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Reduction of Environmental Impact from Tropical Shrimp Trawling, through the introduction of By-catch Reduction Technologies and Change of Management
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Costa Rica

Characterisation of the Costa Rican semi-industrial coastal shrimp trawling fishery and the small scale artisanal shrimp trawling fishery

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

CHARACTERIZATION OF THE COSTA RICAN SEMI-INDUSTRIAL COASTAL SHRIMP TRAWLING FISHERY AND THE SMALL SCALE ARTISANAL SHRIMP TRAWLING FISHERY

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CHARACTERIZATION OF THE COSTA RICAN SEMI-INDUSTRIAL COASTAL SHRIMP TRAWLING FISHERY AND THE SMALL SCALE ARTISANAL SHRIMP TRAWLING FISHERY

Introduction

All kinds of capture fisheries trap organisms that are not their primary fishing target, known as by-catch. The By-catch may include juveniles of the target species and non commercial species, including fin fishes, crustaceans, birds, sea turtles, mammals causing a significant ecological impact.

FAO recently estimated a that the total by-catch discarded in the world is around 20 million metric tons representing a quarter of the total global catch (Cook, 2001), causing billions of economic losses if we take into account all the potential future catches that are lost due to discards.

The by-catch arises because all fishing gears are not selectively perfect; however economic and social pressures make the problem worse, leading to an inefficient use of the resources that will cause overexploitation and changes in the composition of target and non target species and in some cases it could lead the different resource to become threatened with extinction (Cook, 2001). In addition, depending on the kind of gear used by the fishery, specially trawling fishery, the effects on the physical environment can be drastic affecting the overall ecosystem, changing the whole structure of the seabed and water column composition (Kaiser, *et al*., 2001).

There are two kinds of by-catch; one is known as incidental catch and is the portion of by-catch that has commercial value and therefore is retained to be sold in the markets. The other type of by-catch is known as discards; which refers to parts of the catch that do not have economical value and in some cases do not meet the legal requirements to be landed (Cook, 2001). Thus the total catch is equal to target catch + by-catch and

$$Total\ Catch = \text{target catch} + \text{by} - \text{catch}$$

$$By - catch = incidental\ catch + discards$$ faca commercial +discards

or in other words

$$Total\ catch = \text{target catch} + incidental\ catch + discards$$

Since discards depends mainly on the commercial value of the non-target species captured, some changes in the composition of the discards may arise if some of these species begin to have a market value. The incidental catch is usually occupies a good part of the economy of the fishermen and owners of the vessels.

Shrimp trawling in the shallow waters of the tropics is very common; the problem with this kind of fishery causes one of highest mortalities of non-target fish species. According to Alverson, *et al*., (1994, cited by Cook, 2001), on average, the shrimp trawl fishery discards 12 kg of by-catch for every kilogram of shrimp landed, while of the top 20 fisheries by discard rate in the world, 14 are shrimp fisheries.

Reptiles, birds and mammals do not necessarily represent another group of by–catch, is the public perception that makes them “more important” that fishes, crustaceans and others groups, specially in the Western Hemisphere where conservation issues take precedence over resource exploitation, creating a cultural separation rather than a scientific one; this is why they are taken into account separately. Scientifically speaking, one thing that all these groups have in common is low reproduction rates and large age at first maturity, which makes them more vulnerable to the effects of fishing (Cook, 2001).

One of these special groups of animals is the sea turtles. Turtles populations have declined considerately to the extend that they are considered threatened or endangered and all 8 species are included in Appendix 1 of CITES.

Shrimp trawling around the world has been identified as one of the mayor causes of turtle mortality. In order to solve this specific problem some countries have already take some actions by implement the use of turtle–exclusion devises, known as TEDs. Countries like the USA, Australia,

In Costa Rica, it is mandatory to use them since 2000 (INCOPESCA, 2000, Cajiao, 2003), and according to the new Fishery and Aquaculture Law, approved early 2005, the shrimp fishing vessels have to carry and extra pair of TEDs as replacements in case that something happens during fishing operations.

The amount of turtles

Methodology

The characterization of the Costa Rican costal shrimp trawling fleet was done according to the forms presented by FAO to the author, all of which are presented in the Appendix section.

Semi-Industrial Fleet

To gather the information, different sources were used. From the Costa Rican Institute of Fisheries and Aquaculture (INCOPESCA by its Spanish name) Fishing vessels database we obtained the official records of the Fleet Database (INCOPESCA, 2005). The data obtained from INCOPESCA was: The name of the vessel, license number, owner, owner's contact information, base port, year of construction, construction material, length, width, stern length, Total and net weight, brand model and power of the main engine. The rest of the information was gathered from the interviews done to the owner's or captains of the vessels.

With INCOPESCA's official information, the vessels that have only active license for coastal shrimp trawling were determined. There were 45 Semi-industrial coastal shrimp trawling vessels with an active license at the time that this characterization was done, and these were the ones that were interviewed. Of the 45 actives vessels only 36 filled the forms 1 to 4 see appendixes

The two shrimp fishermen associations, The Cámara Puntarenense de Pescadores (Puntarenas Fishermen Chamber) and Unión Independiente de Pescadores (UNIPESCA, Independent Union of Fishermen), present at the city of Puntarenas provided the information of which vessels belonged to their respective association.

The information provided by INCOPESCA and that gathered through the interviews and the Cámaras, were input to a database designed in MS Access 2000 for this purpose, and then analyzed. The economic data provided from the owners of the vessels were given with different time frames. The income data were provided by the duration of the fishing trip while the expenses data were provided usually on figures by month, some were provided by trimester and others were given annually. The information provided by trimester, semester or annually were converted to monthly data in order to input them into the database.

Since there is a big difference among the days that a fishing trip lasts (Figure 5), the income and expense information was converted to daily data to be able to make a comparison of the information provided.

In order to corroborate some of the information provided by INCOPESCA, the website of the Registro Nacional (National Registry) was checked. The US dollar conversion rate was established as the average of the daily rates of the month of July, 2005. The information of the US dollar daily rate was obtained from the website of the Costa Rican Central Bank (BCCR, 2005).

Small Scale Artisanal Fleet

Results

Semi-industrial Shrimp Trawling Fleet

General Characteristics

In Costa Rica, the shrimp trawling is performed in the Pacific Coast of the country. The semi-industrial fleet has 72 registered fishing vessels with the Fisheries National Authority, INCOPESCA, of which 11 have permit to fish deep water shrimp and 61 can fish costal shrimp[1] (INCOPESCA, 2005).

The base port for all the shrimp trawling fleet is the city of Puntarenas, at the central coats of the country. All these vessels use Diesel as fuel and all are privately owned. Of the 72 vessel registered with INCOPESCA, 52 are active (license has not expired) of which 7 catch deep water shrimp and the other 45, have coastal water shrimp license (INCOPESCA, 2005).

The semi-industrial shrimp trawling fleet has an average age of 23,6 years, with a range between 3 and 50 years old. 64% of the coastal shrimp trawling vessels that have an active license are older than the average age. Only one vessel is 50 years old, while there are four vessels that have and age between 36 and 40 years. On the other hand, there are 3 age frequency ranges that have 8 vessels, 35, 30 and 25 years old (18% each). The age frequencies of 20 and 15 years old have 4 vessels respectively (9% each). 18% of the fleet has less than 10 years old. The newest vessel is 3 years old (Figure 1).

The main construction material of the shrimp trawling vessels is wood with a 52% (23 vessels) followed by metal with a 44% (20 vessels). There are only 2 vessels (4%) constructed of plastic fiber (Figure 2)

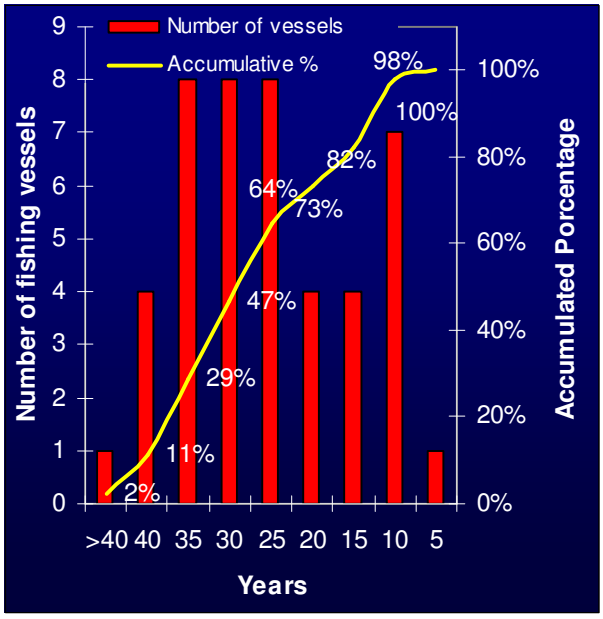


Figure 1. Frequency distribution of the Age of the semi-industrial shrimp trawling fishing vessels. X axis in reverse order. Sample size = 45 Source: Modified from INCOPESCA (2005).

[1] The vessels that have a costal shrimp fishing permit can also fish deep water shrimp.

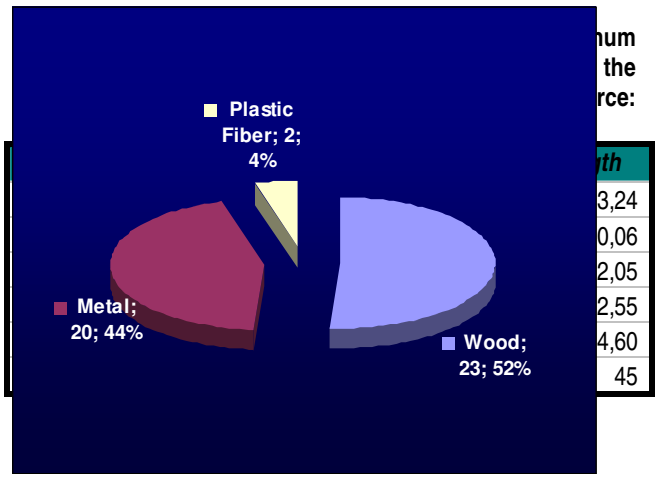


Figure 2. Construction material of the Costa Rican coastal shrimp trawling vessels. Sample size = 45 Source: Modified from INCOPESCA (2005).

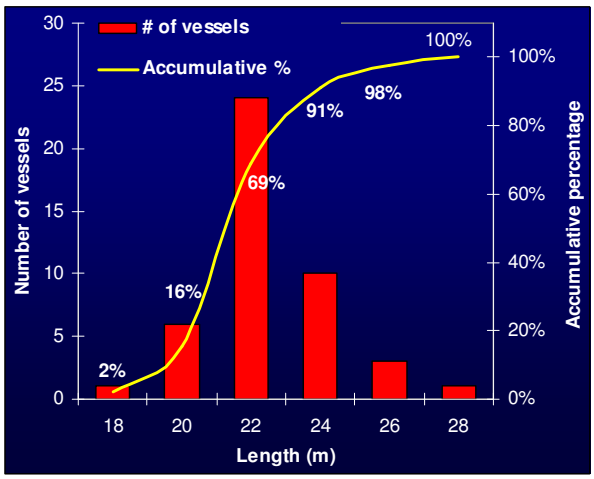


Figure 3. Length frequency of the length (in meters) of the Costa Rican coastal shrimp trawling vessels. Sample size = 45 Source: Modified from INCOPESCA (2005).

The width and length stern of the coastal shrimp trawling vessels have an average length of 6.29m and 3.24m respectively (Table 1). The range of the width is 1.91m, with a minimum of 5.4m and a maximum of 7.3m. The range of the stern length is 2.05m, with a minimum of 2.55m and a maximum of 4.60m (Table 1).

For the length of the vessels, the average is 21.8m ± 0.26 m, with a range of 10m from 17.6m to 27.6m. 54% of the vessels are within the range between 20.1m and 22m, and 69% (31 vessels) are less than or equal to the average vessel length (Figure 3). 91% of the vessels are below or equal to 24m, while there are 4 vessels (9%) larger than 24 meters (Figure 3)

The registered gross tons of the shrimp trawling vessels have a range between 49.1 MT and 142.9 MT with and average of 93.8 MT. For the Net Ton the minimum weight is 6.4 MT while the maximum is 34.3 MT (Table 2).

