Model for upgrading livlihood of fishermen

- Curil Culture Livelihood Model with Artificial Seeds
- Casco de burro Culture Livelihood Model with Artificial Seeds
- Pacific Oyster Culture Livelihood Model with Artificial Seeds
- Livelihood Model of Artificial Reefs for Rock Oyster
- Fish Aggregating Devices (FADs) Livelihood Model for Hand-line Fishers

JICA

CENDEPESCA

Centro de Desarrollo de la Pesca y la Acuicultura

EL SALVADOR

SHELLFISH AQUACULTURE DEVELOPMENT PROJECT IN EL SALVADOR

Informe Técnico Producción Artificial de Semilla y Cultivo de Engorde de Moluscos Bivalvos

Elaborado por:

Hebert Ely Vásquez	Biólogo Proyecto Moluscos de CENDEPESCA
Saúl Patricio Pacheco Reyes	Biólogo Proyecto Moluscos de CENDEPESCA
Iris Mabel Pérez García	Bióloga Proyecto Moluscos de CENDEPESCA
Nadia Elizabeth Cornejo Hernández	Bióloga Proyecto Moluscos de CENDEPESCA
Mario Francisco Córdova Navas	Biólogo Proyecto Moluscos de CENDEPESCA
Kiyotaka Kan	Experto JICA en Jefe de Proyecto

Durante la Gestión de:

Dr. Manuel Ramón Sevilla Avilés	Ministro de Agricultura y Ganadería
Lic. Hugo Alexander Flores Hidalgo	Viceministro de Agricultura y Ganadería / Director del Proyecto
Lic. Sonia María Salaverría	Director General de CENDEPESCA / Gerente del Proyecto
Lic. Reyna Isabel Pacheco	Enlace de Cooperación Externa, CENDEPESCA / Coordinadora del Proyecto

Diciembre, 2009

Publicado por el Centro de Desarrollo de la Pesca y la Acuicultura (CENDEPESCA), dependencia del Ministerio de Agricultura y Ganadería (MAG), San Salvador, Republica de El Salvador Centro America y la Agencia de Cooperación Internacional del Japón (JICA) a través del **Proyecto para el Desarrollo de la Acuicultura de Moluscos en la República de El Salvador,** Oficina Regional CENDEPESCA Zona 3, Puerto El Triunfo, Departamento de Usulután, El Salvador.

Presentación

El Ministerio de Agricultura y Ganadería (MAG), a través del Centro de Desarrollo de la Pesca y la Acuicultura (CENDEPESCA), ha implementado con el apoyo del gobierno japonés, a través de la Agencia de Cooperación Internacional del Japón (JICA), el **Proyecto para el Desarrollo de la Acuicultura de Moluscos en la República de El Salvador** desde enero de 2005 con una duración de 3 años. Luego el Proyecto realizó dos años de tiempo de prorroga para establecer la tecnología de producción artificial de semilla y cultivo de moluscos hasta enero de 2010.

Este Proyecto fue ejecutado en la Bahía de Jiquilísco, Departamento de Usulután y también en la zona costera del Departamento de La Unión, donde muchos ribereños se dedican a la pesca artesanal, principalmente en la recolección de conchas y ostras, siendo el nivel de ingreso económico de las familias el más bajo, en comparación otros lugares del país.

El objetivo principal del Proyecto, ha sido el de **"Proponer el modelo de mejoramiento de la calidad de vida por medio de las actividades de la acuicultura de moluscos principalmente, basadas en la conciencia de manejo de los recursos naturales".**

Después de realizar varios Proyectos Modelos sobre el cultivo de moluscos y otras actividades económicas en las comunidades de las áreas de influencia del Proyecto, era necesario resumir resultados de estas actividades y proponer un "Modelo" con éxito. Para ello, solicitamos el envio de un Experto japones, para ésta área, Ing. Satoshi Chikami, enviado por JICA, quien tiene basta experiencia en los temas referidos a Proyectos de mejoramiento de vida de los pobladores en países Latinoamericanos y de Asia. El ha realizado análisis de la situación actual, el resultado de los Proyectos Modelos y de los ensayos de cultivo para engorde de moluscos realizados durante la ejecución del Proyecto.

Como conclusión de dicho trabajo, ha propuesto resumir en 5 "Modelos", que los ha denominado **Modelo de Mejoramiento de La Calidad de Vida de Los Pescadores Artesanales,** éstos modelos servirán para transmitirlos a otras comunidades, para lograr replicar el éxito alcanzado en las Comunidades Modelos, en las que fueron implementados.

Por lo tanto, en esta oportunidad, la Dirección General de CENDEPESCA/ MAG, se complace en presentar dicho texto no solamente al sector pesquero sino también las personas que se involucran de una u otra forma en el desarrollo rural, como ONGs, Organizaciones Gubernamentales e Internacionales, esperando que la misma, sirva de orientación para que estos Modelos se difundan a varias comunidades donde están intentando salir de la pobreza.

Lic. Sonia María Salaverría
Directora General de
Centro de Desarrollo de la Pesca y la Acuicultura
CENDEPESCA- MAG

Table of content

Introduction

In El Salvador, quite a number of coastal dwellers depend on their livelihoods on wild shellfish extraction in the estuary areas. They are mostly the rural needy including landless farmers, subsistence fishers and socially vulnerable population such as women and children. In the coastal rocky areas, there are also small-scale rock oyster collectors.

As a result of Civil War from 1980 until 1992, many refugees migrated from the mountainous regions to the Bay of Jiquilisco area, and started to engage in the curil extraction from the mangrove forests. The increased pressure on the curil resource stock caused quick decline of the resource base, resulting in reduced income and/or augmented labor time of those people.

To improve these situations, the Shellfish Aquaculture Development Project (hereinafter referred to as the Shellfish Project) was formulated and implemented by the Ministry of Agriculture and Livestock (MAG) through the Fishery and Aquaculture Development Center (CENDEPESCA), in cooperation with the Government of Japan through Japan International Cooperation Agency (JICA). The Shellfish Project has undertaken a variety of livelihood projects concerning different species of shellfish such as curil, casco de burro and Pacific oyster through active participation of model fishers' groups. In addition, some other income diversification projects have been carried out, namely establishment of seaside restaurants, shellfish marketing improvement, chicken rising, cattle fattening, installation of Fish Aggregating Devices (FADs) and so on. On the other hand, the Shellfish Project has conducted experiments on small-scale artificial reefs for the purpose of enhancing resource stock of the rock oyster.

The narrative summary of Shellfish Project is shown in following table.

Narrative Summary of the Shellfish Project

Overall Goal	Models for upgrading livelihoods of fishers through shellfish culture are disseminated in the Jiquilisco Bay of Department of Usulután and the coastal area of Department of La Union.
Project Objective	Models for upgrading livelihoods of fishers through shellfish culture are proposed, based on proper coastal resources management.
Expected Outputs	1. Shellfish seeds production techniques are established in the hatchery of CPT (CENDEPESCA Puerto El Triunfo). 2. Anadara spp. culture techniques that local fishers can adapt are established in the experimental sites and culture techniques of pacific oyster is developed in CENDEPESCA. 3. Awareness towards sustainable utilization of coastal resources and conservation of fisheries environment is increased among coastal people of model communities. 4. Measures for upgrading livelihoods of fishers through shellfish culture are identified from the model projects implemented.
Objective Species	For culture: *Anadara* spp. (curil and casco de burro) and Pacific oyster For stock enhancement: rock oyster
Implementing Agency	Fishery and Aquaculture Development Center (CENDEPESCA) of Ministry of Agriculture and Livestock (MAG)
Area	Jiquilisco Bay area, Department of Usulután Coastal zone, Department of La Unión
Beneficiary Groups	Subsistence fishers, mollusc collectors and their families Technical personnel of CENDEPESCA
Project Period	Original period: Three years (January 11, 2005 to January 10, 2008) Extended period: Two years (January 11, 2008 to January 10, 2010)

In its original period from Jan 2005 to Jan 2008, the Shellfish Project completed technology transfer on artificial seeds production and culture of target shellfish species to the Salvadorian counterpart personnel. Besides, a model for upgrading livelihoods of fishers through curil culture using natural seeds, three types of curil marketing models and two types of income diversification models were developed. And from these results, the Project objective was considered nearly attained but there still remained some more challenges to be addressed as follows.

- The technology of artificial seed production for curil and casco de burro was not stable and the massive production system was not established either.
- The developed model for upgrading livelihoods of fishers through curil culture using natural seeds had low profitability and viability for fishers to adapt.
- The grow-out culture experiments of curil and casco de burro with artificial seeds were only partially carried out, and it was difficult to elaborate the models with its limited results.
- The Pacific oyster artificial seed production depended on imported larvae from other countries that

made the production cost high. After a successful undertaking, no replication took place regarding brood stock maturation, induced spawning and early larval rearing.

- No adequate sites for Pacific oyster culture were found in the Bay of Jiquilisco. After the first successful grow-out experiment in the Gulf of Fonseca, it was necessary to repeat the culture experiments for further verification in the Gulf.
- Since there was too little passage of time after the installation of artificial reefs for rock oyster, it was difficult to obtain data through monitoring and evaluation surveys to measure the effects of artificial reefs.

The terminal evaluation of the Shellfish Project for the original period conducted in Sep 2007 suggested extending the Project period by two more years in order to address the above issues. In response to this, a comprehensive work plan was prepared with emphasis on artificial seed production of *Anadara* spp. and culture of Pacific oyster. The activities in the extension period have been carried out according to the work plan up to date, and eventually the Project has just elaborated five more models for upgrading livelihoods of fishers as follows:

- Curil Culture Livelihood Model with Artificial Seeds
- Casco de Burro Culture Livelihood Model with Artificial Seeds
- Pacific Oyster Culture Livelihood Model with Artificial Seeds
- Livelihood Model of Artificial Reefs for Rock Oyster
- Fish Aggregating Devices (FADs) Livelihood Model for Hand-line Fishers

It is hoped that these five models, in addition to those models already elaborated in the original period, will be adapted by those target people including subsistence fishers of curil, casco de burro and rock oyster residing in the Bay of Jiquilisco, Department of Usultan and the coastal zone of Department of La Unión, and will contribute to the upgrading of their livelihoods in the near future.

1. Curil Culture Livelihood Model with Artificial Seeds

Introduction

The following five model groups have been implementing the curil culture experimental trials during the original and extension periods of the Project.

Table 1 Model Groups of Curil Culture

Name of model group	Number of members	Characteristics
Puerto Ramirez	7	Mollusc collectors
El Jobal	5	Ditto
La Zapateta	18	Hand-line fishers' cooperative
San Hilario	77	Ex-guerrillas' shrimp culture cooperative
Los Mancornados	11	Farmers associated with a shrimp culture cooperative

Note that, in the original Project period, a culture system had already been developed to grow 33mm-sized natural seed up to 45mm in a year on the enclosed mangrove grounds. In addition to this scattering method, a net-bag method was introduced in the extension period as an experimental trial for the 10mm sized artificial seed in all the above sites. The system employs net-bags made of 2mm mesh-size anchovy nets in which the seed is held. The monitoring results show clearly that the net-bag method performs better than the scattering method in terms of stoking capacity and work efficiency, and that no difference is observed between the two in terms of both growth rate and survival rate. Therefore, it is suggested to adopt the net-bag method for the curil culture livelihood model with 10mm sized artificial seeds.

The livelihood model presented here is based on the experiments conducted by the model groups above except those two groups of San Hilario and Los Mancornados who have been affected by external conditions such as drainage water from the shrimp culture ponds.

Beneficiaries and Organizations

Those who engage in curil culture are essentially mollusc collectors and fishers in the Bay of Jiquilisco areas. In the original Project period, the Project provided assistance to those people in the organizing and forming groups to jointly undertake mollusc culture activities. With a few exceptions, the attempts to organize them were found difficult in general due to the facts that the mollusc culture failed to derive immediate income generation to those economically vulnerable people. Some members who had been motivated in the beginning had to leave the group for economic reasons in the end. It is a strong tendency that those who continue the collective culture activities are united based on kinship or close friendship. Small groups of social relationship are deemed only viable to conduct collective undertakings pertaining to the curil culture on a sustainable manner. It is found adequate to form a socially bound group of about five persons. And it is envisioned to organize a cooperative association with three or more small groups. Such an association can be supported by government if registered with relevant agency by complying with given requirements for a juridical person.

For the fisheries sector, the Ministry of Agriculture and Livestock (MAG) through its Department of Farmers' Association is the authorizing agency. Fisheries and Aquaculture Development Center (CENDEPESCA) under the MAG manages a special fund for development of small-scale fisheries (FIDEICOMISO PESCA), and provide financial assistance to those legally established fisheries cooperative associations. The association is required to be formed with at least 15 members.

