signed in September 2019 an agreement and granted a land concession to the startup company PanaSea to establish operations of a sea cucumber hatchery in Puerto Lindo, Colón with the objective of researching and developing a sustainable aquaculture model for these tropical sea cucumber species that could lead to a future commercial operation.

2.6. Although there have been a few attempted sea cucumber aquaculture pilot projects throughout LAC, they have all failed due to similar reasons: *poaching, lack of technical species knowledge and high monetary risk prior to the first harvest.* The tropical species with the highest market price - Isostichopus Badionotus - is also the most delicate and challenging to raise in an aquaculture environment. When sea cucumber juveniles are successfully produced in the hatchery, they are deployed to open, shallow marine waters to continue their growth. Because it is so easy to pick the sea cucumbers from the shallow waters, poaching can easily become rampant and bring projects to bankruptcy.

2.7. Although the potential for a profitable return is evident, these challenges have prevented the success of any commercial tropical sea cucumber ventures in LAC to date. There are a few successful experiences in China, Vietnam, Tanzania, and Madagascar. The Chief Scientist Officer of PanaSea has been involved in several operations in Asia and Saudi Arabia and brings this knowledge to the project.

III. THE INNOVATION PROPOSAL

A. Description of the Solution being Tested

3.1. The objective of this operation is to pilot an inclusive aquaculture model of sea cucumber on the Panamanian Caribbean Coast to demonstrate the adaptability of the species in that geographical marine ecosystem and determine its technical, environmental and economic viability at a scale production.

3.2. The **solution** includes the adoption and tailoring to local context of existing precision aquaculture technology in the production cycle. Traditionally, the process of growing and harvesting sea cucumber has been very analog and a bit of a 'mystical process'. The project will improve this practice by adopting advanced precision aquaculture technology by using IoT sensors, computer vision, artificial intelligence (A.I.), and big data that will enable real-time monitoring and analysis to identify optimal growing conditions for maximizing survival rates. This will also provide insights to better anticipate problems before they occur. The **specific technologies** that will be financed to **improve survival in larval rearing and nursery** are:

3.3. **Creation of an algae production lab.** The project will grow its own algae to ensure that the broodstock (cucumber larvae) and juveniles have the optimal diet for healthy growth to reach higher survival rates instead of relying on outside parties

[6] Guía práctica de identificación de algunas especies de Pepinos de Mar en el Caribe Panameno, February 2017. ARAP

[7] Government of Panama, Strategic Plan 2019-2024

for this crucial input. For this, the project will finance equipment for an algae production lab and hire an expert to identify and reproduce native macro algae species from the surrounding marine eco-system. Further, it is possible that algae production could be its own sub-business by selling to other aquaculture companies in Panama

3.4. **Improvement of hatchery diagnostics.** A.I., machine learning and computer vision will be used by a technical expert to train the computer using a set of cameras and sensors in the tanks (4 per garage) to identify each unique sea cucumber, monitor its condition and identify the water characteristic that led to change in conditions (positive or negative). Sensors will measure other variables (temp, pH, DO[8], light, and turbidity). This technology will help to reduce human error, decrease mortality rate, and enable scalability.

3.5. **Development of coastal community outgrower regime.** The Executing Agency will hire an international consultant to define and implement the first stages of a community outgrower regime so individuals and families in the local community will be trained and employed through raising sea cucumber juveniles into adults in marine plots they will watch over. It will also include the development of a broodstock management program that will help the adult sea cucumbers to live healthily without being poached.

3.6. The project will finance the development of technical manuals, training materials and a workshop considering the local culture and facilitating the participation of women. It will finance similar monitoring technology used in the hatchery, but slightly different devices adapted for the marine environment. The computer program will work with both data sets, from the tanks and the seabed, which will be valuable to explain what is driving the health and growth of the sea cucumbers. Permanent environmental validation will be conducted by ARAP to assure no environmental impacts have been generated by the project to the marine ecosystem.

3.7. PanaSea's 3-phase growth strategy contemplated the introduction of advanced technology in the second phase (2023-2025). Partnering with IDB Lab opens the opportunity to start a prototype using advanced diagnostic and data analysis technology (see 3.4) in the first phase of the project to learn faster. The problem the technology is looking to address is very specific: understanding and controlling for the favorable growth conditions for the sea cucumbers to fast-track the learning curve towards a successful first and future harvests.