The capacity to carry fuel with the shrimp trawling vessels varies from 9 m^3 up to 50 m^3, with an average of 23 m^3. The capacity to carry water ranges from 4 m^3 to 76m^3, with an average of 23m^3 (Table 2).

Table 2. Mean, Standard error, range, minimum, maximum and simple size of gross and net tons, fuel, water oil and storage capacity of the semi–industrial coastal shrimp trawling vessels. Source: Modified from INCOPESCA (2005) and interviews done in the present study.

	Gross Tons (MT)	Net tons (MT)	Fuel Capacity (m^3)	Water capacity (m^3)	Oil capacity(m^3)	Product Storage capacity (Kg)
Mean	93,82	34,3	23	23	0,23	12.362
Standard Error	3,73	2,74	2	4	0,04	1.113
Range	101	85,6	41	72	0,73	45.000
Minimum	41,9	6,4	9	4	0.,06	5.000
Maximum	142,9	92	50	76	0,79	50.000
Simple size	**45**	**45**	**30**	**29**	**23**	**45**

The Costa Rican coastal shrimp trawling vessels have an average capacity of carrying 0.45 m^3 (60,7gal) with holding capacity between 0.06 m^3 (15 gal) and 0.79 m^3 (209 gal; Table 2). 39% of the interviewed vessels (9) have an oil capacity of 0.19 m^3 (50 gal), while 17% (4 vessels) have an oil storage capacity of 0.08m^3 (21.1 gal). Two (9%) fishing boats have the capacity of holding 0.06 m^3 (15.8 gal), while the remaining 32% is composed of vessels with different oil storage capacity as seen in Table 3.

Table 3. Frequency distribution of the oil holding capacity (in m³ and gallons) and its respective percentage of the Costa Rican coastal shrimp trawling fleet.

Oil capacity (m^3)	*Oil capacity (Gal)*	*Number of vessels*	*Percentage*
0,19	50,2	9	39%
0,08	21,1	4	17%
0,06	15,8	2	9%
0,10	25,1	1	4%
0,20	52,8	1	4%
0,21	55,5	1	4%
0,25	66,0	1	4%
0,30	79,2	1	4%
0,62	163,8	1	4%
0,67	177,0	1	4%
0,79	208,7	1	4%

The capacity of storage either shrimp or fish ranges from the 5,000 Kg up to the 50,000 Kg with a mean of 23,362 Kg (Table 3). There are 11 vessels (24%) that have a holding capacity of 10% Kg, 7 (16%) with a storage capacity of 15,000 Kg, 6 (13%) with 8,000 Kg, compromising 53% of the fleet (Figure 4).

The mean autonomy (fishing days per trip) of the interviewed vessels is 23 days, with a range between 15 and 30 days. As shown in Figure 5, 52% of the fishing vessels fish more than the average, and a 77% of the fleet have a fishing trip between 20 and 30 days. Seven of the interviewed vessels have a 30 day fishing trip while 6 vessels have a 20 and 25 fishing trips. For a 17 and 19 days fishing trip, there was one boat only respectively (Figure 5).

The shrimp trawling fleet reports 4 kinds of trawling nets for the capture of shrimp; semi-Ballon is used by 64% of the interviewed owners of the vessels, followed by the flat type of net (21%), American with (11%) and by Western Jeep with a 4% (Figure 6).

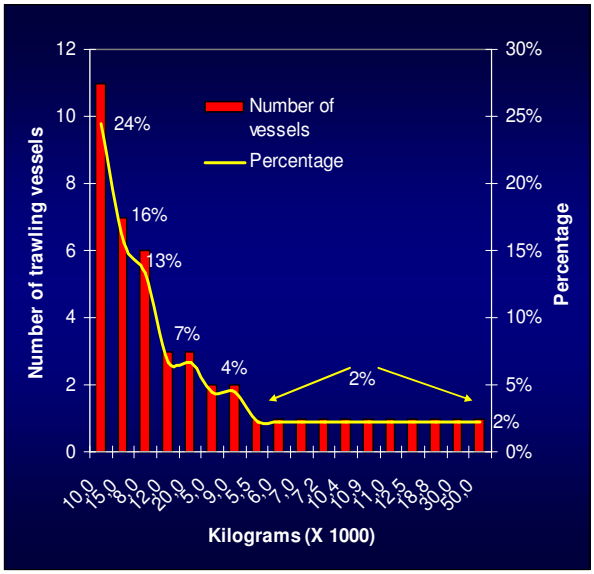


Figure 4. Holding capacity of either shrimp or fish in kilograms of the shrimp trawling fleet. Source: Modified from INCOPESCA (2005).

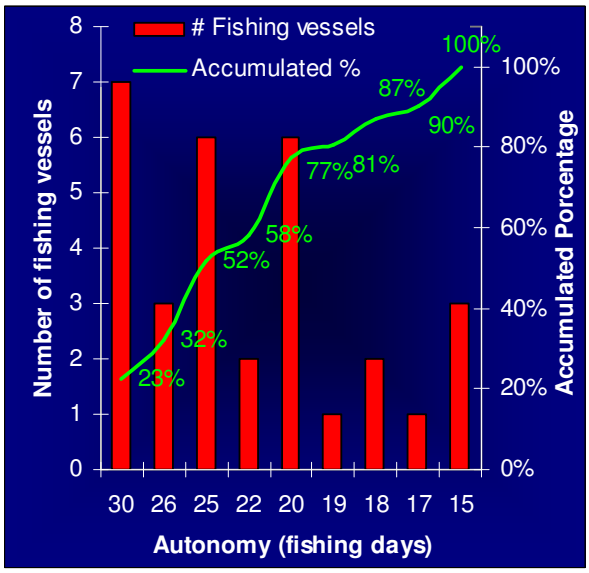


Figure 5. Frequency of Autonomy (fishing days per trip) of the interviewed vessels. X axis in reverse order.

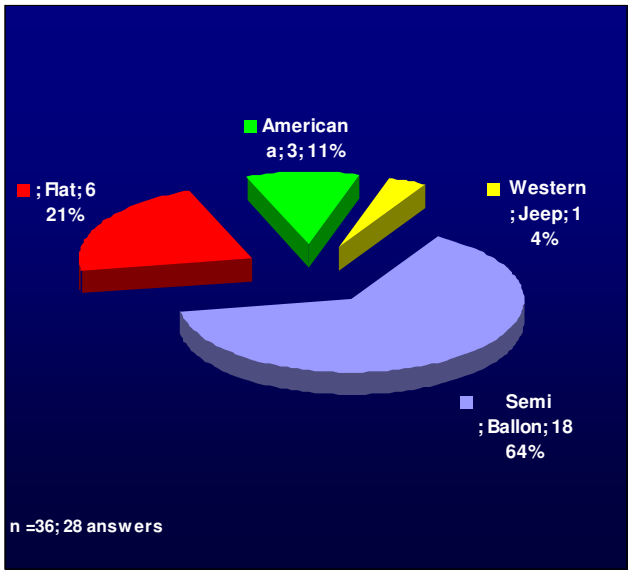


Figure 6. Kinds of trawling nets used by the Costa Rican coastal shrimp fleet.

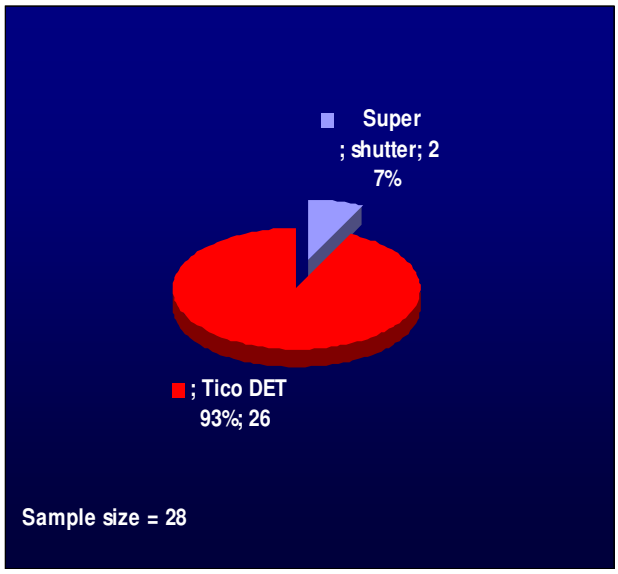


Figure 7. Kinds and percentage of TED used by the Costa Rican coastal shrimp fleet.

All the coastal shrimp fishing vessels carry 2 pairs of trawling nets and some carry replacements in case there is a problem with the ones they are using.

93% of coastal shrimp trawling fleet uses what is known as the "Tico" (Costa Rican) TED (Figure 7), a 6 inches TED as shown in Figure 8a. The remaining 7% (Figure 7) of the fishing ships uses a Super shutter TED (Figure 8b).

Figure 8. Photographs of the kinds of TEDs used in Costa Rica . A) Tico TED of inches and B) super shutter.

Vessels Machinery

Main engine

The shrimp trawling fleet has uses 4 brands of main engines; Caterpillar is used by 32 (71%) of the active vessels, while Cummins is used by 10 vessels (22%), 2 (4%) ships utilize engine from General Motor engines and 1 boat (2%) uses a Detroit engine (Figure 9).

There are 14 different models of Caterpillar engines, while for Cummins there are 3 different models only, two for General motors and 1 for Detroit (See Appendix 6 for a complete list of the different models of the engines).

The main engine of the shrimp trawling fleet was calculated by brand. The Caterpillar engines have an average power of 262.5 KHz, with a range from 133.2 to 314.5 KHz. The Cummins engines have an average power of 288.7 KHz with a range between 270.1 y 347.8. For the General Motors engines the mean power is 260.9 KHz with a range between 251.6 and 270.1 (Table 4).

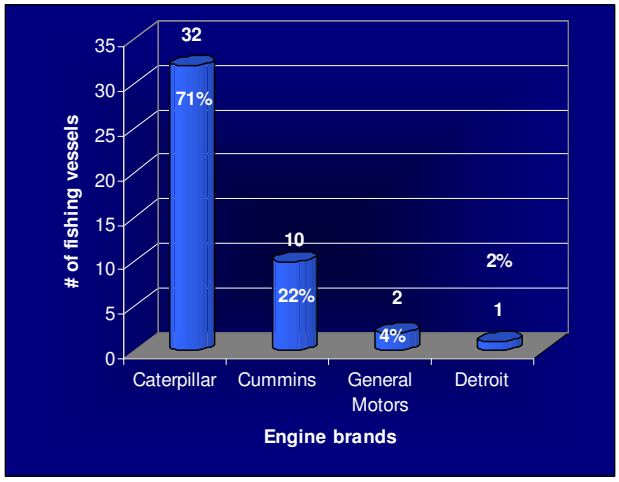


Figure 9. Main engine brands used by the Costa Rican coastal shrimp trawling fleet. Source: Modified from INCOPESCA (2005).

Table 4. Average, minimum and maximum Power (KHz) and Revolutions per Minute (RPM) of the main engines of the Costa Rican shrimp trawling fleet. Source: Modified from INCOPESCA (2005).

	Power (KHz)		
Brands	Average	Maximum	Minimum
Caterpillar	262.5	314.5	133.2
Cummins	288.7	347.8	270.1
Detroit	323.4	323.4	323.4
General Motors	260.9	270.1	251.6
	RPM		
Brands	Average	Maximum	Minimum
Caterpillar	1,867	2,050	1,800
Cummins	2,467	3,800	1,800
General Motors	2,200	2,200	2,200

The average revolutions per minute (RPM) for the Caterpillar engines is 1,867 with a minimum of 1,800 revolutions and a maximum of 2.050 revolutions. For the Cummins main engines the average RPM is 2,467 revolutions with a range between 1,800 and 3,800 revolutions per minute. The General Motors engines have a RPM of 2,200. There was no information reported for the Detroit engine (Table 4).