Out of the five model groups, two are shrimp culture cooperative associations duly registered (San Hilario and Los Mancornados), and one is hand-line fishers' cooperative (Zapateta). On the other hand, four members of Puerto Ramirez group belonged to a fishers' cooperative before, but they left it for the reason of different interests they had from other fishers' group. El Jobal group used to be members of the Community Development Association (ADESCO) before, for which an international Non-Government Organization (NGO) called Ayuda en Accion assisted in the curil culture project. The ADESCO is not a local governmental organization but is usually organized at village level and well recognized by government agencies and foreign donors to represent the community as a whole to undertake various local development activities. As such, small-scale producers usually make efforts to organize themselves for the sake of outside assistance. The curil culture groups for the model are considered to belong to a legitimate cooperative association or ADESCO.

Technology

The culture method of the model employs net-bags. A bag of 60cm x 90cm is made up of 2mm mesh size nylon anchovy nets, which round-sliced plastic bottles and wads of netron nets are put in so that the curil seed and juveniles can stay on in a stabile way.

Fig. 1 Photo of Net-Bags

A net-bag installed in the mangrove forest

Juveniles staying on round-sliced plastic bottle

A net-bag installed in the mangrove forest Juveniles staying on round-sliced plastic bottle

The Mollusc Aquaculture Development Center has exerted efforts to upgrade the curil seed production techniques for the purpose of establishing stable mass seed production, and eventually it has made it possible to supply enough quantity of artificial seed to disseminate the curil grow-out farmers. The proposed curil culture system is to grow 10mm sized artificial seed up to 45mm in net-bags. The performance of the model groups in the Project extension period is summarized in the following table:

Table 2 Growth Rates of Curil in Different Sites

Name of Group (Culture Site)	Monthly Average Growth Rate	Observation Period	Time required to grow from 10mm to 45mm
Puerto Ramirez	1.4mm	21/04/08-28/05/09	25 months
El Jobal	1.5mm	29/10/08-05/05/09	23 months
Zapateta	2.5mm	21/04/08-24/02/09	14 months
Average	1.8mm		20 months

From the past experiments, it is supposed that the growth rate depends more on environmental factors than on culture methods. And from the above table, those sites recording relatively low growth rates such as Puerto Ramirez and El Jobal may have seasonal decline of the salinity level affected by influx of freshwater and poor exchange of seawater. On the other hand, Zapateta shows higher monthly average growth rate of 2.5mm probably because of its better location at the verge of the mangrove forest where constant water exchange keeps the salinity level relatively unchanged. Zapateta may have better environmental conditions such as abundance of natural foods (phytoplankton) and ecological conditions of tidal flats. Therefore, it is advisable to select culture sites with similar conditions to Zapateta. Nevertheless, the model expects a monthly rate of 1.8mm, the average of the three sites, which will lead to the culture period of 20 months to grow 10mm size seed to 45mm.

It is required to adjust the number of individuals in a net-bag depending on its size so that the environment for optimal growth can be maintained. The following stocking density adjustment is suggested as a result of experiments conducted so far.

Table 3 Stocking Density in a Bag-net by Size of Curil

Size (Total Length)	10mm - 25mm	25mm - 35mm	35mm - 45mm
Number of individuals	1,000	500	250
Adjustment Time		8th month	14th month
Number of Net-bags needed	1	1.73	3.12

It is necessary to reduce the number of individuals stocked in 8th month and 14th month, and consequently to increase the number of net-bags. The survival rate of 70% is expected over the whole culture period, based on the result of experiments conducted in Zapateta (Refer to Table 4).

Table 4 Survival Rate during the Experiments in Zapateta

Size	Survival Rate	Cultured Period	Culture Method
10mm - 22mm	87%	Monthly average over 3 months in 5 lots	Net-bag
22mm - 42mm	80%	June 2008 to February 2009	Iron frame
10mm - 45mm (Estimation)	70%		

The net-bag culture method employs simple management, and unlike the scattering method, it does not require laborious collecting work for shipment. It is necessary only to observe growth and survival rates every three months and remove predators such as shellfishes and crabs from the bags. It would be prone to thefts if not kept under 24 hours close guard.

The following table shows the summarized assumptions used in the model:

Table 5 Assumptions for Curil Culture Model

Item	Assumption
Size of seed stocked	10mm
Size harvested	45mm
Culture period	20 months
Number of seed to be stocked	90,000 individuals
Size of net-bag	60cm x 90cm
Stocking density	1,000 to 250 per net-bag (to be adjusted according to size)
Number of net-bag	280 bags (90,000 individuals / 1,000 individuals x 3.12 bags)
Culture area	600m^2 (0.6m x 0.9m x 280 bags x 4)
Growth rate	1.8mm per month
Survival rate	70% over 20 months (monthly average: 98.23%)
Harvest	63,000 individuals

Materials and Equipment

The curil culture in net-bags does not need much materials and equipment. Basically necessary materials are net-bags, used plastic bottles and used netlon nets. It does not require special skills to make net-bags but only sewing skills that many people in the rural villages are equipped with. Both used plastic bottles and netlon nets are usually available. It is highly advisable to construct a watch house near the culture ground in order to protect the product from thefts and other disturbances. The design and size of the watch house may vary but in this model its construction cost including materials and labor is estimated to be 500 US dollars using the wooden materials.

Materials necessary for Curil Culture in Net-bags

	Item	Quantity	Unit Price ($)	Amount($)
a.	Net-bag (including plastic bottles and netlon nets)	280 sets	4	1,120
b.	Watch house	1 unit	500	500
	Total			1,620

Marketing

It is expected that the cultured curil is sold locally to local middlemen based on the sound economic and social relationships between curil growers and middlemen to ensure fair trade exercises. The shipment is

done at three high seasons for seafood such as Easter, August holidays and Christmas when curil price usually goes up.

Direct marketing to the restaurants which was attempted in the original Project period is not recommended since the case of Puerto Ramirez seems not self-sustaining without outside assistance in the sophisticated marketing activities.

Profitability

The profitability of the Curil Culture in Net-bags is shown below:

a. Revenues

	Quantity	Unit Price ($)	Income ($)
Sales of cultured curil	63,000	0.05	3,150

b. Costs

	Quantity	Unit Price ($)	Amount($)
Purchase of artificial seed (10mm)	90,000	0.002	180
Labor for vigilance (1man, 20months)	608 M.M	2	1,216
Labor for seed stocking (5men, 3days)	15 M.D	2	30
Labor for harvesting (5men, 3days)	15 M.D	2	30
Labor for density adjustment (5men, 6days)	30 M.D	2	60
Depreciation of the net-bags			187
Depreciation of the watch house			167
Repair and Maintenance for the net-bags and watch house			62
Total			1,932

c. Profits: $3,150 - $1,932 = $1,218

d. Income Distribution

1) Profits from the culture:	$1,218
2) Labor costs paid:	$1,336
Total:	$2,554
- Per-capita total income:	$511
- Per-capita monthly income:	$26

e. Assumptions

1) Sales of cultured curil

   Quantity harvested for sale is 70% of the initial number of seed stocked, that is, 90,000 x 0.7 = 63,000.

   Unit price is US$3 for 60 individuals or US$0.05 for one individual, sold to local traders.

2) Price for artificial seed of curil

   The price for pacific oyster is not different from that for rock oyster in El Salvador as of today. The price for rock oyster ($0.33) is about 8.25 times higher than that for curil ($0.04). The seed price for curil is assumed therefore 1/8.25 of prevailing price for pacific oyster which is found in the US market ($0.015). This assumption gives unit price of curil artificial seed of $0.002.

3) Labor cost

   Labor cost is based on shellfish collectors' monthly income of US$60. A daily wage as opportunity cost is therefore US$2.

4) Depreciation:

   Life span of the net-bags is assumed to be 10 years and that of the watch house is 5 years. The depreciation cost for respective item is computed over 20 months.

5) Cost for repair and maintenance: 3% of total costs for net-bags and watch house.

Economic Analysis

Two analytical methods, i.e. NPV (Net Present Value) and IRR (Internal Rate of Return) show that the model is feasible with the following figures:

- NPV: US$3,076 (at the discount rate of 10%)
- IRR: 31%

Table 6 Cash Flow of Curil Culture in Net-bags (10 Years) *Unit: US$*

Year	0	1	2	3	4	5	6	7	8	9	10
1. Initial Investment											
1-1 Netbags	1120										
1-2 Watch House	500					500					
2. Benefit											
2-1 Income from Sales			3,150		3,150	3,150		3,150		3,150	3,150
3. Costs											
3-1 Purchase of Seeds		180	180		180	180		180		180	
3-2 Labor for Vigilance		730	730	730	730	730	730	730	730	730	730
3-3 Labor for Stocking		30	30		30		30	30		30	
3-4 Labor for Harvesting			30		30	30		30		30	30
3-5 Labor for Density Adjustment		30	30	60	30	30	30	30	60	30	30
3-6 Repair and Maintenance		37	37	37	37	37	37	37	37	37	37
4. Annual Net Benefit	-1,620	-1,007	2,113	-827	2,113	1,643	-827	2,113	-827	2,113	2,323

2. Casco de Burrro Culture Livelihood Model with Artificial Seeds

Introduction

Casco de burro thrives in the soil with more sandy characteristics as compared to the muddy soil where curil lives in. The culture of casco de burro has been conducted on a experimental basis in the enclosed plots by perimeter fencing with plasticized iron nets and concrete posts. Such experimental culture was made possible with artificially produced seed by the Project which was provided to the model groups three times during the original Project period. The model groups implementing the casco de burro culture are as follows:

Table 1 Model Groups of Casco de Burro Culture

Name of model group	Number of members	Characteristics
El Tular	7	Casco de burro collectors, managing casco de burro fattening and seaside restaurant
La Venada	21	Hand-line fishers' cooperative with 17 active fishermen

The members of El Tular group collect natural shellfish and put them in the enclosure plot to sell to the visitors. In the same plot, small individuals and artificial seed of casco de burro are planted for fattening. In La Vanada, natural and artificial seed are cultured as well. This model will be based on the data captured from the experiment in La Venada which gives more accuracy.

Note also that the marketing information on casco de burro such as prices and the distribution system is limited as this species is not supplied to the market as much as curil.

Beneficiaries and Organizations

Those who are expected to engage in casco de burro culture are subsistence mollusc collectors and fishers in the Bay of Jiquilisco areas.

The group of La Venada, composed of 17 small-scale pole-line fishers, is registered as fishermen's cooperative with Agriculture Association Department, Ministry of Agriculture and Livestock. They used to collect curil in the mangrove forests for their livelihood before, and later started fishing by installing the fallen trees in the sea near the coast of the Jiquilisco Bay. In the Project original period, they started an experimental culture of casco de burro artificial seed in cooperation with the Project in front of their fishing ground. The Project provided them with artificial seed and materials for the enclosure plot. In addition, as an alternative livelihood, the Project installed concrete-made Fish Aggregating Devices (FADs) which dramatically enhanced their fish capture efficiency. They now no longer need to spend much time in the heavy curil extraction work. Since the seed of casco de burro does not reach harvestable size yet, no income has been generated from the culture. However, the combination of mollusc culture with FADs has been proven to be a good livelihood enhancement practice because the laborious vigilance work pertaining to the culture is mitigated by fishing near the culture plot.

El Tular group started with 15 members in the beginning, but turned to be a small group of seven persons who belong to a family residing near the culture plot. The vigilance has been conducted by the family members. Other original members went out of the group because they did not yield day-to-day income from the culture despite they had to work day and night on a rotation basis to watch out the culture plot until the harvest. This implies that the casco de burro culture alone may not be a main livelihood for those needy people. Those members who still stay in the group go together to nearby sandy beaches for casco de burro collection and deposit the collected mollusc in the culture plot; large size for sale to visitors of seaside restaurant and small size for fattening. The group acquired artificial seed of casco de burro from the Project and already started to serve cultured ones to the visitors. Thus, the culture of casco de burro and seaside restaurant is managed well by this family-based small group. For highly vulnerable people, it is likely to mange livelihood on a sustainable manner if the group is based on social relations such as kinship. Nevertheless, in general, for availing of further assistance, the group should consider obtaining membership of ADESCO of the locality.