3.8. The **pilot also includes market research and acceptance** that will involve sending product samples to potential clients in China or other importing countries. This is a process in which PanaSea already has experience and in which no support is required.

3.9. The **global imports market**[9] for sea cucumbers is valued at $US 1.95 billion and has grown +163% in the last 3 years. The top six importers of sea cucumber in 2018 were Japan (USD $ 312.72M; 16.0%), Italy (USD $ 303.9M; 15.6%), China (USD $ 206.20M; 10.6%), South Korea (USD $ 172.96M; 8.9%), Hong Kong (USD $ 118.05M; 6.0%) and the USA (USD $ 97.5M; 5.0%). Demand from these six markets has grown in the 2015-2018 period at an average rate of 313.07% (or 143.76% without considering the growth in demand in Italy). Italy showed the

[8] Dissolved Oxygen

[9] Source: https://www.tridge.com/intelligences/sea-cucumber/import

highest growth rate of demand in the same period, approximately 1,159.6%. If the project focuses on the sale of products only in Asian countries, the demand of this region is sufficient since they represent more than 40% of the market for sea cucumber imports and its average growth rate of demand was more than 100% during the period 2015-2018.

3.10. **Sea cucumber cultivation provides an ideal opportunity for Caribbean coastal fishing communities to sustainably transition out of poverty.** The work builds upon fishers' existing knowledge and produces a high-value product while restoring the marine ecosystem. Production of sea cucumbers is, by far, **the most economically productive aquaculture endeavor in the world** and, crucially, the process is environmentally regenerative rather than destructive. The economic opportunities and ecological restoration impact that sea cucumber ranches along the Caribbean Coast would provide for coastal communities are potentially transformational and Puerto Lindo in Panama is the ideal place to start.

3.11. **If successful, this project will bring know how to other countries in the region** to replicate this experience of how subsistence fishers can restore their own depleted Caribbean fisheries and improve their livelihoods by raising millions of native, regenerative, nutrient recyclers with high market value sea cucumbers. We can assume that at a minimum, this model could be replicated in countries where sea cucumbers used to have healthy populations[10] like Chile, Colombia, Costa Rica, Ecuador, Mexico, Nicaragua, Peru, and Venezuela.

B. Description of the Beneficiaries

3.12. The **local communities** of the District of Portobelo (10,000 population) have relied mainly on artisanal fishing and tourism, which have both been in decline over the past decade. By 2015[11], the average per capita income in the area was US$250, with 26.9% poverty and 8.1% extreme poverty. The COVID-19 crises has made a barely tenable situation even worse and today communities are engaged mainly in self-consumption agriculture. In this pilot phase, **64 jobs (35 permanent and 29 temporary/seasonal) will be created at the Puerto Lindo hatchery**. The participation of women will be promoted particularly in the processing phase, in the cleaning, drying and packaging of the sea cucumber. 30% of the people from the community to be hired is expected to be women and this number is expected to increase after the end of this TC Prototype when the processing phase is more consolidated.

3.13. **The marine ecosystem and natural capital.** Sea ranching, using coastal ocean for the grow-out area, will allow the cultivation of sea cucumbers as valuable food product while simultaneously improving the marine habitat by cleaning the sea floor of surplus organic detritus, preventing and consuming unhealthy algae blooms, distributing ammonia to fertilize other sea life and the calcium essential for coral, and combating the acidifying effects of climate change. In addition, an almost extinct species will be recovered.

3.14. **The indirect beneficiaries** will be the public institutions (ARAP, MiAmbiente) with new knowledge of both species behavior and details related to their feeding, reproduction, and production at scale.

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[10] http://www.fao.org/tempref/docrep/fao/011/i0375e/i0375e07.pdf

[11] Poverty and Inequality in Panama 2015, from the Ministry of Economy and Finance (MEF) and World Bank. https://www.mef.gob.pa/wp-content/uploads/2018/07/Pobreza-y-desigualdad-en-Panama-Mapas-a-nivel-de-Distritos-y-Corregimientos-2015.pdf

IV. THE PROTOTYPE EXECUTION STAGES

Month #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	2020		2021													2022		
Stage	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
I Definition																		
II Implementation																		
III Evaluation/Knowledge Dissemination																		

A. Definition Stage:

4.1. The main goal of this stage will be to conclude on the specifications and data parameters for final selection of technologies for the algae production lab and implementation of the advanced and precision aquaculture diagnostics. The definition stage will have an expected **duration of 4 to 6 months** to:

4.2. **Identify the optimal diet for broodstock and juveniles**. An international aquaculture expert will conduct the research that will define the optimal algae diet for the sea cucumbers at different growth stages and thus the design of the new algae production lab.