Secondary Engine

Of the 36 interviewed vessels only 18 had a secondary engine. Of the different brands, Lister is reported by 4 boats (22%), Nissan by 3 vessels (17%). Two vessels (11%) report having Cummins engines as auxiliary engines and other 2 report Perkins engines also (Figure 10).

There are seven vessels (1% each) that report 7 different auxiliary engine brands like Agrale, Detroit, Diter, Hazt, Izusu, Yamaha and Yanmar (Figure 10).

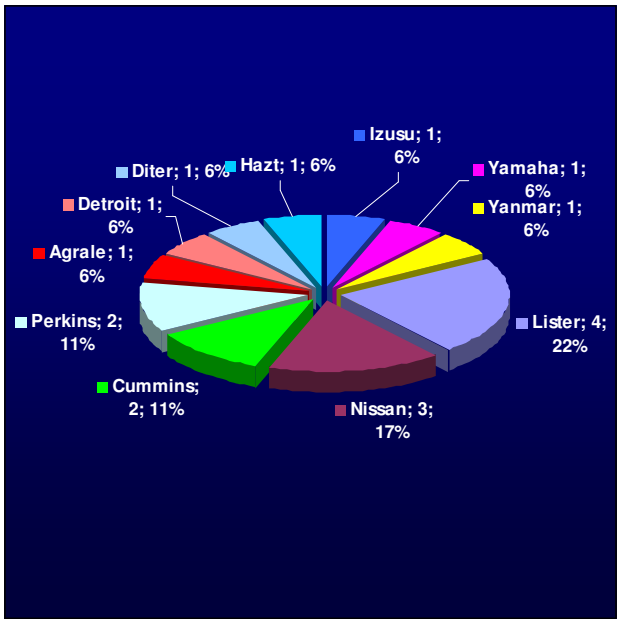


Figure 10. Brands of the secondary engines of the Costa Rican shrimp trawling fleets

Only 4 vessels gave the model of auxiliary engines. A complete list of brands and models of auxiliary engines is provided in the Appendix 7.

The average, minimum and maximum power, in Khz, of the auxiliary engines is shown in Table 5. The Perkins engine has the maximum power 96.94 Khz, since both vessels that have the Perkins engine have the same model, the maximum and minimum power of this brand is the same as the average (Table 5). The Perkins engine is followed by the Detroit 471 engine with a power of 67.11 KHz, while the Cummins 40BT3.4 with a power of 59.66 KHz is ranked as third. The Izusu C240 engine has 52.2 KHz of power. The Nissan SD22 is used by 3 vessels (Appendix 7 and Figure 10) and has a power of 29.83 KHz. The Lister engines have and average power of 19.47KHz with a maximum of 60 Khz and a minimum of 4.47 KHz. The Agrale, Diter and Hazt engines all with 1 vessel have the same power 5.22 KHz. The Yanmar engine is the engine with the lowest power, 3.73KHz (Table 5).

Table 5. Average, minimum and maximum Power (KHz) and Revolutions per Minute (RPM) of the auxiliary engines of the Costa Rican shrimp trawling fleet.

	Sencondary Engine Power (KHz)		
Brand	Average	Maximum	Minimum
Perkins	96.94	96.94	96.94
Detroit	67.11	67.11	67.11
Cummins	59.66	59.66	59.66
Izusu	52.20	52.2	52.2
Nissan	29.83	29.83	29.83
Lister	19.47	60	4.47
Agrale	5.22	5.22	5.22
Diter	5.22	5.22	5.22
Hazt	5.22	5.22	5.22
Yanmar	3.73	3.73	3.73
	RPM		
Brands	Average	Maximum	Minimum
Cummins	2,000	2,000	2,000
Izusu	1,800	1,800	1,800
Perkin	1,800	1,800	1,800
Yanmar	1,800	1,800	1,800
Nissan	1,600	1,600	1,600
Lister	1,300	1,800	800
Detroit	1,200	1,200	1,200

The Cummins engines are the engines with the highest Revolutions per minute (RPM) on average, 2,000, followed by the Izusu., Perkins and Yanmar all with 1,800 RPM. The Nissan engines have 1,600 RPM, while the Lister engines have a range between 800 and 1,800 RPM with an average of 1,300 RPM. AS we can see on Appendix 7, the models of this brand of engines were not provided by the owners of the vessels. The Detroit engine has a RPM of 1,200 RPM (Table 5).

Generators

Of the 45 owners of trawling vessels interviewed, 29 have a generator. 14 vessels (48%) have an alternator, while there are 11 vessels (38%) with a Delco Remi generator. These two brands make 86% of all the generators. Magna Plus and Onan generators have 2 vessels (7% each brand, Table 6).

Table 6. Brands, Number of vessels and Percentage and Capacity (average, minimum and maximum) of Generators.

Brand	# of Vessels	Percentage	Capacity (Kw)		
			Average	Minimum	Maximum
Alternator	14	48%	105	36	220
Delco Remi	11	38%	52	32	100
Magna Plus	2	7%	50	50	50
Onan	2	7%	50	50	50
Total	29	100%			

The capacity to generate electricity by the generators is shown also in Table 6. The Alternators produce an average of 105 Kw, with a range between 36 and 220 Kw. The Delco Rimi Generators generate between 32 and 100 Kw with and average generation of 52 Kw. The Magna Plus engines represent 7% of the generators with an average generation of electricity of 50 Kw, while the Onan generator also generates 50 Kw and represents 7% of the generators (Table 6).

Onboard Machinery and Equipment

Winches

There are 3 brands of winches used by the Costa Rican shrimp trawling vessels and one winche without a brand. The Rise winches are used by 74% of the shrimp trawling vessels, while the McElroy winches are utilized by 17% of the sampled fleet. There are two vessels (6%) that use a refurbished 400T model (Figure 11A).

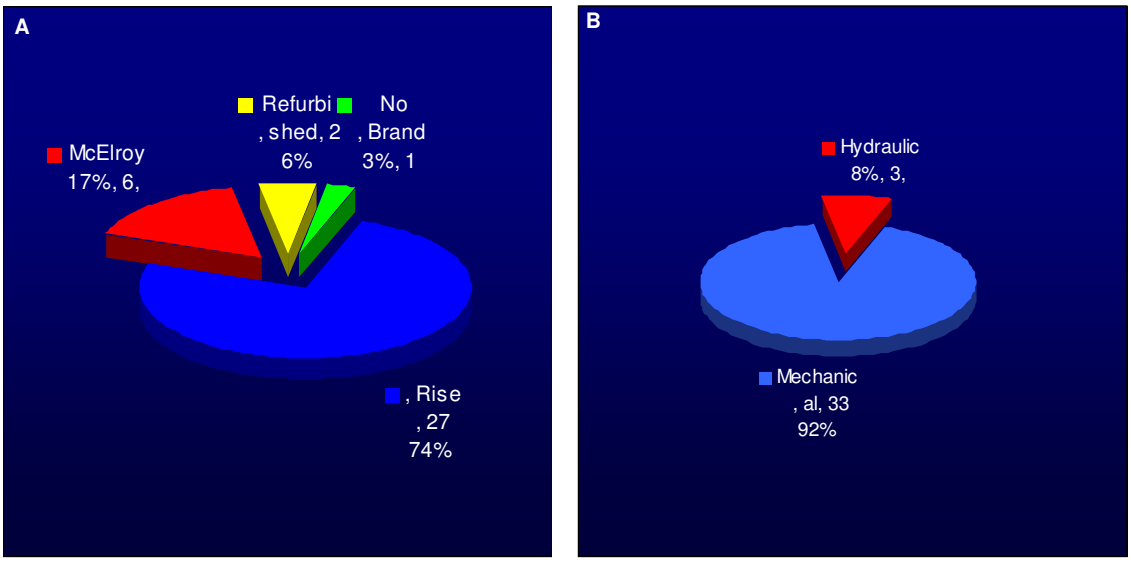


Figure 11. A) Brands of winches and B) Action mechanism of winches utilized by the Costa Rican coastal shrimp trawling vessels.

92% of the winches used by the sampled Costa Rican shrimp trawling fleet are mechanically activated, while the other 8% use a hydraulic mechanism to activate the winches (Figure 11B).

The winches of the Costa Rica shrimp trawling fleet have different power ranging from 10 KHz to 90 KHz. The frequency distribution of the vessels of the winches' power is shown in Figure 12A. 32% (6) of the vessels have 20

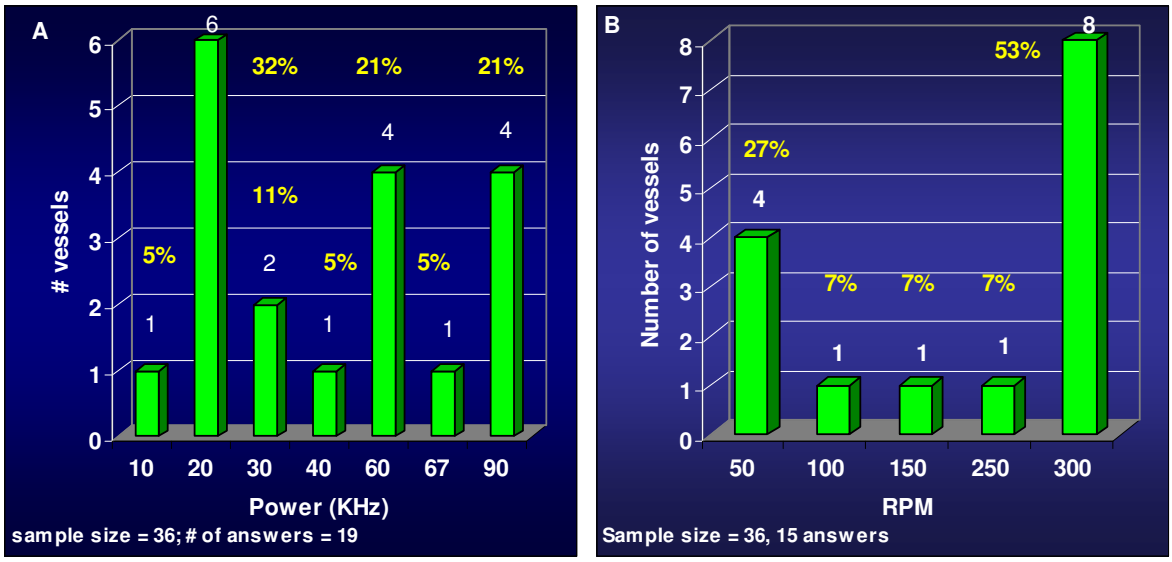


Figure 12. A) Frequency distribution of the winches power in KHz and, B) the revolutions per minute (RPM) of the winches of the interviewed Costa Rican shrimp trawling fleet.

KHz winches, while 21% (4) vessels have 60 KHz winches. Another 21% have 90 KHz winches. Two vessels have a 30 KHz winches; 5% of the vessels (1) has a 40 KHz winche and another 5% of the vessels have a 67 KHz winche. 8 (53%) of the vessels have a winche with 300 RPM, while 4 (27%) have a 50 RPM winches. There are 3 different vessels that have a 100, 150 and 250 RPM winches respectively (Figure 12B).

86% of the vessels have winches that have 3 drums while the rest of the sampled vessels (14%) have 2 drums (Figure 13).

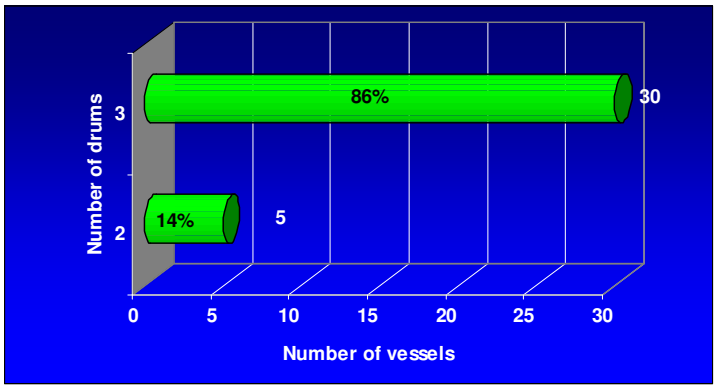


Figure 13. Number of drums of the winches per sampled vessels in the Costa Rican shrimp trawling shrimp.