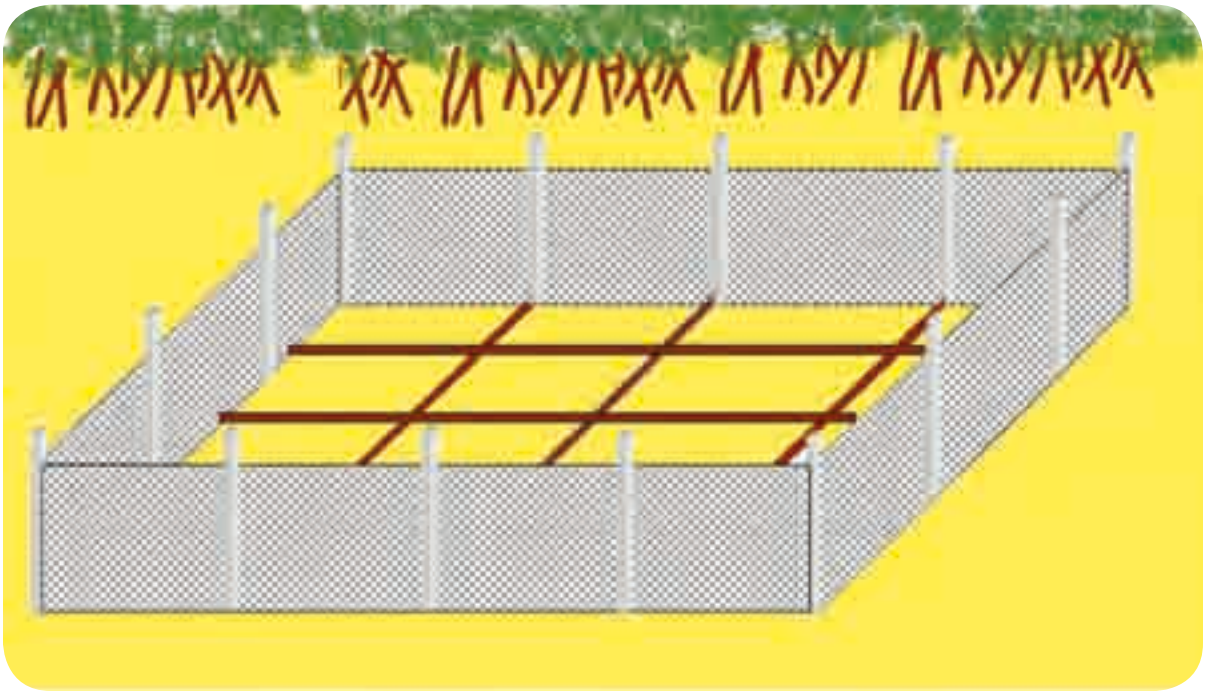
From the above, a group of about five persons is considered adequate to manage the casco de burro culture model for securing a certain amount of income to each member. It seems also easy to undertake group aquaculture activities with small membership unless they have alternative livelihood that can assure good income for many members such as pole and line fishing with FADs. And it is advisable that three or more number of small groups form a cooperative association for future outside assistance.

Technology

Since no other culture methods than the scattering method has not been experimented, the model will be based on this culture method. It is technically simple so that small-scale fishers and mollusc collectors can easily undertake.

A small partial of the sand-mud mixed beach will be enclosed with wire netting and concrete poles where seed is placed to grow by feeding on natural phytoplankton. However, this simple scattering method is not suitable for seed size of 10mm which may go out of the enclosure resulting in reduced recapture rates. Therefore, this model is applicable for the initial stocking size of 20mm or larger. Since 20mm sized seed production capacity of the hatchery is limited, it is required to develop alternative culture methods to stock 10mm sized seed in the future. The net-bag method which is applied to the curil culture model is now under experimental trials.

Figure 1 Enclosure Plot with Iron Wiring and Concrete Posts



The area of culture varies depending on the number of seed to be stocked. The model adopts 300m^2 which can be divided by parcels for the seed stocking density management.

The Project successfully produced artificial seed of casco de burro three times in the original period as follows:

Table 2 Production of Artificial Seed of Casco de Burro in Puerto El Triunfo CENDEPESCA

Production date	Quantity produced (individuals)	Average seed size (mm)	Model group that received seed
January 2006	2,300	-	El Tular
October 2006	4,475	26	El Tular, La Venada
December 2006	4,400	23	El Tular, La Venada

The Project currently carries out research and development activities to develop massive, stable seed production technology of casco de burro. Intensive efforts are now made to develop broodstock maturation and induced spawning techniques. After the spawning, those already developed techniques for curil seed production can be applied to casco de burro seed production process as well. Then, it will be possible to supply the seed constantly to users and clients such as mollusc collectors and fishers.

Collection and marketing of wild casco de burro of less than 100mm is prohibited by the law. But, the majority of marketed casco de burro is found less than the restricted size. Besides, the size restriction may not be based on the biological data since the Project has confirmed from the experiments that at about 60mm size casco de burro reaches reproductive status. There is no restriction on the size for cultured casco de burro at the moment. The model expects to grow 20mm sized seed up to 60mm.

Growth rate and survival rate of casco de burro in the scattering method are based on the experimental trials conducted in La Venada as shown in the following table:

Table 3 Experimental Results of Casco de Burro Culture in La Venada

Size	Monthly Average Growth Rate	Culture Period
20mm - 50mm	3.2mm	9.4 months
50mm - 60mm	1.4mm	7.1 months

The table shows that the growth rate from 20mm to 50mm is 3.2mm per month but over 50mm it slows down to 1.4mm per month. The period required to grow from 20mm to 60mm is 16.5 months. In the model it is assumed to take 18 months including some margins.

As seen in other mollusc aquaculture, casco de burro culture also relies on natural feeding. Population density of casco de burro in the culture plot shall be adjusted in accordance with food requirement. 10kg of casco de burro per m^2 is found adequate for its optimal growth. The number of individuals per m^2 in different size is shown in the following table:

Table 4 Adequate Number of Individuals of Casco de Burro per m^2 in Culture Parcel

Size (Total Length)	20 - 30mm	30 - 40mm	40 - 50mm	50 - 60mm
Number of Individuals (m^2)	1,000	400	200	100
Time for adjustment		3rd month	6th month	9th month

During the 18 month culture period, it is assumed to have 90% survival rate from the experience of the model groups.

It is important to select suitable site for casco de burro culture. Basically the area having similar conditions to those areas where wild casco de burro thrives is suitable. It is expected to attain good growth and survival by selecting those beaches with sand-mud mixed soil characteristics located right next to the mangrove forests in the tidal flats. One of the criteria for the site selection is to manage the vigilance works with ease. La Venada group members conduct fishing day and night in front of the culture site and El Tular group has its culture enclosure plot near the seaside restaurant. This prevents thefts and avoids over-work of the members.

Culture of casco de burro does not require sophisticated management but only regular monitoring on growth rate, survival rate and intrusion of predators. Harvest is also easy and less time-consuming compared to curil culture because the culture site is an open area on the beach.

Summarizing the above, assumptions employed in the casco de burro culture are as follows:

Table 5 Assumptions for Casco de Burro Culture Model

Item	Assumption
Size of seed stocked	20mm
Size harvested	60mm
Culture period	18 months
Number of seed stocked	30,000 individuals
Stocking density	1,000 – 100 individuals per m^2 (to be adjusted according to size)
Culture area	300m^2
Growth rate	3.2mm per month (20 – 50mm), 1.4mm per month (50 – 60mm)
Survival rate	90%
Harvest	27,000 individuals

Materials and Equipment

The casco de burro culture needs a few materials. Basically necessary materials are an enclosure system constructed with iron netting and concrete posts, and a watch house. It is advisable to construct a watch house near the culture ground in order to protect the product from theft and other disturbances. The design and size of the watch house may vary but in this model, its construction cost including materials and labor is estimated to be 500 US dollars using the wooden materials.

Materials Necessary for Casco de Burro Culture in Scattering Method

	Item	Quantity	Unit Price ($)	Amount($)
a.	Enclosure (perimeter fencing with plasticised iron nets and concrete posts)	1 set	465	465
b.	Watch house	1 unit	500	500
	Total			965

Marketing

It is highly recommended to harvest and market the cultured casco de burro at the high seasons that fall three times a year, namely, Easter, summer holidays in August and the Christmas time.

It is assumed that the product is sold locally to the middlemen based on the sound economic and social relationships existing between casco de burro growers and middlemen to ensure fair trade exercises. Direct marketing to the end users such as restaurants may give more profits to the producers by eliminating intermediate margins which middlemen usually enjoy otherwise. Note that it is required for the producers' group to make substantial efforts on the marketing activities such as new customer exploration, quality control, fulfillments of customer's requirements for quantity, size and delivery time, etc. Such transaction costs should be less than additional profits generated by eliminating intermediaries.

Casco de burro currently marketed in El Salvador is found only in limited places such as a sales stand of Tiendona Public Market in San Salvador, some restaurants in La Libertad City and La Union City. The majority of the products come from Honduras and Nicaragua channeled by middlemen of La Union. Jiquilisco area used to be a production site of casco de burro but these years its resource base has declined and the production is minimal. Therefore, only a few middlemen occasionally handle this product for marketing. A middleman based in Puerto Parada is one of them and he purchases a dozen of casco de burro at US$2.50 to mollusc collectors. Another example is that the selling price at La Union Public Market is US$3 per dozen for average size of 77mm and US$5 for 95mm.

Profitability

The profitability of the casco de burro culture in scattering method is examined based on the experiences of model groups and the market study conducted by the short-term experts:

e. Revenues

	Quantity (individuals)	Unit Price ($)	Income ($)
Sales of cultured casco de burro	27,000 (2,250 dozens)	0.20 (2.40)	5,400

f. Costs

	Quantity	Unit Price($)	Amount($)
Purchase of artificial seed (10mm)	30,000	0.016	480
Labor for vigilance (1 man, 18 months)	548 M.M	2	1,096
Labor for seed stocking (5 men, 2 days)	10 M.D	2	20
Labor for harvesting (5 men, 4 days)	20 M.D	2	40
Labor for density adjustment (5men, 6days)	30	2	60
Depreciation of the enclosure system			75
Depreciation of the watch house			150
Repair and Maintenance for the enclosure system and the watch house			44
Total			1,965

g. Profits: $5,400 - $1,965 = $3,435

h. Income Distribution

1) Profits from the culture:	$3,435
2) Labor costs paid:	$1,216
Total:	$4,651

- Per-capita total income: $930
- Per-capita monthly income: $52

e. Assumptions

1) Sales of cultured curil
   Quantity sold: 30,000 x 0.9 = 27,000.
   Unit price: US$2.40 for one dozen or US$0.2 for one individual, sold to local traders.

(The unit price is estimated moderately, referring to the actual price that a middleman at Puerto Parada exercises with mollusc collectors (US$2.50 for a dozen). Quantity supplied in the market is considered limited and it is unpredictable when supply increases in the future.)

2) Price for artificial seed of casco de burro

   The price for casco de burro is US$0.2 per individual (total length of 60mm) whereas that for curil is US$0.05 per individual (total length of 45mm). This ratio of 4:1 is applied to the unit price of 10mm sized seed. Then, the curil seed price of US$0.002 is multiplied by 4 gives the unit price of casco de burro artificial seed of $0.008 (10mm size). This model will culture 20mm sized seed for which the price is assumed double the 10mm sized seed price, that is, US$0.016.

3) Labor cost

   Labor cost is based on mollusc collectors' monthly income of US$60. A daily wage as opportunity cost is therefore US$2.

4) Depreciation:

   Life span of the enclosure system is assumed to be 10 years and that of the watch house is 5 years. The depreciation cost for respective item is computed over 18 months.

5) Cost for repair and maintenance: 3% of total costs for net-bags and watch house.

Economic Analysis

Two analytical methods, i.e. NPV (Net Present Value) and IRR (Internal Rate of Return) show that the model is feasible with the following figures:

- NPV: US$11,825 (at the discount rate of 10%)
- IRR: 105%

Table 6 Cash Flow of Curil Culture in Net-bags (9 Years) *Unit: US$*

Year	0	1	2	3	4	5	6	7	8	9
1. Initial Investment										
1-1 Enclosure	465									
1-2 Watch House	500					500				
2. Benefit										
2-1 Income from Sales			5,400	5,400		5,400	5,400		5,400	5,400
3. Costs										
3-1 Purchase of Seeds		480	480		480	480		480	480	
3-2 Labor for Vigilance		730	730	730	730	730	730	730	730	730
3-3 Labor for Stocking		20	20		20	20		20	20	
3-4 Labor for Harvesting			40	40		40	40		40	40
3-5 Labor for Density Adjustment		30	20	10	30	20	10	30	20	10
3-6 Repair and Maintenance		37	37	37	37	37	37	37	37	37
4. Salvage Value										147
5. Annual Net Benefit	-965	-1,297	4,073	4,583	-1,297	3,573	4,583	-1,297	4,073	4,730

3. Pacific Oyster Culture Livelihood Model with Artificial Seeds

Introduction

In the project original period (Jan 2005 to Jan 2008), the Project conducted experimental culture of pacific oyster in five sites located along the Jiquilisco Bay in cooperation with different model groups. These experiments encountered, in all the sites, problems of fouling (attachment of sessile) such as barnacle and intrusion of predators such as crustaceans, which deteriorated survival rates of seed oysters. No adequate culture site for pacific oyster has ever been identified in Jiquilisco after all. On the contrary, in late 2006, the Project gained suggestive results from the experimental trials in the Gulf of Fonseca near Zacatillo Island, which has lead the Project, in its extension period (Jan 2008 to Jan 2010), another verification attempt in the same gulf but this time near Meanguera Island. As a result, substantial data and technical information has been collected from those two trials in the Gulf of Fonseca that makes this modeling possible.