Dr. Luis Felaco: holds a PhD in integrated multitrophic aquaculture and is an expert in the two sea cucumber species of this project. Dr. Felaco will be engaged full time and from the site of operation for 12 months.

4.3. **Final selection and purchase order for algae production lab equipment.** The specialized consulting firm Precision Aquaculture Production Informatics (PAPI) will make the final recommendation and place the purchase order for the lab equipment based on a comparison analysis report of models, cost, delivery dates and other variables.

4.4. **Define specific data points of interest and corresponding hatchery diagnostic technologies to place purchase order**. The firm PAPI will work in collaboration with pro-bono tech industry expert and angel investor Tasuku Miura to define the viable technologies to capture the desired data, design a draft of the software analysis and place the purchase order for the technology selected.

4.5. **Broodstock management program work plan and technology design collaboration.** Dr. Rose will be hired as the lead consultant to develop the outgrower regime and broodstock management program given his expertise on the subject and familiarity with the specific PanaSea operation from the previous engagement of conducting the feasibility study in 2018 cited in this document. In this stage, Dr. Rose submit for approval the work plan draft for the broodstock management program and collaborate with the firm PAPI in selecting and placing the purchase order for the outgrower regime technology.

Dr. Robert Rose – is a professional aquaculturist with a PhD in marine biology from the University of Sydney and over 30 years of experience in tropical, large-scale sea farming and marketing. Dr. Rose has managed the launch of successful sea cucumber farms, specializing in the creation and implementation of community based out-grower regimes. He will work remotely from Australia as a consultant guiding the onsite research with Dr. Felaco and travel to Panama as needed.

B. Implementation Stage:

The foreseen duration for this stage is **12 months** to:

4.6. **Algae production lab set up.** The first step will be installing and equipping the garage that will host the algae production so the hired expert, Dr. Felaco, can lead the reproduction of native macro algae species to optimize the diet for broodstock and juvenile sea cucumbers.

4.7. **Hatchery garages expansion.** The second step will be expanding the number of garages and installing the tanks. This installation will take place in phases and financed by PanaSea as counterpart in cash for the project. A total of 10 garages will be installed over a period of 12 months, each one with capacity for 12 tanks and in each tank with capacity to fit a range of 30-33k juveniles in each lunar production circle (8 to 9 months). The garages will have capacity to grow vertically, stacking up to 36 tanks, which will help to expand the project once it proves to be successful.

4.8. **Hatchery diagnostics equipment installation.** Six diagnostic technology combos (camaras and sensors) will be installed to collect data, which will help to monitor and learn about the behavior (health, sexual and genetics parameters) of each juvenile and how it impacts the survival and growth rates. With the technical expertise's support coming from the scientific (species expert Dr. Felaco) and the technological expert (consultant Chris Garre), it will be possible to get the information of what is happening at a microscopical level. These results will be key to scale the project to the other garages.

4.9. **Broodstock Management and Outgrower Regime Programs.** As a result of all the data that will be gathered for 6 months and with the use of AI and machine learning, the international expert (Dr. Robert Rose) will define and implement in month 12, the broodstock management program. This same expert will analyze and collect the best practices for community outgrower costal regimes worldwide to adopt them in the one to be developed for this project. With this information, training material will be prepared by Dr. Felaco and an additional hired consultant with experience working in education at the community level.

4.10. **Water quality and seabed sediment changes measurement.** The water quality will be tested periodically to monitor the health of the ecosystem. From the several water quality parameters (oxygen content, temperature, pH, ammonia, salinity, turbidity, nitrogen, total organic content), special attention will be given to the pH or any substantial change (+/- delta) to understand what is affecting it (releasing nitrogen upstream, lack of raining, etc.). The goal is do no harm and the hypothesis to test is that sea cucumber production impacts positively the pH, turning the ocean less acidic and bolstering the reefs. This is a claim scientist have made but has not been proved. These results will be validated periodically by ARAP, to assure compliance with the local regulation.