Transmission shaft

The length of the transmission shaft in meters of the Costa Rican trawling fleet has an average of 6.75m ± 0.35 m, ranging from 2 to 11.28 meters. 36% of the interviewed owners indicated that the length of their transmission shaft is 6 meters, while 25% showed that the length of the transmission shaft of their vessels was 7 meters, 14% of the vessels have a transmission shaft 8 meters long and 11% have 9 meters transmission shaft. The rest of the vessels that answered the questionnaires (32%) had 1 vessel each with transmission shaft with 2, 5 11 and 12 meters long respectively (Figure 14).

67% (16) of the interviewed shrimp trawling vessels have 2 transmission universal joints, while 17% of this fleet has 4transmission universal joints. Two boats (8%) reports having 3 universal joints in their transmission shaft, while another 2 vessels have only 1 universal transmission joints (Table 7).

The transmission shaft of the Costa Rican shrimp trawling vessels are made of Monel (or Alloy 4000, is a nickel alloy containing 65-70 percent nickel, 20-29 percent copper, and small amounts of iron, manganese, silicon and carbon) stainless steel, iron and aquamet [is a precipitation-hardening, martensitic, highly corrosion resistant stainless steel alloy with high strength composed of Carbon, Manganese, Silicon, Chromium, Nickel, Phosphorus, Sulfur, Copper, Columbium + Tantalum, Nitrogen, Molybdenum, Vanadium, and Iron] (Table 8).

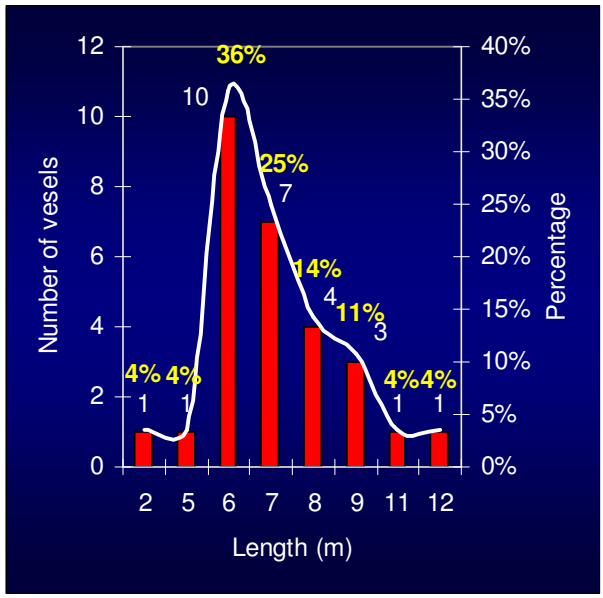


Figure 14. Length distribution for the transmission bar of the sampled Costa Rican shrimp trawling fleet.

Table 7. Number of transmission universal joints per trawling vessels.

# Universal Joints	# of vessels	Percentage
2	16	67%
4	4	17%
3	2	8%
1	2	8%
Total	24	100%

Table 8. Transmission shaft material of the Costa Rican shrimp trawling vessels.

Material	# of vessels	Percentage
Monel	20	65%
Stainless steel	6	19%
Iron	3	10%
Aquamet	2	6%
Total general	31	

Twenty (65%) interviewed vessels uses Monel for their transmission shaft, another 6 vessels (19%) utilizes stainless steel, while for 3 ships (10%), the material used for the transmission shaft is Iron. There are two vessels (6%) that their transmission shaft was constructed of aquamet (Table 8).

The frequency distributions for the diameter for the transmission shafts from the Costa Rican shrimp trawling vessels are shown in Figure 15. 21 (68%) of the interviewed vessels have a diameter of between 9.1 and 11 cm; followed by 5 ships (16%) with a diameter between 7.1 and 9 cm. There are 3 vessels (10%) with a diameter of the transmission bar between 11.1 and 12 cm while there is one (3%) boat with a transmission shaft diameter lower than 7 cm and another ship with the diameter of the transmission bar larger than 12 cm.

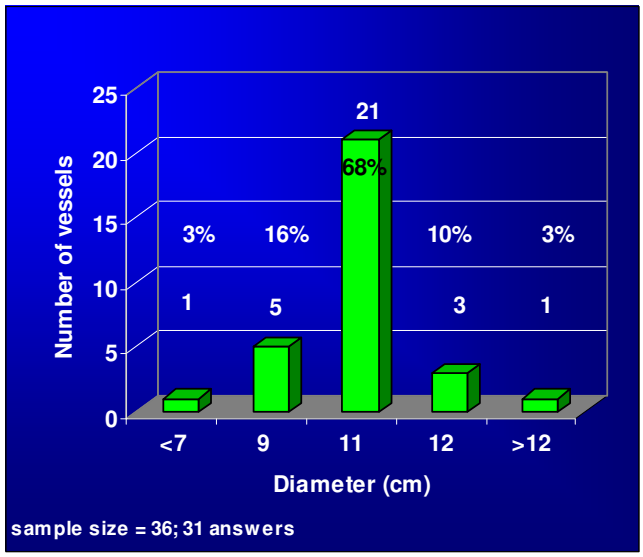


Figure 15. Frequency distribution for the diameter of the transmission shaft from the Costa Rican shrimp trawling fleet.

Reduction

Twin Disk reduction is used by 97% of the interviewed boats of the Costa Rican Shrimp Trawling fleet, the other brand used by this fleet is Caterpillar with 1 vessel (3%; Figure 16). The reduction types reported by the shrimp trawling fleet are MG 514 which is used by 18 (51%) of the interviewed vessels, while 3 (9%) boats uses The reduction type of MG 516. The other two reduction types are used by one ship (3%) each and are the 7211 and the MG 520. 12 (34%) boats owners did not provided the information (Figure 16B).

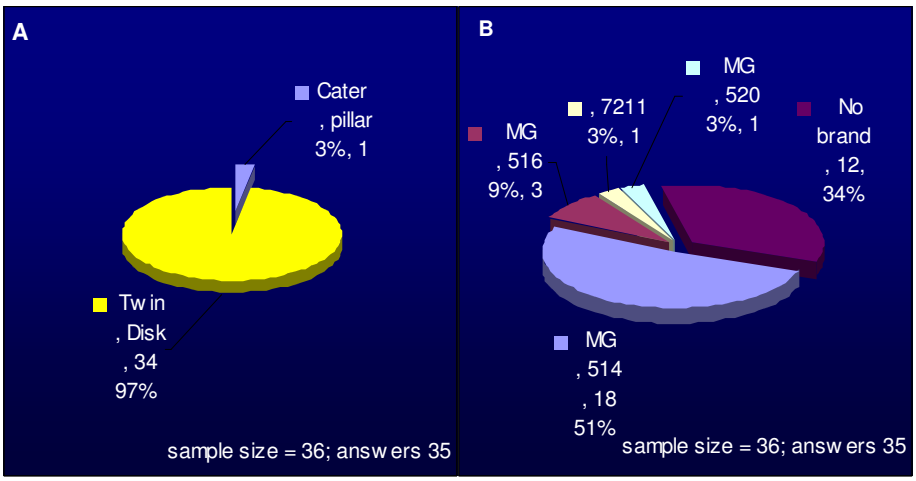


Figure 16. A) Brands and B) types of reductions of the Costa Rican shrimp trawling fleet.

25 (71%) of the interviewed ships' owners use a 6:1 reduction type. In addition, 5 vessels (14%) utilizes the 5:1

reduction type, while two boats (6%) uses the 4:1 ratio for the reduction rate. The other 3 vessels (3% each) employ a different type of reduction rates, 4.5 to 1, 4.1 to 1 and 3.5 to 1 reduction rates respectively (Figure 17).

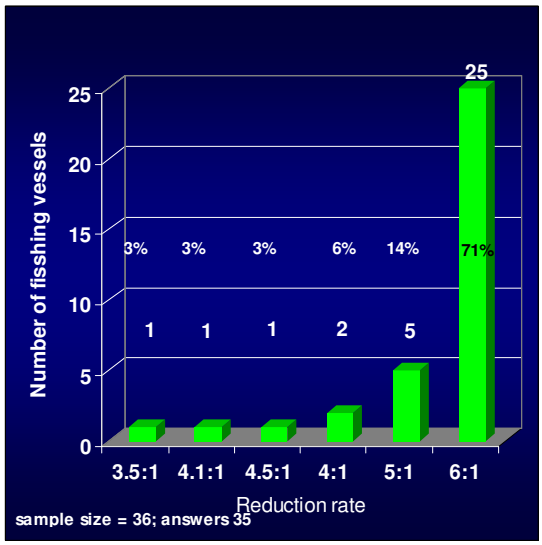


Figure 17. Number of vessels by reduction type of the Costa Rican shrimp trawling fleet.

Propeller

There are 8 types of propellers in the Costa Rican shrimp trawling fleet. 40% of the fleet uses a 4 blade propeller, followed by the Rise brand with 13% and of the vessels. Aerodynamic and E types of propellers are used by 10% of the ships of the fleet respectively. The 5 blade, bronze, fixed star and fixed types of propellers are used by 2 vessels (7%) respectively (Figure 18A).

The propeller pitch has an average size of 1.25 m with a range between 0.91 to 1.45 meters.. Figure 18B shows the distribution of the size of the propeller pitch. 47% (14) of the ships have a pitch between 1.21m and 1.3m, followed by 8 vessels (27%) with a pitch between 1.31m and 1.4m. These two groups area followed by 4 vessels (13%) that have a pitch length between 1.11n and 1.2m, while there are two vessels (7%) with a pitch length grater than 1.4m but bellow 1.5m. The other frequency groups, 1.0 and 1.1 only have one vessel correspondingly.

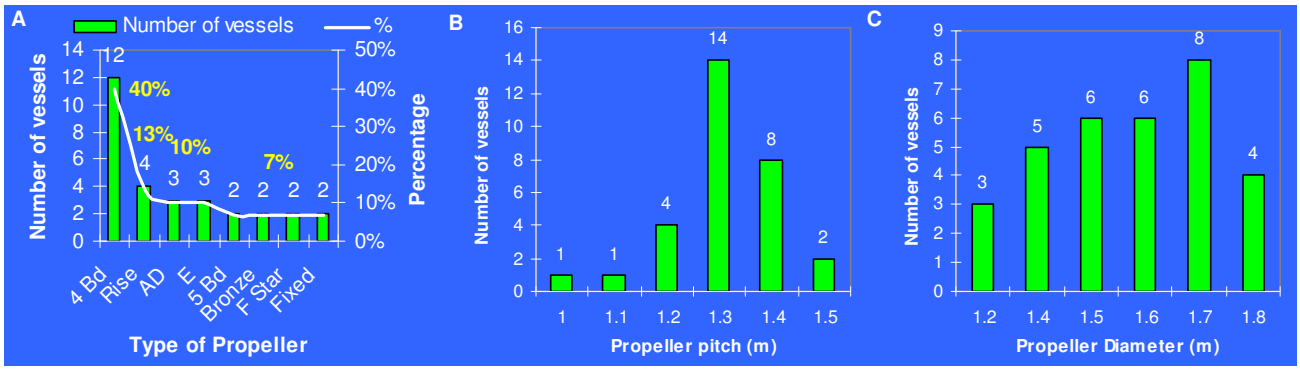


Figure 18. A) Propeller types, number and percentages, B) Propeller Pitch and C) Propeller Diameter of the Costa Rican shrimp trawling fleet. 4 Bd = 4 blades, AD = Aerodynamic, 5 Bd = 5 blades, F Star = fixed star.