There are two structural options for pacific oyster culture method introduced; raft and longline. The former has advantage in the workability and the latter is suitable for relatively rough sea. In the Gulf of Fonseca, a few damages from fouling and predator are observed as against the cases in Jiquilisco, and thus both growth and survival rates are good enough for feasible oyster culture business. The Japanese rack-cages, to contain individual oysters and be suspended from raft or longline, have been substituted with locally fabricated rack-cage, resulting in large cost reduction.

Pacific oyster is a new product to El Salvador. No information on demand and price is available. The Project conducted tasting surveys with 5 – 6cm sized oysters. As a result, 98% of those tasted it showed their acceptance and many of them prefer it to local rock oyster in terms of taste. This indicates potential demand for pacific oyster in El Salvador.

Beneficiaries and Organizations

The model groups implementing the pacific oyster culture are as follows:

Table 1 Model Groups of Pacific Oyster Culture in Gulf of Fonseca

Name of model group	Number of members	Characteristics
Zacatillo	10	Fishers' cooperative with 20 membership, fishing and farming are their main livelihoods
Meanguera	7	Day laborers, underemployed people's group (The group leader is a part-time city government employee)

Since no major industries or stable employment opportunities are found in those two islands, many islanders are forced to leave the islands to seek for sources of their livelihoods. In recent years, they work abroad especially in United States legally and illegally, and remit earned money to family members staying in islands. The above model groups include those who economically rely on the remittance from other family members too. Under such circumstances, it is found difficult for those vulnerable people to keep working in oyster culture management from seed stocking until harvest without income for about six months.

Notwithstanding the above, it is expected that those vulnerable islanders (Zacatillo, Conchagua and Meanguera) become beneficiaries of the proposed pacific oyster culture livelihood model in Gulf of Fonseca (See the map depicting potential culture grounds for pacific oyster).

Map 1 Potential Culture Grounds for Pacific Oyster

Figure 1 View of the Islands Meanguera

As mentioned earlier, livelihoods to sustain life of these island people are limited to subsistence agriculture and fisheries, construction/civil day labors and seasonal local tourism. More than a decade ago, shrimp fishing used to be a major income source for the islanders but it has declined for recent years reportedly due to overfishing. In this respect, oyster culture is expected to be an alternative livelihood for them.

In Meanguera, the model group started experimental culture in cooperation with the Project in March 2009. City government has extended its assistance to the group in the provision of a boat and fuel for daily transportation between the village and the farming site. A part-time city government officer has become the leader of the group and he encouraged those people with no fixed employment to participate in the oyster culture activity. People usually expressed their interest to join the activity, but once they realized that the activity did not bring them immediate income, they lost willingness to continue. Presently, the group has seven active members.

In Zacatillo, the model group is a fishers' cooperative association registered with the relevant government agency. The group has already conducted three times the oyster culture trials since November 2007. The Project provided the group with seed oysters and 10 members of the group actively managed the culture operations in the first production cycle. The second and the third runs did not yield as good harvest as the first run due to high mortality caused by unknown environmental factors and less cares taken by the members. Despite some income was already distributed to those participating members from the sales of the product, motivation of some members towards day-to-day culture manageent gradually diminished. This demoralization might be attributable to the nature of this business that aquaculture could not give the needy people daily subsistence income.

It seems necessary to make payment to the members regularly even before sales of the product take place in order to maintain their routine activities. Or otherwise, participants in the oyster culture livelihood model should be those who have other stable means of income such as agriculture and fishing. Another possible bottleneck for the needy to participate in the oyster culture is high initial cost: US$8,320 for initial setup for raft method and US$7,384 for longline method, which is found difficult for the islanders to prepare at once.

From the above, two types of oyster culture business can be proposed: i) investors run the culture business and pay wage to workers, and ii) people's groups run the business with initial investment assisted by government or donor agencies. In case of i), the investors come from inside or outside the islands, and the participants in the culture will be mere employees or wage workers. Public offices can be investors such as city government of Meanguera. Those who return from overseas work with some money savings can invest in the oyster aquaculture and run the business with other family members. In case of ii), a registered association will be the implementer and the members can jointly manage the culture business and share the yield. The high initial investment cost will be donated or soft-loaned to the group. Like in the case of Zacatillo, those who have income from agriculture and fishing can collectively work in the oyster culture at their convenient time.

The appropriate number of participants varies depending on business type above although it is found that five persons can manage the oyster culture from seed stocking through day-to-day operations to harvest and marketing. Note that a good manager can enhance work efficiency so that the oyster culture business can be profit-oriented by minimizing the operational costs. In this case, three permanent workers (employees) may be sufficient to run necessary operations including day-to-day care and night vigilance.

Technology

Pacific oyster is a new species introduced from overseas to El Salvador. It does not reproduce itself under the natural environment. As a matter of fact, no maturated individual has been found in the experimental culture trials so far. Therefore, natural seed is not available and the culture shall depend on artificially produced seed in the hatchery. The Project initially imported eyed larvae from Chile and USA, and reared it up to 5mm total length size for the supply to model groups. In the extension period, the Project has been establishing techniques on broodstock rearing, induced spawning to be able to produce eyed larvae by itself. This will ensure mass production of artificial seed oysters in the near future.

Regarding the grow-out technology, basically coastal area with negligible existence of fouling and predator is said to be suitable. From this viewpoint, no suitable site has been found in the Jiquilisco Bay, while those points where experimental trials take place now in Gulf of Fonseca are considered suitable for oyster. Other

necessary conditions include i) easy to guard, and ii) not too far from the village to minimize fuel consumption. It is advisable to set up a farm near the village to easily watch out from the land.

There are several oyster farming methods which include hanging individuals from raft (Zacatillo as shown in Figure 3) and from longline (Meanguera as shown in Figure 4). In both cases, seed oysters are individually put in the rack-cage (Figure 2) and suspended from raft or longline. Oysters will grow by feeding on natural phytoplankton.

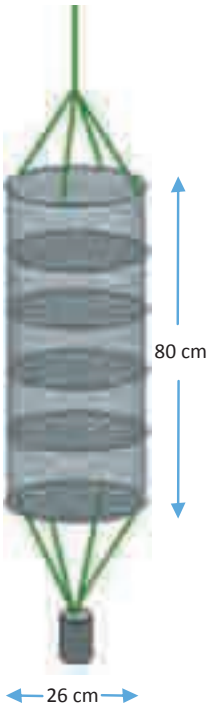


Figure 2 Rack-Cage

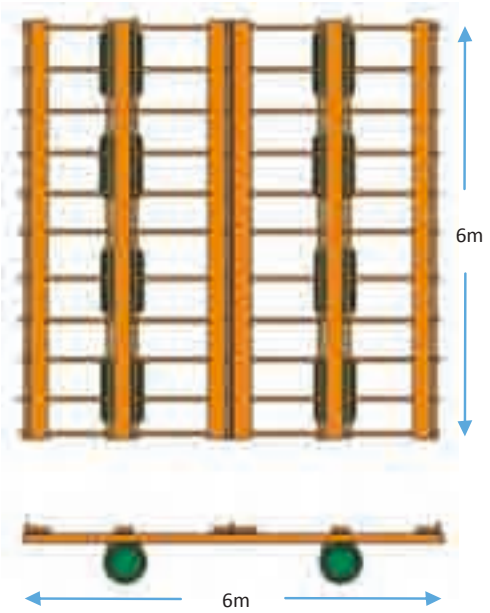


Figure 3 Raft Method

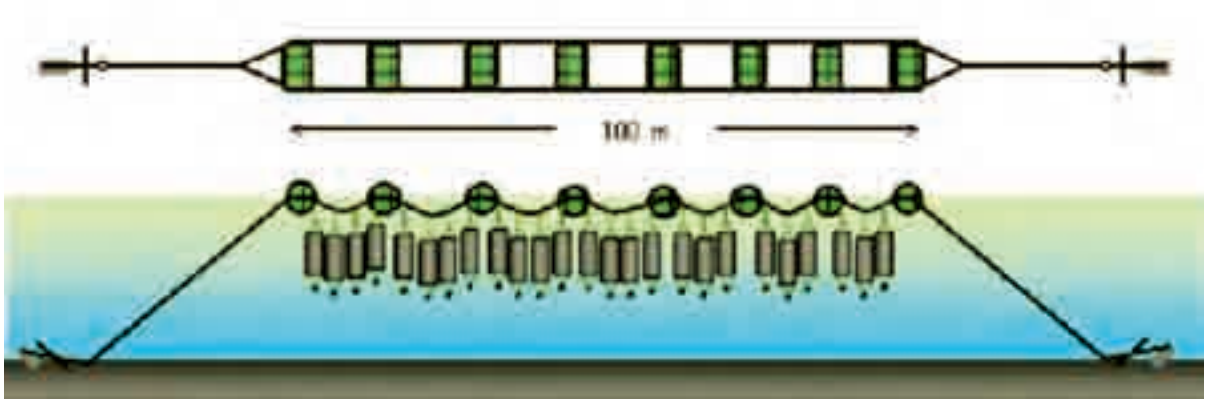


Figure 4 Longline method

Growth in rack-cage has been recorded in both sites as summarized below:

Table 2 Growth Rate of Pacific Oyster in Two Experimental Sites

Name of Group (Culture Site)	Monthly Average Growth Rate	Observation Period	Time required to grow from 5mm to 60mm
Zacatillo	8mm	13/11/07-15/07/08	6.9 months
Meanguera	12mm	11/03/09-12/08/09	4.6 months
Average	10mm		5.5 months

Although Meanguera demonstrates faster growth and apparent suitability for oyster, this livelihood model assumes 10mm as monthly average growth, which is the average of the above two sites. Therefore, harvest time is 5.5 months after seed stocking. Actual harvest will take place from 5th month until 7th month for which six month farming period is assumed in the model.

For optimal growth of oyster, biomass shall be adjusted according to size, one example of which is shown in the following table:

Table 3 Stocking Biomass (Number of Individual per Rack) According to Size

Size (Total Length)	5 – 10mm	10 - 20mm	20 - 30mm	30 - 40mm	40 - 60mm
Number of Individuals (per rack)	1,000	250	100	50	25
Time for adjustment		2nd week	7th week	11th week	18th week

Thinning of biomass in a rack is of utmost importance to obtain good growth. It helps oysters feed on natural planktons without competition. According to the above table, such stoking adjustment shall be done four times during the culture period of six months.

It is also an important task and a routine work to clean the racks regularly and remove fouling and predator if any. Safe-guarding against thefts and any kinds of disturbance is essential all the time. To mitigate this laborious vigilance, it is recommended the oyster farm be set near the village. Nevertheless, night watch shall be undertaken firmly with special attention to harvestable oysters for the last two months.

Over the 6 month culture period, it is assumed to have 30% survival rate from the experience of the model groups (Zacatillo: 25%, Meanguera: 33%).

Summarizing the above, assumptions are set for the pacific oyster culture as follows:

Table 4 Assumptions for Pacific Oyster Culture Model

Item	Assumption
Size of seed stocked	5mm
Size harvested	60mm
Culture period	6 months
Number of seed stocked	100,000 individuals
Stocking density	1,000 – 25 individuals per rack (to be adjusted according to size)
Growth rate	10mm per month
Survival rate	30%
Harvest	30,000 individuals

Materials and Equipment

As mentioned before, there are two types of oyster hanging methods; raft and longline. A watch house raft and high-pressure cleaner for rack-cages are not essential items for culture operations. They are included in the model as otherwise the labor costs for day-to-day management would increase. The materials used for both types are explained in detail in the technical manual and here its brief descriptions are shown as follows:

Materials Necessary for Oyster Suspension Culture in Raft Method

	Item	Quantity	Unit Price ($)	Amount($)
a.	Raft (6m x 6m)	3 sets	736	2,208
b.	Anchor	4 sets	173	692
c.	Rack-cage (5 tiers)	300 pcs.	10.33	3,100
d.	Watch house raft	1 set		1,320
e.	High-pressure cleaner (gasoline engine)	1 set		1,000
	Total			8,320

Note: Prices for a. raft and d. watch house raft include 20% of total material costs as labor cost for the assembly.