4.11. **Training and hiring community members.** PanaSea is exploring to work in alliance with local organizations, as the fishing coops or any women organization. It is expected that 29 individuals will be trained in open ocean environment, for seeding, monitoring and harvesting activities. These roles include activities in which more women could potentially participate since no heavy lifting labor is expected. A pilot with a soft target to attract 30% women will be conducted to assess availability and interest of women in the community. These people will be hired through temporary contracts.

4.12. **The expected results from this stage are:** (i) optimal growing conditions for maximizing survival rates have been identified; (ii) 20 hectares of outgrower

production in coastal marine waters are functioning; (iii) 10 hatchery garages are functioning; and (iv) 40 monthly testing sites for water quality and seabed sediment change measured.

4.13. **Project results and Impact.** The expected project results are: 2 species have shown to be adaptable to the local ecosystem; 64 individuals employed by PanaSea (35 permanent and 29 temporary/seasonal); 30% overall survival rate[12] of the overall Mexicana species juveniles and 5% of the Badionotus species; and no negative impact has been identified in the water quality.

4.14. **Overall survival rate model assumptions:** The feasibility study for PanaSea's aquaculture business project in Panama conducted by Dr. Robert Rose (Sept. 2018) concludes that the survival percentages of embryos (developing eggs) to larvae, metamorphosing larvae to juveniles, and juveniles to harvestable adults, as proposed by PanaSea's model, are commensurate with those of other similar tropical species from the Indo Pacific, South East Asia and northern Australia (James, et al., 1994; and Giraspy & Ivy, 2008). The following tables summarize the overall survival rate model assumptions for each species based on this study:

Figure 1. Mexicana Species

	Month 12	Month 18	Goal
	2020	2021	2022
Fertilization Rate	65%	66%	68%
Hatch Rate	75%	80%	80%
Larvae Survival	72%	75%	80%
Juvenile Surival	60%	63%	70%
Total Survival	**21%**	**25%**	**30%**

Figure 2. Badionotus Species

	Month 12	Month 18	Goal
	2020	2021	2022
Fertilization Rate	90%	90%	90%
Hatch Rate	50%	55%	60%
Larvae Survival	13%	15%	18%
Juvenile Surival	50%	53%	55%
Total Survival	**3%**	**4%**	**5%**

C. Evaluation and Knowledge Dissemination Stage:

4.15. The main objective of this stage will be disseminating knowledge and supporting PanaSea obtain the technical endorsement by ARAP of the sea cucumber aquaculture model.

4.16. **Systematization of knowledge.** PanaSea will systematize lessons learned in the adoption of precision aquaculture technology to increase survival rates; engagement of the local community in the use of technology and production activities, and other information relevant to the development of this potential new industry in Panama and the LAC region. The project will include activities (workshops) and products (video and lessons learned) to share with ARAP, IDB

[12] Overall survival rate = # eggs produced x fertilization rate (%) x hatch rate (%) x larvae survival rate (%) x juvenile survival rate (%)

Group, Mi Ambiente, communities, universities, and other stakeholders, to track interest in the development of this potential new industry.

4.17. **IDB Lab portfolio synergies.** IDB Lab will identify and promote synergies and knowledge exchange with other portfolio projects such as Turning Aquaculture into Science (PE-T1406 and PE-L1243), MiPesca (HO-Q0003 and HO-T1257), EcoSea (CH-L1151) and Althelia Ocean Fund (RG-Q0042).

4.18. **Environmental Impact Assessment.** PanaSea currently has the accompaniment and support of biologists from the Smithsonian Tropical Institute who will help carry out the environmental impact assessment of the project and prepare the technical and scientific support documents. These results will be presented to ARAP.

4.19. **Academic paper.** During the implementation, one paper will be submitted to renowned research entities for their review and future publication, which will contribute to attract investors, resources and provide an important input into public policy making. In turn, it is expected that by demonstrating the positive impact of the cultivation of the sea cucumber on the Atlantic coast of Panama, ARAP can engage its production at scale, contributing to the creation of a new industry and source of income in the area.

4.20. **Training materials.** The technical and scientific results will be shared with local entities related to the subject, such as the national aquaculture organization, universities and cooperatives and fisheries organizations. In addition, audiovisual material and manuals will be developed that will serve for promotion and training.

4.21. **Technical documents.** PanaSea will prepare technical documents that will help ARAP, IDB Group and Mi Ambiente to understand both species behavior and details related to their feeding, reproduction and production in scale.