The propeller's diameter has an average of 1.51m with a range between 1.17m and 1.78m. Eight ships (25%) have a diameter between 1.61m and 1.7m, while there are two ranges of propeller diameter that have 6 boats (19%) each, one group has a diameter between 1.41m and 1.5 and the other between 1.51m and 1.6. Five ships (16%) have a propeller with a diameter between 1.21m and 1.4m, followed by 4 vessels (13%) with a propeller diameter larger than 1.7m but shorter than 1.8m. In addition, there are 3 vessels (9%) with a propeller diameter less than 1.2m (Figure 18C).

Sixty four % (23) of the interviewed vessels uses 4 blades propeller while 36% (13) of the fleet have 5 blades propellers (Table 9).

Table 9. Number of propeller blades used by the Costa Rican shrimp trawling fleet.

Number of blades	Number of vessels	%
4 blades	23	64%
5 blades	13	36%
Total	36	100%

Refrigeration system

The Costa Rican shrimp trawling fleet uses 5 different brands of refrigeration systems. Bitzer is used by 59% (21) of the fleet, while 23% (8) of the ships uses Thermatrol systems as refrigerators. On the other hand, 9% (3) of the fleet used a compressor to refrigerate the cargo. Vitzon equipment is used by 9% of the vessels (2) while only one boat uses a Siemmes–Schckert refrigeration system (Figure 19A).

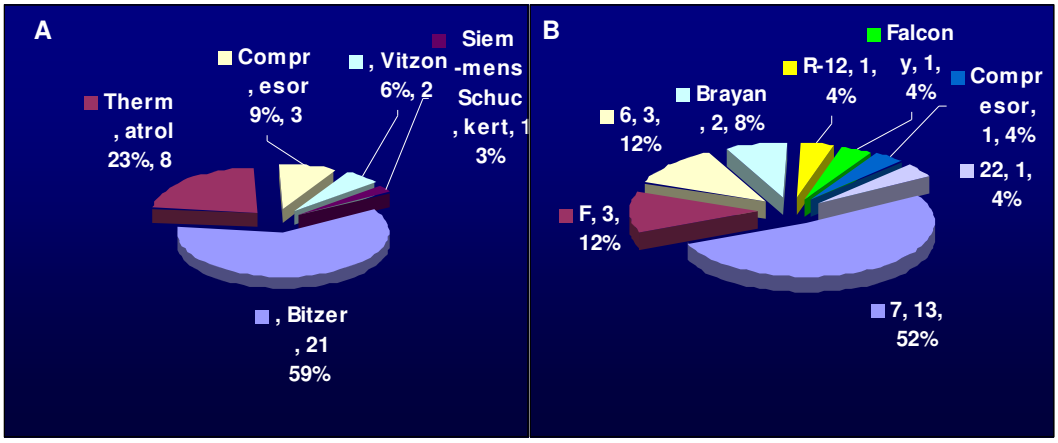


Figure 19. A) Brand and B) type of refrigeration system used by the Costa Rican shrimp trawling fleet.

52% of the interviewed fleet used the type 7 refrigeration system, while 12% (3) uses the refrigeration type F and another 12 (3) uses type 6 refrigeration systems. Bryan refrigeration types are used by 8% (2) of the fleet. R-12, Falcon, Compressor and 22 types of refrigeration systems are used by 1 vessel (4%) respectively of the fleet (Figure 19B).

53% of the Costa Rican shrimp trawling vessels have a minimum refrigeration temperature (MRT) of 0 ºC, while 17% have a MRT of –20 °C. Another 10% of the ships have a MRT of –5 °C, in addition, another 10% of the ships have a MRT of –18 °C. There is one ship (3%) that has a MRT of 4 °C, another vessel with a MRT of –2 °C and another vessel with –30 °C (Figure 20A).

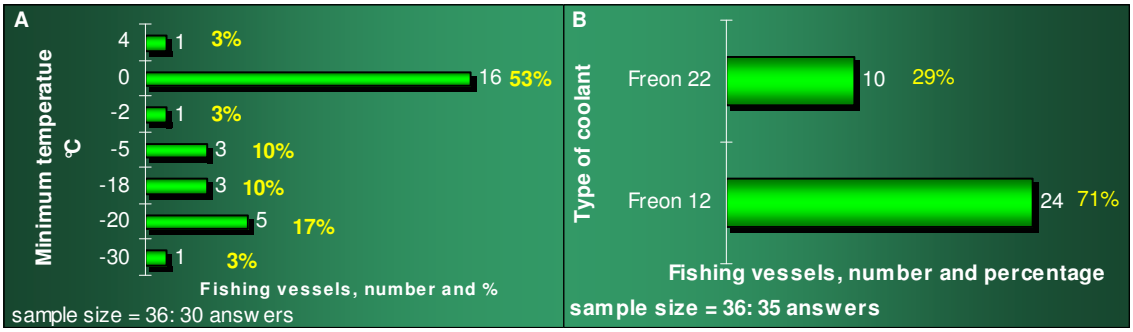


Figure 20. A) Minimum temperature in °C, and B) Type of coolant used by the Costa Rican shrimp trawling fleet.

The coolant most widely used by the Costa Rican shrimp trawling fleet is Freon 12, with 71% of the interviewed vessels, while 29% utilizes Freon 22 (Figure 20B).

Electronic equipment

The range of electronic equipment used by the Costa Rican shrimp trawling fleet is between 3 and 6. There is only one ship that has 6 electronic equipments, however this vessel has two GPS. There are 12 vessels with 5 different types of electronic equipment, while there is one vessel with 2 cellular telephones and 3 other types of electronic equipment (see Appendix 9 for a complete list of devices per vessel). 11 ships uses 4 different types of electronic equipment and 8 boats uses 3 different kinds of electronic equipment (Table 10).

Table 10. Number of electronic equipment used per vessel

No. Electronic Equipment	# of vessels	Percentage	Total equipment
6	1	4%	6
5	13	39%	65
4	11	33%	44
3	8	24%	24
Total	**33**		**139**

The Costa Rican shrimp trawling fleet uses different types of equipment for navigation and communication. For navigation equipment, the electronic device most used by the Costa Rica vessels is the GPS. While there are 33 GPS in the fleet, the results of the interviews indicate that there are two vessels with 2 GPS, while the rest of the 29 vessels have only 1 GPS . Following the GPS, the video sounder device is the most used navigation equipment, 26 vessels have it. The Eco sound is reported by 9 ships and the radar is registered by 2 ships (Table 11).

With the communication equipment, the Radio VHF is reported by 31 of the vessels, while the Radio SSB is used by 20 ships. Also there is one boat that carries two mobile (cellular) telephones, while the rest of the 16 vessels only have one (Table 11).

Table 11. Electronic equipment used by the interviewed Costa Rican shrimp trawling fleet.

	Electronic Equipment						
No. units	GPS	Radio VHF	Video sounder	Radio SSB	Celular	Echo sounder	Radar
2 units	2	–	–	–	1	–	–
1 unit	29	31	27	20	16	8	2
Total Electronic eq.	**33**	**31**	**27**	**20**	**18**	**8**	**2**
Vessels without a specific Electronic eq.	2	2	6	13	16	25	31

GPS

Appendix 8 shows the complete list of electronic devices, brands and models used by the Costa Rican shrimp trawling fleet. For the navigation systems, the most widely GPS brand used by the fleet are the Sitex GPS with 27 vessels using them. No information regarding the Power, frequency and reach was able to be gather. Sitex 8000 is the most used model (10 ships). The other GPS brands include Furuno with 5 ships and 1 without a brand.

Video Sounder

Of the 27 video sounder machines used by the shrimp trawling fleet, 22 are from Furuno; there are 16 Furuno video sounders that have no model. The other 6 video sounder, each has different models. For the ones without a model, only one report a power of 12 KW, and the average frequency is 150 KHz, ranging from 50 to 200 KHz. The average reach, in meters, is 727 ranging from 365.76 to 1,463m. The Furuno's 621 and 651 have no

information regarding the Power, frequency and reach. The FCU-667(or FCV) has a frequency of 200KHz and 732 m range. The FCV-501 Furuno's video sounder has a frequency of 28 KHz and a reach of 2000 m, and the FCV-551 video sounder from FCV, has a power of 1 KW, a frequency of 28 KHz and a reach of 2000 m. For the other four brands of video sounders, the Si-Tex brands do not have any specific specification regarding model, power, frequency reach. the three CU video sounders our from the same model, CU 261, and there is no information regarding frequency and reach (Appendix 8).

Echo sounders

There are 8 Echo sounders in the Costa Rican shrimp trawling fleet. Seven are from Furuno, six without a model and one is the Furuno 400. The reach of this model is 732m. The other Brand of echo sounder is Si-Tex but there is no information about the model (Appendix 8).

Radars

There are only two vessel with a radar, they owners did not provided information of the model, power, frequency or reach of their radars (Appendix 8).

VHF Radios

The VHF Radio is used by 31 vessels of the fleet. There are 9 different brands and other 3 equipments did not have the brand available. The brands includes Horizon with 1 unit, I com with 9, Precto Marine with 1, Ralton with 3, Seivan with 1, Sitex with 4, Standard with 6, Uniden with 1 and Yaseu with 2. There is no information regarding the models for Horizon, Precto Marine, Ralton, Seivan, Sitex, Standard, and Yaseu VHF Radios. For the I Com Radios, there are 8 ships that gave no model and only one boat has the IC-M55 model with a frequency range 156 ~ 163 MHz IC-M55 (I Com, 2005). The Uniden MC535, is used by 1 vessel and has a power of 1 Watt or 25 Watt (switch selectable) and has a frequency range between 156 to 158 MHs (Uniden, 1998).

The Single Sided Band (SSB) Radios

The SSB radios are used by 20 interviewed vessels (Table 11). There are 4 vessels that did not provided the brand of the SSB radios. The other brands are Arizona, Furuno, I Com, Sitex and Yaesu. The Arizona (1 radio), Furuno (1) and Si-Tex (4) brands have no description of the models that have onboard. There are 4 I Com SSB Radios without a model and 2 I COM M-700. The I COM M-700 has a power of 150 Watts and has a Wide band receive coverage .5 - 29.9999 MHz (http://www.icomamerica.com/products/marine/m700pro/; Appendix 8).

Mobile phones

There are 18 cellular or mobile phones in the shrimp trawling fleet. No brands and model were provided by the interviewed owners of the vessels (Appendix 8).

Characteristics of the Trawling net

Type of trawling net

Bridles or sweeps

Figure 21 shows a diagram of a typical bottom net. The superior bridle or sweep has an average length of 22.8m ± 0.65m with a range between from 12 to 29.9 m. The inferior sweep has an

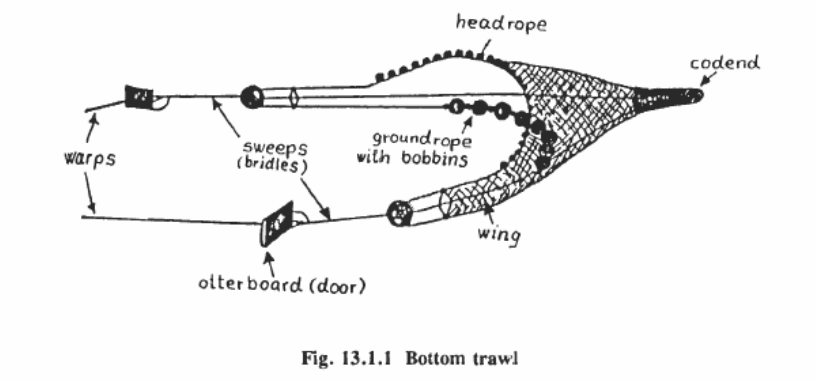


Fig. 13.1.1 Bottom trawl

Figure 21. Diagram of a typical trawling net. Source, Spare & Venema, 1998. This image is shown as a reference point only of the trawling nets used by the Costa Rica Shrimp trawling fleet.