Materials Necessary for Oyster Suspension Culture in Longline Method

	Item	Quantity	Unit Price ($)	Amount($)
a.	Longline (rope 220m, float 8 pieces)	2 sets	636	1,272
b.	Anchor	4 sets	173	692
c.	Rack-cage (5 tiers)	300 pcs.	10.33	3,100
d.	Watch house raft	1 set		1,320
e.	High-pressure cleaner (gasoline engine)	1 set		1,000
	Total			7,384

Note: Prices for a. longline and d. watch house raft include 10% and 20% of total material costs as labor costs for the assembly respectively.

Marketing

In general, oyster is a luxury food commodity and consumed mainly by wealthy people often in restaurants of major cities. Rock oysters are usually marketed by traders based in La Union and La Libertad, who procure them from local shellfish collectors and sell them to city restaurants. Middlemen in La Union also handle imported rock oysters from Nicaragua for the domestic distribution.

On the other hand, pacific oyster is not common in El Salvador because quantity of domestic production or supply from import is almost nil. However, its potential demand has been confirmed through tasting surveys conducted by the Project. A substantial number of people answered that they prefer pacific oyster to local rock oyster for better taste. It is likely to market pacific oyster in the same channel as that for rock oyster since no market is yet established for it. According to some rock oyster middlemen interviewed, pacific oyster is generally smaller and therefore should be less priced than local rock oyster. This perception has lead to their expected price for pacific oyster to be US$4 per dozen. Necessary marketing efforts shall be made to differentiate pacific oyster from rock oyster in terms of taste so that the pacific oyster can command a higher price.

It is envisaged for pacific oyster to be marketed in El Salvador soon and then be shipped by producers directly to consumers (restaurants) so that producers can take more profits. But this direct marketing will require sophisticated business transactions that small producers hardly deal with in general.

This livelihood model assumes that 6cm sized pacific oyster is sold to local oyster middlemen at US$4 per dozen at La Union seaport. The price is based on the prevailing price of US$5 for a dozen of over 7cm sized rock oyster. The marketing is possible all year round but better to be concentrated in high seasons such as Easter, August summer holidays, and the Christmas time.

Profitability

The profitability of the pacific oyster culture both in raft and longline methods is examined respectively based on the experiences of model groups and the market study conducted by the Project:

1. Raft method

i. Revenues

	Quantity (individuals)	Unit Price ($)	Income ($)
Sales of cultured pacific oyster	30,000 (2,500 dozens)	0.33 (4/dozen)	10,000

j. Costs

	Quantity	Unit Price($)	Amount($)
Purchase of artificial seed (5mm)	100,000	0.015	1,500
Labor for vigilance (1 man, 180 days)	180 M.D	6	1,080
Labor for seed stocking (5 men, 1 days)	5 M.D	2	10
Labor for harvesting (5 men, 10 days)	50 M.D	2	100
Labor for density adjustment (5men, 8days)	40 M.D	2	80
Labor for cage cleaning (5 men, 8 days)	40 M.D	2	80
Depreciation of the culture rafts	3 sets		221
Depreciation of the anchors	4 sets		69
Depreciation of the rack-cages	300 sets		310
Depreciation of watch house raft	1 set		132
Depreciation of high-pressure cleaner	1 set		100
Repair and Maintenance for the raft, rack-cages, watch house, pressure cleaner			125
Total			3,807

k. Profits: $10,000 - $3,807 = $6,193

l. Income Distribution

3) Profits from the culture: $6,193
4) Labor costs paid: $1,350
Total: $7,543

- Per-capita total income: $1,509
- Per-capita monthly income: $251

e. Assumptions

1) Sales of cultured curil

Quantity sold: 100,000 x 0.3 = 30,000.

Unit price: US$4.00 for one dozen or US$0.33 for one individual, sold to local traders.

2) Price for artificial seed of pacific oyster

Seed oysters are commonly produced and transacted internationally. Its prevailing price for 1/4" screen size or 5mm size in total length has been on-line searched. As a result, it ranged from US$4 to US$22 for 1,000 individuals, being fluctuated by seasonal demand-supply situation. This model assumes US$15 for 1,000 individuals or US$0.15 for one individual.

3) Labor cost

Since the island people face unemployment and underemployment, income level of the target group is assumed to be the same as that of mollusc collectors in the Jiquilisco Bay area. Suppose their monthly income is US$60, then a daily wage as opportunity cost is US$2.

6) Depreciation:

Life span of all the facilities and equipment is assumed to be 5 years. The depreciation cost for respective item is computed over 6 months as follows:

Item	Quantity	Amount ($)	Life span	Depreciation over 6 months ($)
Rafts	3 sets	2,209	5 years	221
Anchors	4 sets	690	5 years	69
Rack-cages	300 pcs.	3,100	5 years	310
Watch house raft	1 set	1,320	5 years	132
High-pressure cleaner	1 set	1,000	5 years	100
Total		8,319		832

7) Cost for repair and maintenance:

3% of total costs for all the facilities and equipment is assumed to be annual repair and maintenance cost. It is halved to compute the cost for six months.

2. Longline method

a. Revenues

	Quantity (individuals)	Unit Price ($)	Income ($)
Sales of cultured pacific oyster	30,000 (2,500 dozens)	0.33 (4/dozen)	10,000

b. Costs

	Quantity	Unit Price($)	Amount($)
Purchase of artificial seed (5mm)	100,000	0.015	1,500
Labor for vigilance (1 man, 180 days)	180 M.D	6	1,080
Labor for seed stocking (5 men, 1 days)	5 M.D	2	10
Labor for harvesting (5 men, 10 days)	50 M.D	2	100
Labor for density adjustment (5men, 8days)	40 M.D	2	80
Labor for cage cleaning (5 men, 8 days)	40 M.D	2	80
Depreciation of the longline	2 sets		127
Depreciation of the anchors	4 sets		69
Depreciation of the rack-cages	300 sets		310
Depreciation of watch house raft	1 set		132
Depreciation of high-pressure cleaner	1 set		100
Repair and Maintenance for the longline, rack-cages, watch house, pressure cleaner			111
Total			3,699

c. Profits: $10,000 - $3,699 = $6,301

m. Income Distribution

5) Profits from the culture: $6,301

6) Labor costs paid: $1,350

Total: $7,651

- Per-capita total income: $1,530
- Per-capita monthly income: $255

d. Assumptions

The same assumptions as the raft method are applied to this longline method except depreciation and repair and maintenance as described below:

<Depreciation>

Item	Quantity	Amount ($)	Life span	Depreciation over 6 months ($)
Longline	2 sets	1,271	5 years	127
Anchors	4 sets	690	5 years	69
Rack-cages	300 pcs.	3,100	5 years	310
Watch house raft	1 set	1,320	5 years	132
High-pressure cleaner	1 set	1,000	5 years	100
Total		7,381		738

<Cost for repair and maintenance>

3% of total costs for all the facilities and equipment is assumed to be annual repair and maintenance cost (US$221). It is halved to compute the cost for six months (US$111).

Economic Analysis

Two analytical methods, i.e. NPV (Net Present Value) and IRR (Internal Rate of Return) show that the model for both methods is highly feasible with the following figures:

1. Raft Method
   - NPV: US$44,942 (at the discount rate of 10%)
   - IRR: 168%

Table 5 Cash Flow of Pacific Oyster Culture in Raft Method (5 Years) *Unit: US$*

Year	0	1	2	3	4	5
1. Initial Investment						
1-1 Culture Raft, 3 sets	2,209					
1-2 Anchors, 4 sets	690					
1-3 Suspending Netcage, 300 sets	3,100					
1-4 Watchhouse Raft, 1 set	1,320					
1-5 High-presure Cleaner, 1 set	1,000					
2. Benefit						
2-1 Income from Sales, 2 harvests		20,000	20,000	20,000	20,000	20,000
3. Costs						
3-1 Purchase of Seeds		3,000	3,000	3,000	3,000	3,000
3-2 Labor for Vigilance		2,160	2,160	2,160	2,160	2,160
3-3 Labor for Stocking/Harvesting		220	220	220	220	220
3-4 Labor for Density Adjustment		160	160	160	160	160
3-5 Labor for Netcage Cleaning		160	160	160	160	160
3-6 Repair and Maintenance		250	250	250	250	250
4. Annual Net Benefit	-8,319	14,050	14,050	14,050	14,050	14,050

2. *Longline Method*
   - NPV: US$45,989 (at the discount rate of 10%)
   - IRR: 190%

Table 6 Cash Flow of Pacific Oyster Culture in Longline Method (5 Years) *Unit: US$*

Year	0	1	2	3	4	5
1. Initial Investment						
1-1 Longline, 2 sets	1,271					
1-2 Anchors, 4 sets	690					
1-3 Suspending Netcage, 300 sets	3,100					
1-4 Watchhouse Raft, 1 set	1,320					
1-5 High-presure Cleaner, 1 set	1,000					
2. Benefit						
2-1 Income from Sales, 2 harvests		20,000	20,000	20,000	20,000	20,000
3. Costs						
3-1 Purchase of Seeds		3,000	3,000	3,000	3,000	3,000
3-2 Labor for Vigilance		2,160	2,160	2,160	2,160	2,160
3-3 Labor for Stocking/harvesting		220	220	220	220	220
3-4 Labor for Density Adjustment		160	160	160	160	160
3-5 Labor for Netcage Cleaning		160	160	160	160	160
3-6 Repair and Maintenance		221	221	221	221	221
4. Annual Net Benefit	-7,381	14,079	14,079	14,079	14,079	14,079

Financial Analysis for Private Business Model

In this section, models applied by a private enterprise will be examined as opposed to those cases already verified as livelihood models that small producers work on together as a group.

In this private business model, three permanent workers will be employed to engage in day-to-day culture management such as seed stocking, density adjustment, rack-cage cleaning and harvesting. Vigilance work will be done by these three employees on a rotation basis. It is assumed that monthly wage is US$250 per person. The model can also be applied to the family-based culture, in which monthly payment to the employees can be considered as income for the family members.

1. Raft Method

a. Revenues

	Quantity (individuals)	Unit Price ($)	Income ($)
Sales of cultured pacific oyster	30,000 (2,500 dozens)	0.33 (4/dozen)	10,000

b. Costs

	Quantity	Unit Price($)	Amount($)
Purchase of artificial seed (5mm)	100,000	0.015	1,500
Salary for workers (3 men, 6 months)	18 M.M	250	4,500
Depreciation of the culture rafts	3 sets		221
Depreciation of the anchors	4 sets		69
Depreciation of the rack-cages	300 sets		310
Depreciation of watch house raft	1 set		132
Depreciation of high-pressure cleaner	1 set		100
Repair and Maintenance for the raft, rack-cages, watch house, pressure cleaner			125
Total			6,957

c. Profits: $10,000 - $6,957 = $3,043

d. Economic analysis

- NPV: US$21,060 (at the discount rate of 10%)
- IRR: 89%

Table 7 Cash Flow of Pacific Oyster Culture in Raft Method (5 Years) Financial Analysis

Year	0	1	2	3	4	5
1. Initial Investment						
1-1 Culture Raft, 3 sets	2,209					
1-2 Anchors, 4 sets	690					
1-3 Suspending Netcage, 300 sets	3,100					
1-4 Watchhouse Raft, 1 set	1,320					
1-5 High-presure Cleaner, 1 set	1,000					
2. Benefit						
2-1 Income from Sales, 2 harvests		20,000	20,000	20,000	20,000	20,000
3. Costs						
3-1 Purchase of Seeds		3,000	3,000	3,000	3,000	3,000
3-2 Wage for Laborers/vigilants		9,000	9,000	9,000	9,000	9,000
3-3 Repair and Maintenance		250	250	250	250	250
4. Annual Net Benefit	-8,319	7,750	7,750	7,750	7,750	7,750