4.22. The expected stage results are: (i) the knowledge has been shared with 3 institutions (ARAP, IDB Group, Mi Ambiente); (ii) ARAP endorsed the scale cultivation of sea cucumber on the Caribbean coast; and (iii) the impact environmental assessment has been developed and submitted.

V. EXECUTION AGENCY AND ARRANGEMENTS FOR EXECUTION:

A. Executing Agency

5.1. **PanaSea Global, S.A.** is Panama´s first sustainable sea cucumber hatchery. After 6 years of experience processing and exporting sea cucumbers from Latin America to Asia, the founder of PanaSea reached the conclusion that the only way to achieve both scale and sustainability was to develop a proprietary hatchery complex. Thus, PanaSea was born in 2018 with the vision of achieving a triple bottom line: i) planet – restore depleted fisheries, ii) people – cash crop for communities, iii) profit – highest ROI in aquaculture.

5.2. After completing the construction of the first phase of the hatchery, PanaSea began production in May 2020 with the first spawn of sea cucumbers and aims to achieve the first harvest by the end of 2021 (18-month cycle of the species). The team is composed by professionals with business experience in Central America and Panama, and a technical team of local and international specialists including Dr. Beny Giraspy who is the original pioneer of commercial sea cucumber farming and has launched over 10 commercial sea cucumber hatcheries worldwide.

5.3. PanaSea signed a technical cooperation agreement and land concession with **Autoridad de los Recursos Acuáticos de Panamá (ARAP)** to further the development of the marine species and evaluate different cultivation methods for

the 2 tropical sea cucumber species I. Badionotus and H. Mexicana. ARAP also coordinates the relationship with the ministry of environment, MiAmbiente, for strategy alignment, collaboration, and environmental permits and acts as the third-party evaluator of progress and results of the operation. The participation of ARAP in this project is a critical confidence factor to ensure the replicability of the model with other actors and in other regions.

5.4. The PanaSea team, with the combined endorsement of ARAP, has the technical and business expertise, connections, and vision of sustainability to take on the challenge of biotechnology experimentation for this high-risk activity. It also has the relationships at the community level to co-create an inclusive business model to achieve a positive environmental and development impact.

5.5. **Business Plan.** The EA presented the following business plan projections:

USD	2020	2021	2022	2023	2024
Net revenue	0	411,600	1,936,872	8,382,528	23,832,816
COGs	63,000	251,066	559,556	1,483,503	1,717,469
Gross Profit	-63,000	160,535	1,377,316	6,899,025	22,115,347
SP&G Expenses	194,871	319,600	640,500	674,530	713,627
EBITDA	-533,781	-607,716	232,294	5,305,565	20,059,255

* Scenario based of 40% out of total eggs produced for each specie type

Despite seeming to be a promising business model, these targets will be accomplished only if proof of concept, product validation and go to market strategy is successfully undertaken. The proper achievement of these business stages will be determinant of the revenue streams consecution, which depend directly on the performance of survival rates to be tested and proved. Based on IDB Invest experience in the sector, leapfrogging these business stages is crucial to achieve the financial sustainability of an aquaculture project.

B. Implementation Mechanism

5.6. PanaSea Global, S.A will be the Executing Agency (EA) for the operation and thus responsible for implementing all the activities of the prototype stages. Likewise, the EA will actively collaborate in the development of the activities of the evaluation and dissemination of knowledge stage.

5.7. Resources of the technical cooperation will be divided into $US50,000.00 non-reimbursable (PN-T1265-001) and $US100,000.00 reimbursable. The combination of these instruments resulted from a comprehensive analysis of the company as an early stage start up. Panasea is considered a for profit venture. Nevertheless, the company is still in the ideation and proof of concept business model stage. Panasea has not fulfilled its product validation and go to market strategy. Moreover, as an early stage start up operational, administrative and managerial organization needs to be strengthened. Lastly, specific sector related risks such as species healthy growth, attuned logistics and legal requirements to undertake aquaculture as a productive activity may influence the performance of the project.

Instrument I. Non-Reimbursable Technical Cooperation (PN-T1265-001): $US50,000.00 will be allocated as Non-Reimbursable Technical Cooperation.