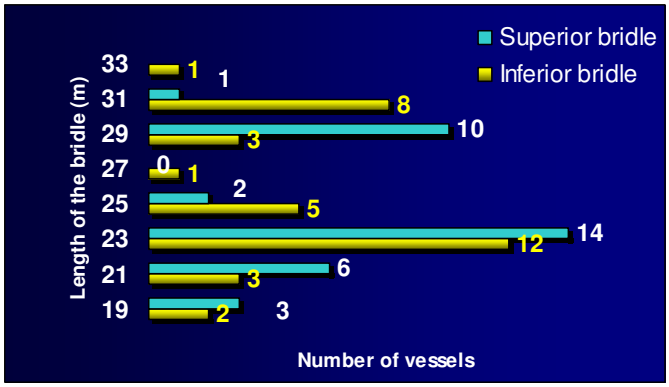


Figure 22. Length of the bridle or sweep of the Costa Rican Shrimp trawling fleet.

average length of 24.6±0.66m, with a range between 18.3m and 31.7m. A frequency distribution of the bridle's length is shown in Figure 22. There are 14 vessels with a superior bridle's within 23m, followed by 10 boats with a range between of 29m. Also there are 6 ships with a superior sweep length within 21m. There are no ships with bridles with 27m or 33m of length. The inferior bridle's length presents two peaks, one with 12 vessels ant 23m and another with 8 ships at 31m.

The superior and inferior sweeps are constructed of the same material. 86% are made of Nylon while 8% are constructed with a polyethylene mesh. Steel and Nylon and wire both represent 3% each of the construction material of the bridle (Figure 23A).

With the bridle's diameter, both the superior and inferior sweep have the same diameter in all the vessels inquired. Eighty three % of the vessels have a sweep with a diameter of 1.27cm (½ inches), while 11% have a diameter of 1.91cm (¾"). Another 6% have a diameter of 4.45cm (1 ¾") (Figure 23B).

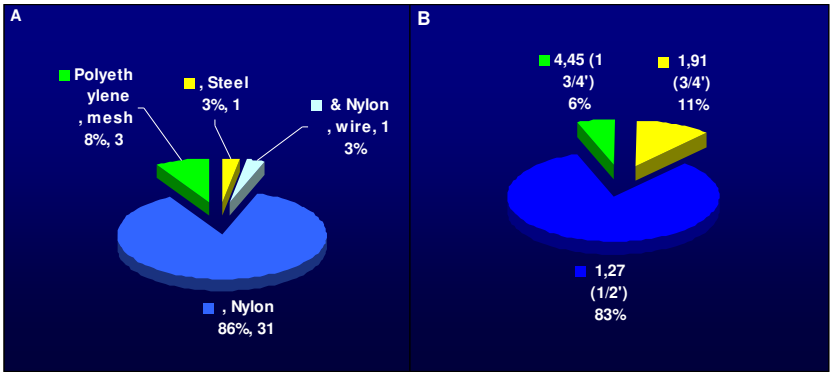


Figure 23. A) Construction material and B) Diameter of the bridle in the Costa Rican shrimp trawling fleet.

All vessels carry two trawling nets, and have on average 2 replacement nets while they are fishing.

Trawling net design

The different sections of the trawling nets of the Costa Rican shrimp trawling fleet are made basically of nylon, followed by thread and nylon with cotton. 83% of the Head rope is done of nylon, while thread and nylon with cotton, each has a 8%. For the ground rope with bobbins, 81% are made of nylon, 8% of thread and nylon with cotton each and 3% is made with a chain. For all the other sections of the net, except for the codend and the extension, the principal construction material is nylon with 83%. The other construction materials are thread (8%) and nylon with cotton also with an 8% (Table 12).

The codend is made principally from nylon (80%), and thread (9%). There are 4 boat that were not able to provide the construction material of the codend at the time of the interview. For the extension section, 82% are made from nylon and the rest 18%, there is no information of the type of construction material also (Table 12).

All the trawling nets used in Costa Rica have no treatment done by the fishermen, all come pre-treated from factory.

Table 12. Construction material of the different sections of the Costa Rican shrimp trawling fleet.

Section of the net	NI	Chain	Thread	Nylon	Nylon with cotton	Number of vessels
Head rope			3	30	3	36
Ground Rope with bobbins		1	3	29	3	36
Superior Wings			3	30	3	36
Inferior Wings			3	30	3	36
Superior shaft			3	30	3	36
Inferior shaft			3	29	3	35
Codend	4		3	28		35
Extension	4			18		22

Number of threads

All the sections of the trawling net, except for the codend and the extension, are constructed with thread size or number of 18 (89%) or 21 (11%; Table 13). In the case of the codend, 85% are made with thread number 42, while 9% are built with thread number 18. Two vessels have a codend built with 48 (3%) and 30 (3%) thread number (Table 13). The extension are made of thread number 18 (89%), 21 (6%) and 42 (6%, Table 13).

Table 13. Number of thread used to construct the shrimp trawling net in Costa Rica.

Secction of the net	*Number of thread*										*# vessels*
	18		*21*		*42*		*48*		*30*		
	# vessels	*%*	*# vessels*	*%*	*# vessels*	*%*	*# vessels*	*%*	*# vessels*	*%*	
Head rope	32	89%	4	11%							36
Ground rope with bobbins	32	89%	4	11%							36
Superior wing	32	89%	4	11%							36
Inferior wing	32	89%	4	11%							36
Superior shaft	32	89%	4	11%							36
Inferior shaf	31	89%	4	11%							35
Codend	3	9%			29	85%	1	3%	1	3%	34
Extension	16	89%	1	6%	1	6%					18

The average length of the codend is 133m with a range between 49 and 160 meters, the extension of the net has an average length of 116m with a range between 46 and 160 (Table 14).

Table 14. Number of vessels interviewed, average, minimum and maximum length of the codend and extensión of the net of the Costa Rican shrimp trawling fleet.

	Count	Size (m)	Maximum	Minimum
Codend	**16**	**133**	**160**	**49**
Extension	**9**	**116**	**160**	**46**

The size of the net 2a from half knot to another half knot fully extended

The distance, in millimeters, from half knot to another half knot fully extended for all the different sections of the trawling net is detailed in Table 15. As we can see, the distance between knots is 44.45 mm in more than 84% of the different sections of the net. The range is from 84% in the codend to 97% of the headrope. In most of the sections, the distance of 44.45mm is present in 94% of the interviewed vessels.

Table 15. 2a, size of the net: from one half knot to another half knot fully extended in millimeters.

		Size of the net				
Sección	**Material**	**19.05**	**32.5**	**38.1**	**44.45**	**# of vessels**
Headrope	Thread				3	3
	Nylon		1		29	30
	Nylon with cotton				3	3
Total Headrope			**1**		**35**	**36**
Ground rope	Chain				1	1
	Thread				3	3
	Nylon	1	1		26	28
	Nylon with cotton				3	3
Total Ground rope		**1**	**1**		**33**	**35**
Superior Wing	Thread				3	3
	Nylon	1	1		27	29
	Nylon with cotton				3	3
Total Superior Wing		**1**	**1**		**33**	**35**
Inferior wing	Thread				3	3
	Nylon	1	1		27	29
	Nylon with cotton				3	3
Total Inferior wing		**1**	**1**		**33**	**35**
Superior shaft	Thread				3	3
	Nylon	1	1		27	29
	Nylon with cotton				1	1
Total Superior shaft		**1**	**1**		**31**	**33**
Inferior shaft	Thread				3	3
	Nylon	1	1		26	28
	Nylon with cotton				3	3
Total Inferior shaft		**1**	**1**		**32**	**34**
Extension						
	Nylon	1			14	15
Total Extension		**1**			**14**	**15**
Codend				3		3
	Thread				3	3
	Nylon	1		1	23	25
Total Codend		**1**		**4**	**26**	**31**

Number of nets on the border of the section

The average number of nets of the horizontal superior border (Nmbs), of the horizontal inferior border (Nmbi) and the number of dropped nets of each vertical section (Nmh) are shown in Table 16.

Table 16. Average number of nets of the horizontal superior border (Nmbs), average number of inferior border (Nmbi) and average number of dropped nets of each vertical section (Nmh) of the Costa Rican

Section of the trawling	Average Nmbs	Average Nmbi	Average Nmh
Head rope	362	296	153
Ground rope with bobbins	366	290	158
Superior wing	253	232	137
Inferior wing	256	232	134
Superior shaft	80	91	61
Inferior shaf	80	94	64
Codend	88	122	114
Extension	151	151	143

On average, the Nmbs of the head rope, ground rope, superior and inferior wing are greater than the Nmbi, while for the superior and inferior shaft, and codend have greater Nmbi than Nmbs. With the extension, the Nmbs has the same number of nets than the Nmbi. The head rope has less Nmbs than the groundrope while the Nmbi is on the contrary. For the superior and inferior wings, the Nmbs of the superior wing are smaller than the inferior wing, while the Nmbi for both wings are the same. For the superior and inferior shafts, the average number of Nmbs are the same, while the inferior wing has more Nmbi the the superior (Table 16).

Number of cuts per section

The cut of the net 6X1 is the most common cut for the headrope, groundrope, superior wing and inferior wing. It is followed by the 4X1 cut. The superior and inferior shaft use the 2X1 cut in more than 75%, while for the extension and codend, the flat cut and the 2X1 are the main cuts (Table 17).

Table 17. Number of cuts per section of the net of the Costa Rican shrimp trawling fleet. The information of this table is given by rows.

Section of the Net	1X1	2X1	3X1	3x2	4X1	6X1	8X1	Flat	# vessels
Headrope		3%	3%		40%	51%	3%		35
Groundrope		7%	4%		30%	44%	4%	11%	27
Superior wing	9%	4%	4%		26%	43%		13%	23
Inferior wing	9%	4%	4%	4%	26%	39%		13%	23
Superior shaft		81%	5%		10%	5%			21
Inferior shaft		75%	6%		13%	6%			16
Extension		33%	17%					50%	6
Codend		29%	14%					57%	7

Net elements and cables

Trawling line

The average length of the trawling line of the shrimp is 823 meters with a mean diameter of 1.27cm (half inch; Table 18). The relative long trawling line is due that since most of the vessels can fish deep shrimp also. Also, according to the target shrimp species, the trawling line has to have a particular length. For example, the *Heterocarpus spp* (camarón Camellón) is fished at an average depth of 1829 m, the fidel shrimp (*Solerocera agassizi*) is captured at an average depth of 686m; the Pinky shrimp (*Penaeus brevirostris*) is fished at 274m deep and the white shrimps (*Litopenaeus vannamei, L. stylirostris and L. californiensis*) are fished at an average of 137 m (Gerardo Marín, Per. Comm.). The patas de gallina have an average length of 81m with a diameter of 1.27cm.

Of the 34 interviewed vessels, 33 (97%) of the ships have a trawling line made of steel and the other boat is made of steel. For the patas de gallina all the interviewed vessels are made of steel (Table 18. Average length of the trawling line and patas de gallina of the shrimp trawling fleet from Costa Rica.

	Mean Length (m)	Mean Diameter (cm)
Trawling line	823	1.27
Patas de gallina	81	1.27

Table 19).

The construction material of the chain and the weight are shown in Table 20. 77% of chains are made of galvanized steel, 19% are made of steel and 4% are made of metal. For the weight 69% of the weights are made of galvanized steel, while 19% are made of steel and 12% are constructed from metal.

The average weight of the chain is 47Kg and for the weight is 59Kg. 23 of the interviewed have a chain diameter of 0.95 cm, while the other 3 have a chain diameter of 0.79. For the weight, all the interviewed ships have a diameter of 0.95 cm (Table 21).

The frequency distribution of the length of the weight line shows that 9 vessels have 45m long, followed by 6 ships with 35m. The average weight line length is 34.4m±2.2m, indicating the more than 50% of the weight line length is above the mean length (Figure 24).

The length of 30m of the groundline weight length is the most common used by the Costa Rican shrimp trawling fleet, it is used by 9 vessels. The average weight line length is 32m±1.7m, indicating that more 76% of the ships have a groundline weight length below the average (Figure 24).