2. Longline Method

a. Revenues

	Quantity (individuals)	Unit Price ($)	Income ($)
Sales of cultured pacific oyster	30,000 (2,500 dozens)	0.33 (4/dozen)	10,000

b. Costs

	Quantity	Unit Price($)	Amount($)
Purchase of artificial seed (5mm)	100,000	0.015	1,500
Salary for workers (3 men, 6 months)	18 M.M	250	4,500
Depreciation of the longline	2 sets		127
Depreciation of the anchors	4 sets		69
Depreciation of the rack-cages	300 sets		310
Depreciation of watch house raft	1 set		132
Depreciation of high-pressure cleaner	1 set		100
Repair and Maintenance for the longline, rack-cages, watch house, pressure cleaner			111
Total			6,849

c. Profits: $10,000 - $6,849 = $3,151

d. Economic analysis

- NPV: US$22,108 (at the discount rate of 10%)
- IRR: 102%

Table 8 Cash Flow of Pacific Oyster Culture in Longline Method (5 Years) *Financial Analysis*

Year	0	1	2	3	4	5
1. Initial Investment						
1-1 Longline, 2 sets	1,271					
1-2 Anchors, 4 sets	690					
1-3 Suspending Netcage, 300 sets	3,100					
1-4 Watchhouse Raft, 1 set	1,320					
1-5 High-presure Cleaner, 1 set	1,000					
2. Benefit						
2-1 Income from Sales, 2 harvests		20,000	20,000	20,000	20,000	20,000
3. Costs						
3-1 Purchase of Seeds		3,000	3,000	3,000	3,000	3,000
3-2 Wage for Laborers/vigilants		9,000	9,000	9,000	9,000	9,000
3-3 Repair and Maintenance		221	221	221	221	221
4. Annual Net Benefit	-7,381	7,779	7,779	7,779	7,779	7,779

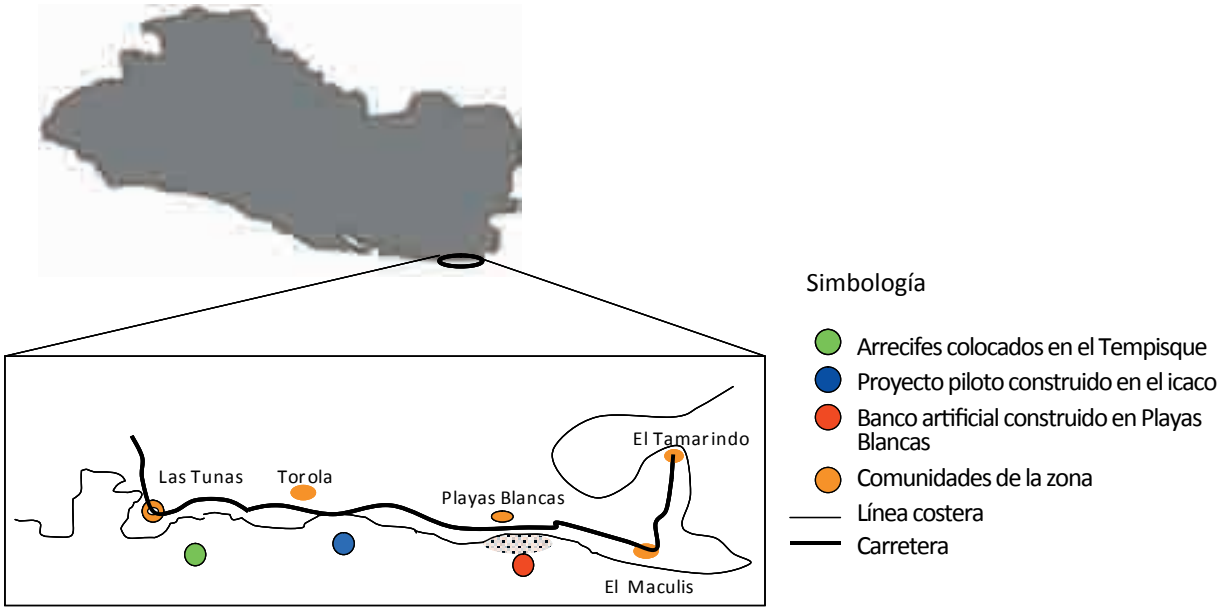
4. Livelihood Model of Artificial Reefs for Rock Oyster

Introduction

Rock oyster thrives on the coastal rocky areas and there are not a few oyster fishers who live on natural oyster collection[1]. Their main fishing grounds are found along the coastlines of La Union Province fronting to the open sea. In its original period (Jan 2005 – Jan 2008), the Project conducted a survey on the resource endowment in the area from Las Tunas to El Faro, which estimated the number of natural rock oysters harvestable (over 8cm in total length) was about 489,600. Note that the present law in El Salvador bans extraction of rock oysters less than 8cm[2].

It is reported that the resource base of rock oyster recently has been declined which is shown in the form of decrease in the catch per oyster collector. Those fishers themselves perceive the resource decline. With this background, the Project has implemented experimental installation of the artificial reefs for the stock enhancement of rock oyster in La Union with the purpose to increase income level of small-scale oyster collectors.

Figure 1 Experiment Sites of Artificial Reefs for Rock Oyster



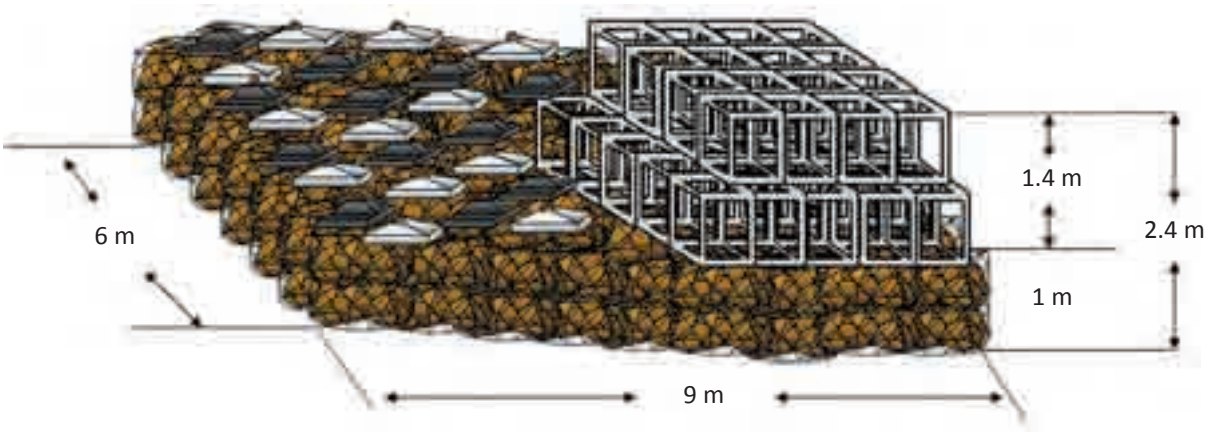
1 *According to the past survey, there are about 100 full-time and part-time rock oyster fishers in La Union Province. Another survey estimated the number of rock oyster fishers in the provinces of La Union, San Miguel and Usultan was 184. In addition, there are some more rock oyster fishers in La Libertad Province.*

2 *This regulation is not much respected by oyster collectors. It is their common practice to delineate the price by height and it is usually determined whether it is smaller than 7cm.*

First, through the experiments conducted in El Tempisque, it was confirmed that there was no significant difference in the number of oyster larvae attached to the artificial reef blocks among five different substrates used in terms of shapes and materials. Second, in El Icaco where natural rock reefs are scarce and higher density of per area larvae attachment is found, the Project installed two types of concrete blocks: pyramid type and cubic type. 50 blocks of only pyramid type were installed in April 2006 and combination of 64 pyramid blocks and 41 cubic blocks were installed in November – December 2006. The former area was 36m^2 and the latter 54m^2. Because the seabed was sandy, rock-filled gabion foundation was necessary to place the blocks on. According to the monitoring survey of the Project, the attached oyster larvae were found dead in its majority at the size of 2cm, instead, other sessile covered the surface of the reefs. In addition, sand accumulated and covered partially the gabion foundation, which lead to the conclusion that El Icaco was considered unsuitable for rock oyster artificial reefs.

Based on the experience in El Tempisque and El Icaco, the Project installed newly artificial reefs in Playas Blancas in February – March 2007. 64 pieces of pyramid blocks and 41 pieces of cubic blocks were installed at the depth of 4 to 7m in an area of 54m^2 (See Figure 2). Moreover, in March – April 2008, additional 182 pieces of pyramid blocks and 118 pieces of cubic blocks were installed next to the above Project site through Japanese Grass-roots Grant Aid.

Figure 2 An Image of Rock Oyster Artificial Reefs



The Project carried out site surveys to measure the effects of the reefs above in February – March 2009. It was observed that a lot of rock oysters were attached to the Project reefs while it was minimal on the Grant Aid reefs probably because the latter had been installed after the spawning season of the rock oysters. Therefore, this model will be based on the artificial reefs installed by the Project in Playas Blancas.

Beside the above, there have been observed spill-over effects of the reefs to aggregate high valued fish and lobsters. Such economic effects as fish stock recruitment and enhancement including reproduction and nursing of fry and juveniles can hardly be measured quantitatively. Hence, this livelihood model does not include such secondary benefits.

Beneficiaries and Organizations

The artificial reefs for rock oyster put in place in Playas Blancas were principally treated as an experimental research of the Project which did not address much participation of the would-be beneficiaries, i.e. oyster collectors in the beginning. In other words, fabrication of the concrete blocks was done by a local factory, the gabion and blocks were installed by contracted workers and the monitoring was conducted by the Project personnel. Soon after confirmation of good attachment of oysters on the reefs, the Project started to organize local oyster collectors into a group and let them manage the reefs. However, the oyster collectors did not get interested and their participation was not promoted. Eventually a fishers' cooperative was organized as the managing entity in which only a few oyster collectors joined. As for the artificial reefs of the Grant Aid, the organizing of an oyster collectors' group was so tardy that the ADESCO took it over in which there were only a few oyster collectors. As a result, in both cases there are only few oyster collectors in the reef management organizations but the majority of them are fishers who are considered as primary beneficiaries of the artificial reefs. They can enjoy spill-over of the Project, that is, increased catch of fish and lobsters near the reefs and inside the gabion. It is advisable though that more oyster collectors participate in the fishers' cooperative or ADESCO as soon as possible to make necessary coordination and collaboration in the management of fish resources and oyster stock enhancement as a united group. Rules and regulations need to be set on the management and utilization of the reefs.

Generally speaking, no ownership is given over the marine resources to any individual or organization, and thereby its utilization is driven through the "open access" regime. Unless otherwise regulated, useful aquatic resources attached or aggregated onto the artificial reefs can be accessed and utilized by anyone. If fishing right or use right of demarsal fisheries resources is furnished to a specific organization or group for a certain area, sustainable resource management can be attained without over-exploitation. In this regard, it is important to stipulate ownership of artificial reefs, use/management right over a sea area in line with existing laws and policy of relevant government offices such as CENDEPESCA. Needless to say that, for this to be made possible, resource users shall be formed into a registered organization with juridical personality.

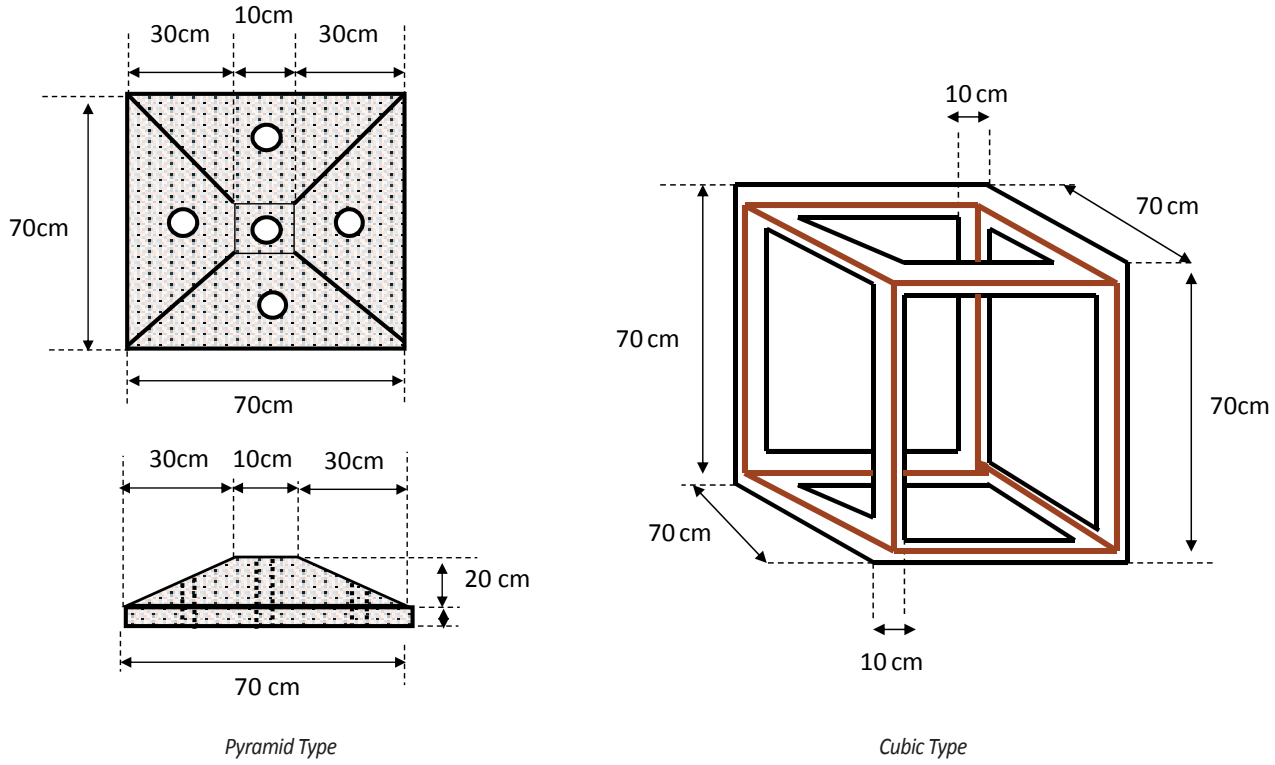
From the discussions above, implementing body of this livelihood model is assumed to be a fishers' cooperative or ADESCO which include memberships of rock oyster collectors.