Instrument II. Contingent Recovery Technical Cooperation (PN-T1265-002): $US100,000.00 will be allocated as Non-Reimbursable Technical Cooperation, via the contingent recovery terms outlined in Annex VI. Panasea shall begin to repay

the Contingent Recovery Technical Cooperation to the Bank in the first year following Panasea's first fiscal year in which gross revenues exceed US$ 1.9 million or EBITDA exceeds US$ 230,000 (each, a "Repayment Trigger"). If neither Repayment Trigger indicator is reached within the first 4 (four) complete fiscal years after the effectiveness of this agreement, then the obligation of Panasea to make any payment in respect of the Contingent Recovery Technical Cooperation shall expire.

Starting the first fiscal year after having achieved either Repayment Trigger, Panasea shall repay the Contingent Recovery Technical Cooperation to the Bank in semi-annual payments which shall equal 2.5% of gross profit of each prior year, until the US$100,000 Contingent Recovery Technical Cooperation is repaid in full. Such payments shall be made no later than 150 days following the end of the prior fiscal year.

5.8. The EA will select, contract, and supervise the suppliers associated with the technical cooperation resources of the TORs in Annex V, namely:

- Contract 1: The specialized consulting firm Precision Aquaculture Production Informatics (PAPI) will provide the technical expertise and technology for the algae production lab, hatchery diagnostics and outgrower regime. Approximate cost US$48,000.00 (TORs attached in Annex V)
- Contract 2: Dr. Rose will be hired by the EA as a consultant dedicated to the development of the coastal community outgrower regime and broodstock management program. Approximate cost US$45,000.00 (TORs attached in Annex V)
- Contract 3: A individual consultant or consulting firm will be hired by the EA to develop a science- based communication strategy, support coordination of knowledge sharing activities and produce compelling knowledge sharing products in video and other formats. Approximate cost US$20,000.00 (TORs attached in Annex V)
- Contract 4: Dr. Felaco will be engaged as the algae and species specialist consultant to investigate the ideal algae diet for broodstock and juveniles as well as design and lead the initial operation of the algae production lab. Approximate cost US$22,000.00 (TORs attached in Annex V)
- Contract 5: Consultancy to develop and implement a training program for the use of technology and protocols for the community outgrower regime. Approximate cost US$15,000.00 (TORs attached in Annex V)

VI. ALIGNMENT WITH IDB GROUP, SCALABILITY, AND RISKS

A. Alignment with IDB Group

6.1. The prototype is aligned with IDB Lab´s mandate of innovation for inclusion and the thematic area of Climate Smart Agriculture by piloting a technological solution at farm-level that has the potential to increase incomes, raise productivity at a low average operating cost and is gender inclusive. In addition, the project is aligned with the strategy to develop new natural capital markets that have high potential to restore ecosystems with the use of a blended finance mechanism to de-risk and

incentivize private actors to invest in a new-to-market solution with high potential to restore the local marine ecosystem[13].

6.2. The project contributes to IDB Lab in creating additional knowledge in AgTech use in marine ecosystems and on how to scale innovation in an inclusive manner in the value chain.

6.3. From a SDGs standpoint, the project is aligned with SDG 8 ("Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all"), SDG 9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization *and foster innovation")* and SDG 14 (Life below water).

6.4. As per the country context, Panama´s trade balance has had a negative contribution to growth of approximately 10% in the last decade and exports have decreased 26 points of GDP between 2007 and 2017[14]. To respond to this, and other development challenges, the government has prepared a Government Strategic Plan (PEG) which includes a strategic pillar to diversify its productive matrix and improving its competitiveness[15]. For the IDB and the country, the aquaculture sector is strategic for attaining both objectives. However, the aquaculture sector has suffered a long crisis since the mid-1990s when the shrimp production was affected by the white spot disease[16]. Furthermore, a recent 2020 evaluation of the sector led by the RND division of the IDB (RG-T3162) identified that the Panamanian aquaculture crisis has been intensified during many years by other factors, such as: i) a very high dependence on a single species, shrimp; ii) high operating costs; iii) low prices; and iv) lack of financing and technical assistance.

6.5. This project is aligned with the IDB recommendations[17] on how to revitalize the aquaculture sector in Panama in that it helps to solve the problems of poor diversification and low income generation through the introduction of a species that has a very high market value (one kilo cost between USD$ 250 and USD$ 350 but its price has reached values as high as USD$ 3,000 per kilo[18]) and a low average production cost. If this project is successful, it would not only generate an important source of income but also many jobs, as well as kickstart the beginning of a very profitable industry along the two coasts of Panama.