Floats

The Costa Rican shrimp trawling fleet uses floats mainly of corch (24 vessels) and plastic (8), foam (5) and Styrofoam (1) (Figure 25A). They normally use between 3 and 6 floats (more than 71%). The fleet also uses other number of floats such as 6 and 8 (4 vessels each). The mode is 4 floats with 10 ships using this amount (Figure 25B).

Table 18. Average length of the trawling line and patas de gallina of the shrimp trawling fleet from Costa Rica.

	Mean Length (m)	Mean Diameter (cm)
Trawling line	823	1.27
Patas de gallina	81	1.27

Table 19. Construction material of the trawling line and patas de gallina

	Steel	Iron	# of vessels
Trawling line	33	1	34
Patas de gallina	32		32

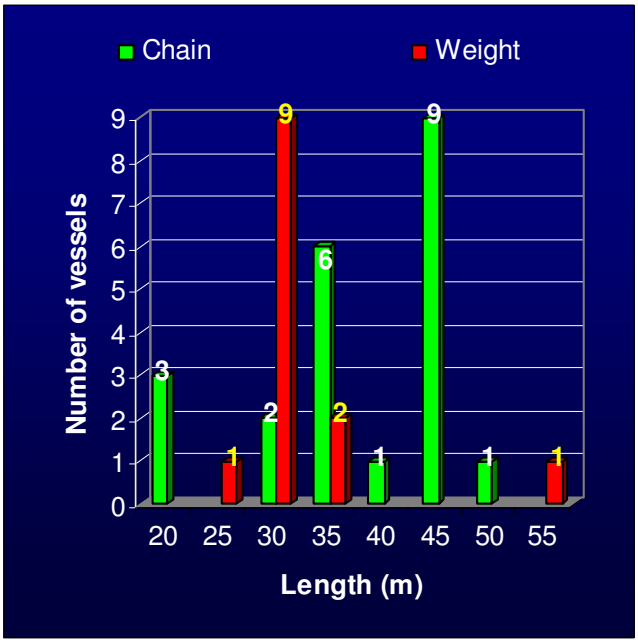
Table 20. Construction material of the chain and weigth and number of vessels interviewed form the Costa Rican shrimp trawling fleet.

Element	Steel	Metal	Galvanized Steel	# vessels
Chain	5	1	20	26
Weight	3	2	11	16

Table 21. Number of vessel per diameter of the chain and weight .

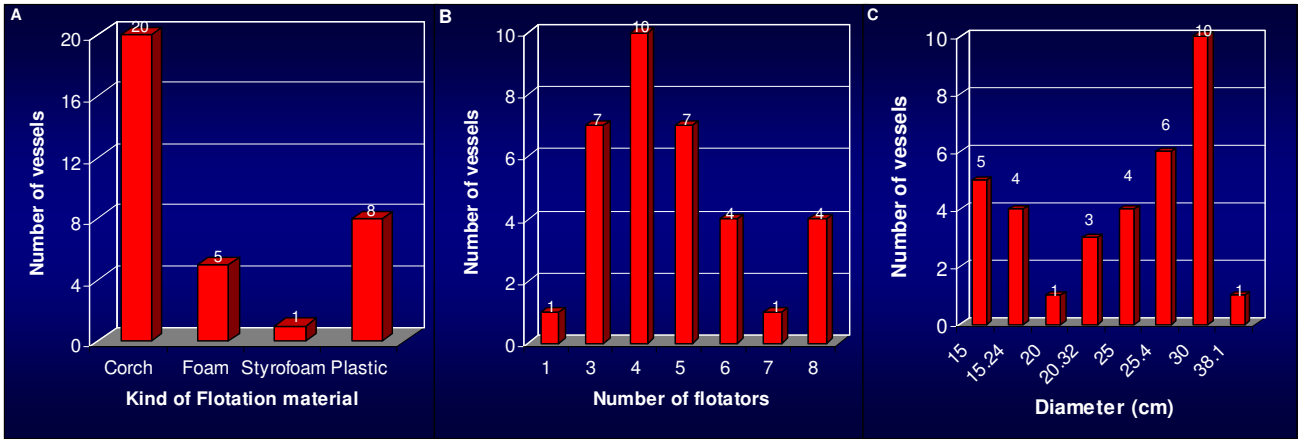
	Díametro(cm)		
Element	0.79	0.95	# of vessels
Chain	3	23	26
Weight		16	16

Figure 24. Distribution length of the weight and chain of the Costa Rican shrimp trawling fleet.



The most common diameter of the floats used by the Costa Rican fleet is 30cm with 10 ships, followed by 25.4cm with 6 vessels(Figure 25C) .

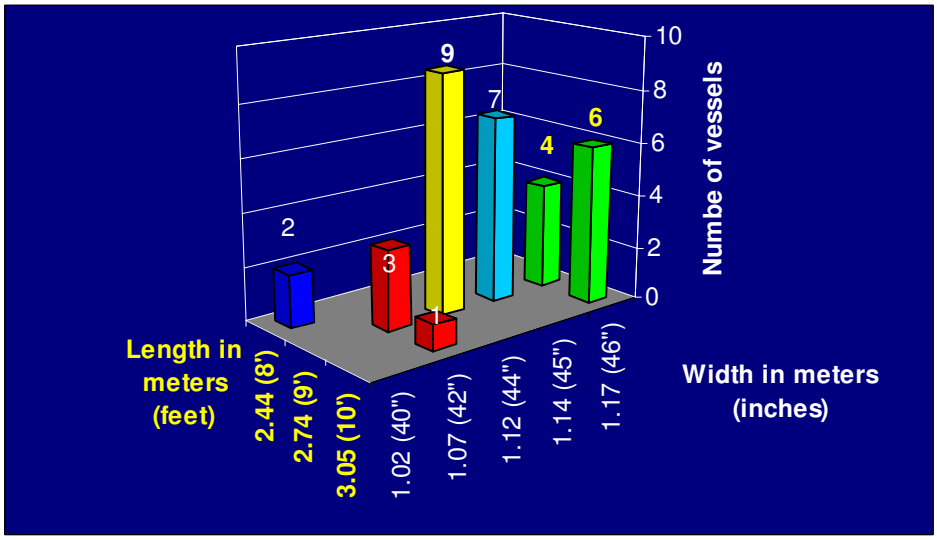
Figure 25. A) Different kinds of Flotation Materials and their distributions, B) Number of floats per vessels and C) Diameter of the floats of the Costa Rican shrimp trawling fleet.



Otterboards

The length and with of the otterboards in the Costa Rican shrimp trawling fleet is present in Figure 26. There are three different sizes of length: 2.44m (8 feet), 2.74m (9') y 3.05m (10'). In addition, there are five different widths of the otterboards: 1.02m (40 inches), 1.07m (42"), 1.12m (44"), 1.14 (45") and 1.17 (46"). There are only two boats (6%) with an otterboard of 2.44m and 1.02, while there 23 vessels (72% of the interviewed) with an otterboard length of 2.74m (9'). However, of these 23 ships, there are 3 with a width of 1.07m (42"), 9 with a 1.12m (44") width, 7 with a 1.14m (45") width and 4 vessels with an otterboard of 1.17 (46"). The remaining 22% are 7 boats with an otterboard length of 3.05m (10'). Of these seven vessels, 1 has a width of 1.07m (42") and 6 have a with of 1.17m (46"; Figure 26).

Figure 26. Number of vessels per length and width of the otterboard of the Costa Rican shrimp trawling fleet .



The area of the otterboards ranges from 2.49m^2 to 3.57m^2. The area is a function of the length and width of the otterboard, implying that those board

Table 22. Area of the otterboard in square meters of the Costa Rican shrimp trawling fleet. ordered by the length and width.

Length (meter; feet)	Width (meters; inches)				
	1.02 (40")	1.07 (42")	1.12 (44")	1.14 (45")	1.17 (46")
2.44 (8')	2.49				
2.74 (9')		2.94	3.07	3.13	3.21
3.05 (10')		3.26			3.57

with the largest length and with will have the biggest area (Table 22).

Economic analysis

Income

A total of 16 vessels answered the economic information. The average, minimum and maximum income for the Costa Rican costal shrimp trawling fleet is presented in Table 23. it can be observed that the average daily income of a vessel is US$311.21. The shrimp provides US$ 280.27 or 90% of the total daily income, while the other 10% is provided by the incidental catch. The capture of the is done by three vessels that have a fishing permit to fish near the coast or shallow waters shrimp, however must of their effort is centered to deep water shrimp suchs as *Heterocarpus spp* (Camellón) or *Solerocera agassizi* (Camarón Fidel) and their captures make an skew to the information analyzed here.

Table 23. Type and kind of product, number of vessels, average quantity in kilograms and average daily income of the Costa Rican shrimp trawling fleet.

Type	Product		# of vessels	Quantity (Kg)	daily income		
Principal	Common name	Scientific name			average	minimum	maximum
	White	*Litopenaeus spp.*[1]	9	19.01	245.59	117.94	524.19
	Camellón	*Heterocarpus spp*	3	384.62	1,451.59	1,451.59	1,451.59
	Fidel	*Solerocera agassizi*	12	78.54	225.01	25.16	489.24
	Pinky	*Penaeus brevirostris*	9	32.96	171.08	48.23	262.09
	Titi	*Xiphophenaes riveretii*	6	8.89	20.92	4.61	39.42
Principal Total				67.11	280.27		
By catch							
	First[2]		9	24.67	35.20	12.58	64.52
	Second[3]		10	23.12	16.96	8.39	40.26
	Fishes (First&Second)		2	64.91	81.66	79.46	83.87
By catch Total				27.84	30.94		
Total (Principal + By catch)				95	311.21		

Notes: 1). White shrimps includes 3 species (*Litopenaeus vannamei, L. stylirostris* and *L. californiensis*), **2)** First (or primera in Spanish) includes different species such as robalos (Centroppomus spp) corvinas (drums; scianidae) **3)** second or chatarra (in Spanish) includes many different species such as corvinas (drums; scianidae), snappers or pargos (Lutjanidae spp), flounders (lenguados in Spanish: Paralichthyidae spp., Bothidae spp., and Soleidae spp).

Expenses

Type of Cost	Type of expenses	# of vessels	daily expemses (US$)		
Operation Costs			average	minimum	maximum
	Lubricants	16	11.61	2.84	36.29
	Main Engine	16	329.63	119.14	546.31
	Others	2	6.29	6.29	6.29
	Food prevision	15	19.08	12.16	32.26
	INS insurance	16	4.92	0.87	12.58
	CCSS insurance	16	19.01	6.60	32.26
	Wages & Salaries	16	90.50	31.45	153.62
Operation Costs Total			**68.72**	**25.62**	**117.09**
Indirect Costs					
	Fishing gear	14	4.52	1.68	11.18
	Vessel	10	31.98	5.24	34.95
	Electronic equipment	9	2.15	1.05	4.19
	Tools	16	5.87	0.58	17.47
	Machines	9	52.63	3.84	139.78
	Spare parts	9	2.41	0.70	3.49
	Manteinance	7	12.61	1.05	23.59
	Vastecas	3	4.19	4.19	4.19
Indirect Costs Total			**14.54**	**2.29**	**29.86**
Production Costs					
	Administrative	12	34.52	12.23	62.90
	Accountants	13	11.32	1.05	31.45
	Depreciations	3	36.69	36.69	36.69
	Taxes	6	6.53	3.15	7.55
	Licence of INCOPESCA	16	0.62	0.62	0.62
	Port	9	5.71	2.45	15.38
Production Costs Total			**15.90**	**9.36**	**25.77**
Subtotal (Operational +Inderect + Production)			**99.16**	**37.28**	**172.71**
Investments					
	Vessels	4	576.60	244.62	1,188.15
	Equipment	4	279.09	33.06	559.13
	Refrigeration	1	244.62	244.62	244.62
Investments Total			**366.77**	**174.10**	**663.97**
Financial Obligations					
	Interests	2	37.31	34.95	39.67
	Others	1	419.35	419.35	419.35
	Principal downpayment	2	1,057.31	17.88	2,096.74
Financial Obligations Total			**504.66**	**157.39**	**851.92**

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Personal communications

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Appendixes

Appendix 1. Main characteristics of the shrimp trawling vessels.