Technology

The artificial reefs for rock oysters were installed by the Project in Playas Blancas in February – March 2007. Two years later, the Project conducted a survey to measure its effects in February 2009. A summary of the survey is described below:

Two types of concrete blocks have been installed as shown in the following figure:

Figure 3 Two Types of Concrete Blocks used in Artificial Reefs for Rock Oysters



Pyramid Type *Cubic Type*

64 blocks of pyramid type and 41 blocks of cubic type were used to construct the artificial reefs. They were placed on the gabion filled with rocks as shown in Figure 2.

The survey was to count the number of rock oysters attached onto those blocks and to record the sizes through a sampling method. Six pyramid blocks and three cubic blocks were extracted as samples. A total of 807 individuals of rock oyster were observed on those 9 blocks. The average number of oysters per block and its average size were taken. Eight control points were established in nearby rocks by enclosing 0.5m square which was supposed to have flat surface. The result was shown in the following table:

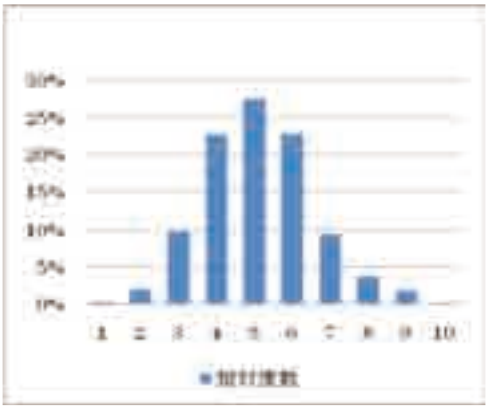
Table 1 Rock Oysters attached to Artificial Reefs in Playas Blancas

Type of substrate	Average number of oysters per block	Average number of oysters per m² (bottom)	Average number of oysters per m² (surface)	Average size of oysters (cm)
Pyramid block	64.5	131.6	98.5	5.47
Cubic block	140.0	285.7	58.3	5.55
Total				5.50
Control	16.7	67.0	67.0	4.72

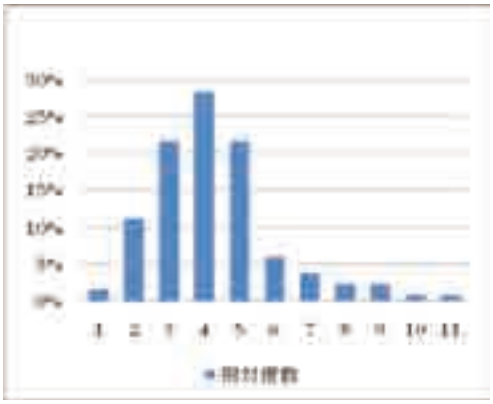
In terms of the bottom area, compared to the control (67.0 individuals per m²), the significant number of oysters were attached on both types of artificial blocks: about two times in pyramid block (131.6) and about four times in cubic block (285.7), which confirms the effects of artificial reefs in the enhancement of rock oyster resource. In terms of the surface area, there was no significant difference among two types of blocks and the control, and therefore, it would be the surface area per bottom area which could affect the number of oysters to be attached on. Note that both types of block have the same bottom area, that is 0.49m², but the surface area of pyramid type has 0.59m² and that of cubic type 2.4m², the latter is about four times larger than the former.

The average size of the sampled oysters attached onto the artificial blocks two years after the installation of the reefs was 5.5cm. It is significantly different from 4.72cm recorded by oysters found in the control area. Frequency distributions of the sample sizes for these two cases are described as follows:

Figure 4 Frequency Distributions of Sampled Oysters by Size in Playas Blancas



Artificial Reefs installed by the Project



Control (Natural Rocks)

As shown in the figures above, the peak is found at the 5cm in the artificial reefs and 4cm in the control. This could be attributable to the reproduction cycle that only newly recruited oysters for last two years were attached to the artificial reefs, and that the oysters attached for the first year have been dominant. This distribution pattern will be changed to that of the control over the years.

It is assumed in this livelihood model, the harvest of oysters will be done for four years from the 2nd year until 5th year. And 50% of oysters sized from 4cm to 7cm and 100% of over 7cm sized will be harvested. The reason why only 50% of the former size is harvested is that it may not command good market prices due to its small size and also the remaining 50% of oysters can grow better due to the thinning effect. In the short-run, it can be assumed that no frequency distribution pattern is changed. Therefore, it is assumed constant that frequency for 4cm to 7cm accounts for 73% and that for over 7cm 15%. These figures will be important parameters for this modeling.

Right after the harvest, other aquatic living things may adhere on the spots where the harvested oysters formerly occupied before. This means reduction of future harvest of oysters and the model assumes 10% reduction of harvest year by year.

Effective life span of the artificial reefs may depend on the installation place. But in general, artificial reefs are installed in shallow water with the depth of 4m at low tide and 7m at high tide. In this situation, the reefs might be covered with sand accumulated by the wash, waves and tides. Therefore, life cycle of the artificial reefs is estimated to be five years.

Summarizing the above, assumptions are set for rock oyster artificial reefs as follows:

Table 2 Assumptions for Livelihood Model of Rock Oyster Artificial Reefs

Item	Assumption
Area of reefs	54m²
Time for installation	Spawning period (October through March)
Type and number of concrete blocks	Pyramid: 41 pieces Cubic: 64 pieces
Number of oysters adhered by type of block	Pyramid: 140 individuals Cubic: 65 individuals
Growth rate of oyster	5.5cm / 2 years
Frequency distribution of oyster by size 2 years after the installation (constant for 4 years)	Over 7cm: 15% 4cm – 7cm: 73%
Selective harvesting (once a year)	Over 7cm: Total harvest 4cm – 7cm: 50% harvest
Yearly reduction in the harvest	10% less than previous year
Life span of the reefs	5 years due to sand accumulation

Materials and Equipment

The materials and equipment necessary for setting the proposed artificial reefs are as follows:

Materials Necessary for Artificial Reefs for Rock Oysters

	Item	Quantity	Unit Price ($)	Amount($)
a.	Transportation raft for materials	1 unit		847
b.	Natural stones	13 loads	100	1,300
c.	Gabions	19 rolls	27	513
d.	Pyramid type concrete blocks	64 psc.	20	1,280
e.	Cubic type concrete blocks	41 pcs.	25	1,025
f.	Unskilled labor (5men, 15 days)	75 M.D	8	600
g.	Skilled labor for diving (3 men, 15 days)	45 M.D	30	1,350
h.	Hire of transportation boats (2 ships, 15 days)	30 S.D	100	3,000
	Total			9,915

Notes

(1) It takes 15 days to install the artificial reefs in the sea. Unit labor cost for materials transportation and on-the-sea installation works is considered the same as that for general civil works ($8 per day).
(2) Labor cost for divers (skilled labor) includes rental of diving equipment and pressured air.
(3) Cost for transportation raft includes labor cost for operator and fuel cost.
(4) No maintenance and repair cost will incur.

Marketing

Rock oysters are consumed in El Salvador by better-off people particularly in those restaurants located in San Salvador, La Libertad, San Miguel, etc. It is being sold at the public markets of La Union too. At the moment, marketing of rock oysters is chiefly tasked to local middlemen of La Union and La Libertad who intermediate producers and consumers through its distribution channel. They handle imported oysters from Nicaragua, which reportedly account for about 75% of domestic consumption. Rock oysters are marketed by dozen and size. 7cm is the critical size. The prevailing producers' prices in La Union are $2.50 to $4.00 for 4cm to 7cm size and $5.00 to $6.00 for over 7cm size.

In this livelihood model, it is expected to harvest only once a year which shall fall in the high season for seafood. Considering the spawning time of rock oysters from October through March, it is advisable to

harvest them for the sale in the Christmas vacations. In so doing, after harvest, it is likely to have newly reproduced rock oyster larvae attached onto the artificial reefs again.

There might be two marketing methods for the producers: locally selling to middlemen and direct shipment to city restaurants. Generally it is not easy for small producers to entertain perpetual purchase orders from customers. Therefore, it is recommended not to consider direct marketing from the beginning but to market the product to local middlemen who has already established the marketing channels and fixed clients.

It is assumed the selling prices to local middlemen at the Christmas time are: $3.00 for 4cm to 7cm size and $6.00 for over 7cm size per dozen respectively.

As shown below, the number of rock oysters harvested and income from the sale for the second year are estimated from the number of oysters adhered, relative frequency distribution by size and harvest rate.

Table 3 Number of Rock Oysters attached onto the Model Artificial Reefs

Type of concrete blocks	Number of blocks	Average number of oysters per block	Total number of oysters
Pyramid	64	65	4,160
Cubic	41	140	5,740
Total (a)			9,900

Table 4 Income from the First Harvest (2nd Year)

Size of oyster	Frequency (b)	Harvest rate (c)	No. of oysters harvested (a x b x c)	Unit price per dozen ($)	Income ($) 2nd Year
4cm – 7cm	73%	50%	3,614	3	904
Over 7cm	15%	100%	1,485	6	743
Total					1,646

From the 3rd year, the harvest will diminish by 10%, which gives five-year income as follows:

Table 5 Income from Harvest of Rock Oysters for 5 Years

Year	1	2	3	4	5
Income ($)	0	1,646	1,481	1,333	1,200

Economic Analysis

Two analytical methods, i.e. NPV (Net Present Value) and IRR (Internal Rate of Return) show that the model for both methods is not feasible with the following figures:

1. Raft Method
   - NPV: -US$5,786 (at the discount rate of 10%)
   - IRR: -15%

Table 5 Cash Flow of Livelihood Model for Rock Oyster Artificial Reefs (5 years) Unit: US$

Year	0	1	2	3	4	5
1. Cost (Initial Investment)	9,915					
2. Benefit (Income)		0	1,646	1,481	1,333	1,200
3. Annual Net Benefit	-9,915	0	1,646	1,481	1,333	1,200

Alternative Version of Artificial Reefs for Rock Oyster Livelihood Model

From the survey to measure the effect of the artificial reefs conducted in February to March 2009, it is possible to compare the numbers of oysters adhered onto the two types of concrete blocks (Table 1). It indicates clearly that the cubic block has more oysters attached than the pyramid one. In addition, the cubic type is 70cm in height, and it does not require gabion for its placement, but rather, it can be placed directly on the seabed. Therefore, this alternative version of artificial reefs will be composed of only cubic type concrete blocks without using gabion. Although cost for the concrete blocks increases, no cost for gabion nor cost for divers (skilled laborers) to assemble the gabion or adjust the positions of pyramid blocks under water. Installation works of this simplified version of artificial reefs may take only five days.

The details of this alternative model are shown below for future consideration.

1. Materials Necessary for Alternative Version of Artificial Reefs for Rock Oysters

	Item	Quantity	Unit Price ($)	Amount($)
a.	Transportation raft for materials	1 unit		847
e.	Cubic type concrete blocks	105 pcs.	25	2,625
f.	Unskilled labor (5men, 5 days)	25 M.D	8	200
h.	Hire of transportation boats (2 ships, 5 days)	10 S.D	100	1,000
	Total			4,672

2. Number of Rock Oysters attached onto the Alternative Model Artificial Reefs

Type of concrete blocks	Number of blocks	Average number of oysters per block	Total number of oysters (a)
Cubic	105	140	14,700

3. Income from the First Harvest (2nd Year)

Size of oyster	Frequency (b)	Harvest rate (c)	No. of oysters harvested (a x b x c)	Unit price per dozen ($)	Income ($) 2nd Year
4cm – 7cm	73%	50%	5,366	3	1,342
Over 7cm	15%	100%	2,205	6	1,103
Total					2,445

4. Income from Harvest of Rock Oysters for 5 Years

Year	1	2	3	4	5
Income ($)	0	2,445	2,201	1,981	1,783

5. Economic Analysis

- NPV: US$1,462 (at the discount rate of 10%)
- IRR: 20%

The cost-benefit analysis reveals that the alternative model is feasible.