6.6. Finally, this project was originated and designed in collaboration with RND division colleagues who, as team members, will continue to provide technical knowledge, coordinate the engagement with relevant public institutions and support knowledge dissemination. In the project team are also participating the regional public-private coordinator who will act as liaison with IDB Invest, and a colleague from IDB Lab's investment unit (INV), in case a future investment opportunity arises and in order to share potential lessons learned from this solution.

B. Scalability / Replicability

6.7. As per the scalability for the solution, areas suitable for sea ranching run along the entire Caribbean coastline of Panama and, in some areas, extend out into water for

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[13] There is evidence that echinoderms like sea cucumbers serve as carbon sinks. Pending to determine the form of measurement that would be used.https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/09-0553.1

[14] Country Development Challenges (March 2019), IDB Panama

[15] Government Strategy Plan (PEG), Pillar 3. A competitive economy that generates jobs.

[16]https://oec.world/en/profile/bilateral-product/fish-and-crustaceans-molluscs-and-other-aquatic-invertebrates/reporter/pan

[17] Castrejon M (2020) "Comprehensive diagnosis of the fishing and aquaculture sector of the Republic of Panama", IDB

[18] https://www.tridge.com/intelligences/sea-cucumber/import

many miles. PanaSea has worked with the government to secure a special permit for aquaculture production and harvest of sea cucumbers in Panamanian waters starting in Puerto Lindo (100 hectares), with the vision to expand into the more than 25,000 hectares of Panama's Caribbean coast.

6.8. Thus, scale in the country will be a public-private effort, where the public sector (ARAP) will play the role of evaluator of the economic and environmental impact as well as collect the knowledge to Panama's advantage. Looking further into the future, PanaSea's current strategic plan aims to seek out opportunities to expand into the rest of Caribbean and Central America, where native sea cucumber populations have been similarly overfished.

6.9. PanaSea will raise the funds needed to scale its own operation with a strategy including series A (convertible notes) capital raising targeting friends, family and angel investors, bankable purchase orders and impact/ethical investor funds. IDB Lab could make a reimbursable follow up investment and the IDB Group can facilitate the knowledge transfer to other countries in the region.

6.10. If the project succeeds by proactively implementing the processes and technology necessary for a commercial scale operation, it will be able to leap to the other side of the learning curve in less than 18 months

C. Risks

6.11. **Risk of poaching and secondary black market.** The inclusive outgrower regime with training and employment opportunities for the local community, as well as the virtual security system will help mitigate this risk.

6.12. **Failure to establish trust with local communities about the use of security technology in the area.** PanaSea will maintain an open communication policy with the community regarding the use of the information collected through the virtual security system for the unique purpose of monitoring sea cucumbers.

6.13. **An extreme and unprecedented environmental event causes a massive die off the sea cucumbers in the coastal marine waters stage.** As a mitigation measure, PanaSea is in the process of quoting several forms of insurance for the operation including a policy that would pay out on the actual sales of the harvest in the case of an extreme event.

D. Special Conditions and Exceptions

Due to the technical specificities of this project, the following exceptions are presented regarding the conditions of a prototype technical cooperation project:

6.14. **More than 3 contracts will be made.** In this case, a total of 5 contracts out of which 4 service providers have already been identified for having the specific and scarce technical expertise in sea cucumber aquaculture and related technologies. All 4 service providers have the required academic background and years of practical experience required as well as prior on-site engagement with the PanaSea aquaculture operation in Panama which is critical for fast onboarding into the project. Direct contracting will be used in for contracts 1, 3 and 4 of Annex V.

VII. SUMMARY BUDGET

7.1. The project has a total cost of US$237,000.00 of which US$150,000.00 (63%) will be provided by IDB Lab, and US$87,000.00 (37%) by the counterpart.

7.2. The instrument to be used is a hybrid technical cooperation of US$50,000 non-reimbursable funds and US$100,000K contingent recovery funds. Given the high

profitability of the business if successful in achieving proof of concept in the next 18 months, it is reasonable and feasible for the EA to start repayment when it reaches 1.9 million of revenue and 0.23 million of EBITDA. The detailed Terms Sheet included as Annex VI.

Project Categories	IDB Lab	Counterpart	Total
1. Definition	$50,250	$31,000	81,250
2. Implementation	$62,500	$47,000	109,500
3. Evaluation & Knowledge Dissemination	$37,250	$9,000	46,250
Grand Total	**$150,000**	**$87,000**	**237,000**
% of Financing	**60%**	**40%**	**100%**

VIII. COMPLIANCE WITH MILESTONES, FIDUCIARY AND REPORTING ARRANGEMENTS

8.1 **Disbursement by Results.** The EA will adhere to the standard IDB Lab disbursement by results as established in the "Operational Guidelines for Management of Milestones and Financial Supervision for IDB Lab and PES Technical Cooperation Projects" (updated in 2019). Monitoring will be undertaken in accordance with the performance and risk management policies (fulfilment of milestones) established in these Operational Guidelines. Project disbursements will be contingent upon verification of the achievement of milestones. These milestones will be verified using their means of verification, which will be agreed upon between the EA and the IDB Lab. Achievement of milestones does not exempt the EA from the responsibility of reaching the logical framework indicators and the project objectives.

8.2 **Project Supervision.** The Project will be associated with the Line of Activity RG-O1676[19] in Bank systems. It will be supervised by the IDB Lab Specialist based in the Panama IDB Country Office and executed in coordination with the Project Team for RG-O1676.

8.3 **Procurement**. The Executing Agency shall have a procurement policy in place to ensure that Project-related procurement is done at competitive market prices. It shall also prepare a procurement plan (the "Procurement Plan") acceptable to the Bank, that describes the contracts for goods and services required to carry out the Project, including the estimated cost of each contract, and the proposed methods for acquisition of its goods and services, including consultants' services. The Bank may request annual reports on execution of the Procurement Plan by the Executing Agency. Implementation of the procurement policies, terms of reference, and contracts for the acquisition of goods and services, as well as the Procurement Plan and fulfillment thereof may be subject to ex ante review or ex post supervision by the Bank, at its discretion.

8.4 **Financial Management:** Disbursements will be made in accordance with the Financial Management Guidelines for IDB-Financed Projects (OP-273-12) July 2, 2019 or future updates. The Executing Agency shall maintain *financial data and internal accounting and administrative control systems acceptable to the Bank* so as to provide the necessary documentation to permit verification by the Bank of the

[19] Umbrella operation for technical experimentation cooperation "TC Prototype" of IDB Lab

procurement and expenditures for the Project and facilitate the timely preparation of financial statements, budgets, and reports. The Bank reserves the right to audit all financial statements, internal controls, procurement, or other aspects of the Project.

8.5 **Financial Statements.** The Executing Agency shall prepare and make available for the Bank its annual financial statements, which must be certified by an external auditor acceptable to the Bank and include a note on the use of the Contribution and Counterpart Resources for the Project. The financial statements must be submitted to the Bank within 90 calendar days of the close of each fiscal year. Together with its annual financial statements, the Executing Agency must submit to the Bank a certification of integrity, transparency and use of funds in the format to be outlined in the Technical Cooperation Agreement. **Audited annual financial statements for first year of operations included in Annex VIII**.

8.6 **Project Status Reports:** The Executing Agency is responsible for presenting a PSR to the IDB Lab within 30 days within 30 days following the end of each semester or more frequently if required by IDB Lab. The PSR must include information on the implementation of the project, results obtained and contribution to reaching the project objective as presented in the Result Matrix (Annex I) and other planning instruments. Additionally, the document must include information on challenges encountered during the implementation period and possible paths to address these challenges. Within 90 days of finishing the execution period, the Executing Agency will present to IDB Lab a Final PSR giving priory to reporting on key results achieved, a sustainability plan, scaling up strategy and lessons learned.

8.7 **Project Coordinator:** The Executing Agency will appoint a Project Coordinator either from its existing staff or at its own cost. Expenses relating to project coordination and/or administration costs are not eligible under the IDB Lab contribution, rather such expenses must be financed by the counterpart contribution. The Project Coordinator shall have overall responsibility for the management of the project, including submission of PSRs, tracking milestones and results and coordination with IDB Lab.

APPROVAL

This Technical Cooperation Prototype is recommended and approved for funding under IDB Lab's Line of Activity for Innovation Prototypes MIF/GN-123 (project number RG-O1676, document number MIF/AT-1565, and resolution number MIF/DE-8/19).

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