6. Cash Flow of Alternative Model for Rock Oyster Artificial Reefs (5 years) *Unit: US$*

Year	0	1	2	3	4	5
1. Cost (Initial Investment)	4,672					
2. Benefit (Income)		0	2,445	2,201	1,981	1,783
3. Annual Net Benefit	-4,672	0	2,445	2,201	1,981	1,783

5. Fish Aggregating Devices (FADs) Livelihood Model for Hand-line Fishers

Introduction

In its original period from Jan 2005 to Jan 2008, the Project implemented various income diversification projects towards those model groups who engaged in experimental trials of mollusc culture. The purpose of these livelihood projects was to supplement their income while the mollusc culture was not able to generate immediate income for those needy beneficiaries. From the experience in the artificial reefs for rock oysters implemented in Playas Blancas, La Union, it was confirmed that the reefs had spill-over effects to aggregate fish and other aquatic resources that could contribute to the increased catch for fishers. The concrete blocks used for the oyster artificial reefs might be effective for fish aggregation for hand-line fishing as well. Based on this idea, the Project assisted two mollusc culture groups near Puerto El Triunfo, Jiquilisco in the installation of Fish Aggregating Devices (FADs) made of concrete blocks near their mollusc culture grounds. Soon after the installation, their fish capture has been improved drastically to contribute to the increased income level. The hand-line fishing has become their main source of income as opposed to the original idea to supplement the mollusc culture project. Specifically, the fishing with FADs is found more lucrative undertaking which provides expeditious and stable income to small-scale fishers.

Beneficiaries and Organizations

There are two model groups who implement the FADs livelihood projects as follows:

Table 1 Model Groups of FADs for Hand-line Fishing

Name of model group	Number of members	Characteristics	Species of mollusc
Zapateta	21	Hand-line fishers, shellfish collectors	Curil
La Venada	17	Hand-line fishers, Shellfish collectors	Casco de burro

Those members of two groups used to engage in hand-line fishing not far from Puerto El Triunfo in Jiquilisco Bay, and at the same time in the extraction of curil from the mangrove areas. Their income from the both activities is minimal and unstable, which made them economically vulnerable. The two model groups belongs to the same community called Palmera, and divided their fishing grounds in Jiquilisco Bay with by tacit agreement. They set up the mollusc culture plots near their respective fishing grounds. In accordance with soil characteristics of their mollusc culture sites, they chose target culture species: curil or casco de burro. Pacific oyster culture had been experimented in both sites but it failed due to massive fouling of barnacles. As a self-help effort of the groups, they placed snags and driftwood on the seabed of their fishing grounds to enhance fishing efficiency. It was found effective only for the first four months and then they came up with an idea of placing concrete block artificial reefs for the prolonged effectiveness. Through a series of consultations with the Project, both groups succeeded in establishing the FADs.

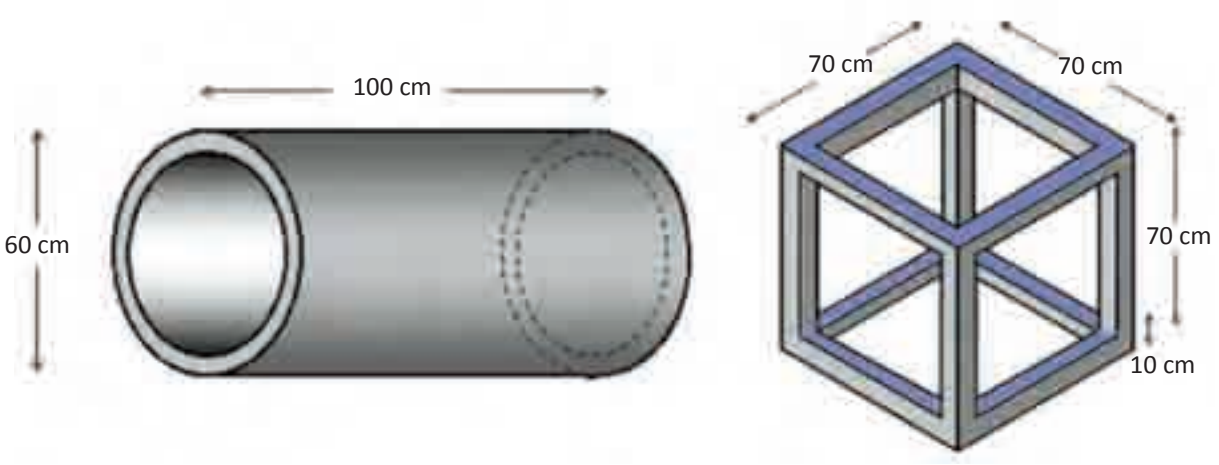
These groups are registered fishers' cooperatives with Department of Farmers' Associations, Ministry of Agriculture and Livestock, composed of fishers licensed by CENDEPESCA. Basically utilization of fisheries resources is practiced under "open access" and unless otherwise regulated, anyone have the opportunity to utilize those aquatic living resources aggregated to the FADs. It is necessary for the groups to acquire permit or licence from the authority as to such rights of resource utilization.

It has been proven that hand-line fishing with FADs can be better combined with mollusc culture because the watch house constructed next to the mollusc culture site is a good place for vigilance, storage of equipment/ materials and stand-by.

Technology

For the purpose of aggregating fish, the following two types of concrete blocks have been used:

Figure 1 Two Types of Concrete Blocks used as Fish Aggregating Devices



Cylindrical Type *Cubic Type*

In an area of about 225m^2 at the depth of 10m and 100 to 140m far from the coastlines, 38 cylindrical blocks and 164 cubic blocks were placed in respective sites of Zapateta and La Venada in Jan–Feb and Jun–Jul 2008. The sites are generally characterized with poor visibility and strong current. Ever since the placement, the fishers enjoyed increased catch from the FADs. In Feb-Mar 2009, the Project conducted a survey to measure the impact of the FADs in a quantitative manner as much as possible. This modeling is based on the survey results.

Catch data for five months from June to October 2008 that the Project took in cooperation with fishers of Zapateta group is summarized in the following table:

Table 2 Monthly Average Catch Data per Fisher in Zapateta June to October 2008

Fish classification	Monthly average catch (Lbs.)	Class composition (%)	Standard unit price per Lb.	Monthly average sale per fisher ($)
1st class[1]	225.8	29	1.40	316.14
2nd class[2]	395.5	50	0.90	355.93
3rd class[3]	165.7	21	0.40	66.29
Total	787.0	100		738.37

The monthly average sale or income per fisher was US$738.37. This period was considered as rainy season that is generally good for fishing. On the other hand, the remaining period from November to May, that is dry season, might be considered as lean fishing time. Therefore, an assumption is made for the monthly average sale for these months to be one third of that in the rainy season, i.e. $246.12. Out of 21 members of the group, four persons are female who do not go for fishing and other 17 members are those who engage in fishing on a daily basis. Based on the above, total sale for the first year after the installation of FADs is estimated as follows:

Table 3 Estimation of 1st Year Sale from the Fish Aggregating Devices in Zapateta

Period	Monthly average sale per fisher ($) (a)	Number of fishers (b)	Number of months (c)	Total sale ($) (a) x (b) x (c)
Jun to Oct	738.37	17	5	62,761
Nov to May	246.12	17	7	29,288
Annual total				92,050

According to the site diving survey conducted by the Project in February to March 2009, there observed aggregated fish resources of pargo, robalo and etc. As juveniles of some fish species including pargo and Heamulon spp. were also observed, the FADs area was most likely serving as a nursing ground for these fish species. The fishers pointed out the outstanding effects of the FADs to contribute to the enhanced catch of fish especially high valued demarsal species. According to them, their income has increased by 20% to

1 *Lutjanus spp., Centropomus Lobalito, Odontoscion sp., etc.*
2 *Haemulon spp, etc.*
3 *Carangidae, etc.*

50% compared to what they yielded before the FADs installation. In this model, the effect of the FASs in the increase of fish catch is assumed to be 20% increase of the sale.

The same survey in La Venada that was conducted about one year after the installation revealed that some cylindrical blocks had been submerged or sunk into the sandy seabed and lower half part of the block was covered with sand. This fact implies that the cylindrically shaped block is not suitable for sandy seabed that is predominant in Jiquilisco Bay. Therefore, the model uses only cubic type blocks for FADs, given there is no difference in the effects between the two types. Note that the area where the cubic blocks were concentrated, the seabed appeared a little hollowed in a mortar shape. It is unpredictable how this would further change, but at least no sand covering or sinking into the seabed has ever happened. A conservative assumption is made for the effective life of the FADs of cubic blocks to be five years, and for reduction rate of fish catch effectiveness to be 20% a year due to possible gradual sinking of the concrete blocks.

Summarizing the above, assumptions are set for FADs as follows:

Table 2 Assumptions for Fish Aggregating Devices Livelihood Model

Item	Assumption
Area of FADs fishing ground	225m^2 to 1,000m^2
Type and number of concrete blocks	Cubic type: 202 pieces
1st year sale from the catch	$92,050
Effect of the FADs in terms of fish catch (sale)	20% ($18,410)
Rate of reduction in the effect a year	20%
Effective life span of the FADs	5 years

Materials and Equipment

The materials and equipment necessary for setting the proposed FADs are as follows:

Materials Necessary for Fish Aggregating Devices

	Item	Quantity	Unit Price ($)	Amount($)
a.	Transportation raft for materials	1 unit		847
b.	Cubic type concrete blocks	202 pcs.	25	5,050
c.	Unskilled labor (5men, 10 days)	50 M.D	8	400
d.	Hire of transportation boats (2 ships, 10 days)	20 S.D	100	2,000
	Total			8,297

Notes

(5) It takes 10 days to install all the blocks in the sea. Daily labor for materials transportation and on-the-sea installation works is considered the same as that for general civil works ($8 per day).

(6) Cost for transportation raft includes labor cost for operator and fuel cost.

(7) No maintenance and repair cost will incur.

Marketing and Income

In general, fish is marketed by middlemen who intermediate producers and consumers except the case of direct shipment of fish by fishers to consumers such as restaurants. Marine products have different characteristics from other food commodities. For example, they need careful and speedy handling under refrigeration, planned production as to quantity and quality is not possible and price may fluctuate mostly due to supply side reasons. It is the very reason why specialized intermediaries are necessary for market distribution of marine products. In this respect, the model assumes that fish caught in the FADs will be marketed through local middlemen. Some middlemen have already been good clients of the model group fishers.

The catch enhancement effects derived from the installation of FADs may decrease year by year due to their own sinking into the seabed. And it obviously affects fish catch and sale. Such diminution of the effects is assumed to be 20% a year. Total fish catch and increased portion of fish catch are shown below:

Table 5 Increased Sale as Effects of Fish Aggregating Devices for 5 Years *Unit: US$*

Year	1	2	3	4	5
Total sale of fish caught (100%)	92,050	73,640	58,912	47,130	37,704
Increased portion of sale (20%)	18,410	14,728	11,782	9,426	7,541

Economic Analysis

Two analytical methods, i.e. NPV (Net Present Value) and IRR (Internal Rate of Return) show that the model is highly feasible with the following figures:

1. Raft Method

- NPV: US$40, 584(at the discount rate of 10%)
- IRR: 202%

Table 6 Cash Flow of Fish Aggregating Devices Livelihood Model (5 years) *Unit: US$*

Year	0	1	2	3	4	5
1. Cost (Initial Investment)	8,297					
2. Benefit (Income)		18,410	14,728	11,782	9,426	7,541
3. Annual Net Benefit	-8,297	18,410	14,728	11,782	9,426	7,541

Contáctenos

Proyecto JICA-CENDEPESCA

Oficina de CENDEPESCA - Puerto El Triunfo
Col. Las Palmeras, Calle a Atarraya, Puerto El Triunfo, Usulután. **Telefax: 2633-7416**

CENDEPESCA/Ministerio de Agricultura y Ganadería (MAG)
Final 1a. Av. Norte y Av. Manuel Gallardo,
Santa Tecla, La Libertad. **Tel.: 2228-1066**