Nombre Embarcación	Puerto Base	Año de construcción	Material	Eslora (mts)	Manga (mts)	Puntal (mts)	Máquina Principal			Tobera		Refrigeración		Sector		Tipo de red	Tamaño (Lrs)
							Marca	Modelo	Potencia	Si	No	1	2	1	2		

Nombre Embarcación.- El nombre con el cual esta registrada la embarcación.
Tamaño (Lrs).- Longitud de la relinga superior de la red en metros.
Tipo de red.- Diseño de red con que cuenta la embarcación (mixto, fantasma, volador, etc).
Sector.- Marca 1 para el sector social; 2 para el sector privado.
Refrigeración.- 1 en caso de refrigeración mecánica; 2 refrigeración con hielo.
Tobera: Marcar si o no la embarcación cuenta con tobera. Máquina Principal. Registrar la marca, modelo y potencia nominal en Caballos Fuerza (Hp) de la máquina principal.
Puntal.- Puntal máximo de la embarcación en metros.
Manga.- Manga máxima de la embarcación en metros.
Eslora.- Eslora máxima de la embarcación en metros.
Material.- Material de construcción del casco de la embarcación (madera, acero, fibra de vidrio)
Año de Construcción.- El año en que fue construida la embarcación.
Puerto Base.- Es el puerto donde esta matriculada o registrada la embarcación.

Appendix 2. Questionnaire of the income, costs and expenditure structure for the economic impact assessment on the shrimp trawling fishery

PROYECTO FAO-UNEP-GEF

ESTIONARIO DE ESTRUCTURA DE INGRESOS, COSTOS Y GASTOS PARA EL ANALIS
DE EVALUACION DEL IMPACTO ECONOMICO EN LA PESQUERIA DE CAMARON

CONCEPTO	TEMPORADA		
	CANTIDAD	PRECIO UNITARIO	MONTO TOTAL
INGRESOS			
Producto principal			
Subproductos			
Otros (específique)			
COSTOS DE OPERACIÓN			
Máquina principal			
Máquina auxiliar			
LUBRICANTES			
Máquina principal			
Máquina auxiliar			
PREVISION DE BOCA			
INSUMOS (específique)			
SUELDOS Y SALARIOS			
OTROS (específique)			
COSTOS INDIRECTOS			
HERRAMIENTAS			
REFACCIONES			
Embarcación			
Artes de pesca			
ENSERES MENORES			
REPARACION Y MANTENIMIENTO			
Embarcación			
Máquinas			
Cubierta			
Equipo electrónico			
Artes de pesca			
OTROS (específique)			
GASTOS DE PRODUCCION			
CONTABLES			
ADMINISTRATIVOS			
PORTUARIOS			
IMPUESTOS			
DEPRECIACIONES			
OTROS (específique)			
OBLIGACIONES FINANCIERAS			
PAGO A PRINCIPAL			
INTERESES			
CAPITAL DE TRABAJO			
INTERESES			
OTROS ADEUDOS			
INVERSIONES			
EMBARCACION			
EQUIPO			
ARTES DE PESCA			
OTRAS (específique)			

Appendix 3. Technical characteristics of the trawling nets

REGISTRO No. 2. CARACTERISTICAS TECNICAS DE REDES DE ARRASTRE CAMARONERAS

Nombre Embarcación:

Tipo de red:	**Material**	**Diámetro**
Longitud relinga superior (Lrs):		
Longitud relinga inferior (Lri):		
No de redes:		

Sección		**Material**	**Tratamiento**	**No. Hilo**	**Diámetro**	**2a (mm)**	**Nmbs**	**Nmbi**	**Nmh**	**Corte**	**Encabalgadura o angola**	**Tipo DET**
Tapa superior o boyado												
Tapa inferior o arrastre												
Tapa lateral o brazo	Superior (a)											
	Inferior (b)											
Cuchillas	Superior (a)											
	Inferior (b)											
Traslape												
Bolso												
Otra:												

APAREJAMIENTO Y CABLES

ELEMENTO	**Longitud**	**Diámetro**	**Material**
Cable de arrastre			
Galgas			

ELEMENTO	**Material**	**Diametro**	**Longitud**	**Peso total**
Lastre				
Cadena espantadora				

ELEMENTO	**No. de flotadores**	**Material**	**Diámetro**	**Flotación total**
Flotación				

ELEMENTO	**Largo**	**Ancho**	**Peso**	**Area**
Puertas de arrastre				

2a.- Tamaño de la malla, medida de medio nudo a medio nudo totalmente estirada.
Nmbs: Número de mallas en el borde superior de la sección (horizontales).
Nmbi: Número de mallas en el borde inferior de la sección (horizontales).
Nmh.- Número de mallas de caída de la sección (verticales).

Esquema del Dispositivo Excluidor de Tortugas utilizado
(dimensiones en cm)

Appendix 4. Shrimp trawling fleet questionnaire.

REGISTRO 3. EMBARCACIONES PESQUERAS CAMARONERAS

PROYECTO FAO-UNEP-GEF

I. CARACTERISTICAS PRINCIPALES

Nombre de la embarcación: _____
Año de construcción: _____ Autonomía (días): _____
Valor Inicial: _____ Valor actual: _____
Ton. Registro Bruto: _____ Ton. Registro Neto: _____
Material del Casco: _____ Desplazamiento: _____ ton
Eslora:_____ m Manga:_____ m Puntal:_____ m
Capacidad: Combustible: (m^3) Agua: (m^3) Lubricante: (m^3) Bodega: (m^3)

II. MAQUINARIA

	Máquina Principal	Maquinaria Auxiliar	Generador
Marca:			Marca: _____
Modelo:			
Potencia:			Capacidad:_____
R.P.M.:			

III. MAQUINARIA DE CUBIERTA	**IV. EJE DE TRANSMISION**	**V. REDUCION**
Malacate o winche		
Marca:	Longitud:	Marca:
Accionamiento:	No. Descansos:	Tipo:
Potencia:	Diámetro:	Razón:
R.P.M. :	Material:	
No. Tambores :		

VI. HELICE	**VII. SISTEMA DE REFRIGERACION**
Tipo:	Marca:
Paso:	Tipo:
Diámetro:	Temperatura mínima:
No. de palas:	Refrigerante:

VIII. EQUIPO ELECTRONICO

	Marca	Potencia (KW)	Frecuencia (KHz)	Alcance (m)
Videosonda:				
Ecosonda:				
Radar:				
Radio SSB:				
Radio VHF:				
GPS				
otro				
otro				
Otro				

Appendix 5. Samll scale artisanal fleet questionnaire

Anexo 5

Flota camaronera trasmallera (artesanal a pequeña escala)

Numero de permisionarios por puerto base:

Número de pescadores por embarcación:

Características de las embarcaciones
Tamaño: % con Eslora menor a 8 metros_____% con Eslora de 8 a 10 metros_____ % con Eslora mayor a 10 metros_____
% con Manga menor a____metros % con Manga mayor a____metros
% con Puntal menor a ____metros % con Puntal mayor a ____metros
Materiales de construcción_____

Año de Construcción:
____% de 1 año o menos
____% de más de 1 año y hasta 3 años
____% de más de 3 años y hasta 5 años
_____% de más de 5 años

Motores

Tipo_____ potencia: % de 5 hp o menos_____
% de más de 5 hp y hasta 25 hp_____
% de más de 25 hp y hasta 40 hp_____
% mayores de 40 hp_____

Modelo
____% de 1 año o menos
____% de más de 1 año y hasta 3 años
____% de más de 3 años y hasta 5 años
_____% de más de 5 años

Días de trabajo promedio por mes_____
Número de horas promedio trabajadas por día_____
En la mañana_____
En la tarde_____
En la noche_____
Mixto (día –noche)_____

Describa características generales sobre manejo que hacen los pescadores del producto:

Artes de pesca

Trasmallo:
Luz de malla_____Altura_____largo_____

Appendix 6. Models of the engines of the Costa Rican shrimp trawling fleet.

Brand	# of vesseles	Model	RPM	Power (KHz)
Caterpillar				
	8	D-343-TA	1,850	270
	6	3406	1,850	287
	5	3408	2,050	275
	2	D-3406	1,800	270
	2	D-342	134	155
	1	3406-365	1,800	270
	1	3406B	1,800	270
	1	3406-B-D	1,800	270
	1	342		185
	1	4TB07118	1,800	270
	1	D-353-TA		315
	1	NR		272
	1	P-342PC	2,000	167
	1	3406DI		270
Caterpillar Total	**32**		**1,758**	**263**
Cummins				
	5	KT-1150-M	2,467	299
	4	KT-19-M		281
	1	KT-14 M		270
Cummins Total	**10**		**2,467**	**289**
Detroit				
	1	76		323
Detroit Total	**1**			**323**
General Motors				
	1	12VA2855	2,200	270
	1	V-12-71N		252
General Motors Total	**2**		**2,200**	**261**
Grand Total	**45**			

Appendix 7. Brands and models of the auxiliary engines of the Costa Rican shrimp trawling fleet.

Brand	# of vesseles	Model	RPM	Power (KHz)
Agrale				
	1	No model		5
Cummins				
	2	40BT3,4	2,000	60
Detroit				
	1	471	1,200	67
Diter				
	1	No model		5
Hazt				
	1	No model		5
Izusu				
	1	C240	1,800	52
Lister				
	4	No model	1,300	19
Nissan				
	3	SD22	1,600	30
Perkin				
	2	236	1,800	97
Yamaha				
	1	No model		
Yanmar				
	1	No model	1,800	4
Total	18			

Appendix 8. Electronic equipment used by the interviewed Costa Rican shrimp trawling fleet

System	Brand	Model	N	Power (KW)	Frequency (KHz)	Reach (m)
Video sounder						
	CU					
		CU 261	3			
	Furuno					
		No Model	16	12	150	727
		FCU 667	1		200	732
		FCU-561	1			
		FCV-501	1		28	2,000
		FCV-551	1	1	28	2,000
		Furuno 400	1			732
		Furuno 621	1			
	Sitex					
		No Model	2			
Video sond Total			**27**			
Echo sounder						
	Furuno					
		No Model	6		50	869
		Furuno 400	1			732
	Sitex					
		No Model	1			
Ecosound Total			**8**			
Radar						
	Furuno	No Model	2			
Radar Total			**2**			
Radio SSB						
	No Brand	No Model	4		16	
	Arizona	No Model				
			1			8,300
	Furuno	No Model				
			1			
	I Com					
		No Model	4			
		I COM M700	2			
	Sitex					
		No Model	4			
	Yaesu					
		No Model	3		8	
		FT840	1			
Radio SSB Total			**20**			
Radio VHF						

System	Brand	Model	N	Power (KW)	Frequency (KHz)	Reach (m)
	No Brand	No Model	3			
	Horizon					
		No Model	1			
	I Com					
		No Model	8			
		IC-M55	1			
	Precto Marine					
		No Model	1			
	Ralton					
		No Model	3			
	Seivan					
		No Model	1		8,900	
	Sitex					
		No Model	4			
	Standard					
		No Model	6	8		
	Uniden					
		MC535	1			
	Yaesu					
		No Model	2			
Radio VHF Total			**31**			
GPS						
	No Brand	No Model	1			
	Furuno					
		No Model	4			
		1650	1			
	Sitex					
		No Model	8			
		NAV-ADD-8000	1			
		R1000	3			
		Sitex 40	1			
		Sitex 7000	1			
		Sitex 8000	10			
		Sitex 90	2			
		Sitex K	1			
GPS Total			**33**			
Celular						
	No Brand	No Model	18			
Total			**139**			

Appendix 9. Number and type of electronic equipment per vessels in the Costa Rican shrimp trawling fleet.

Electronic Equipment							
GPS	Radio VHF	Videosound	Radio SSB	Celular	Ecosound	Radar	Total
2	1	1	1	1			6
1	1	1	1			1	5
1	1		1	1	1		5
1	1	1	1		1		5
1	1	1	1	1			5
1	1	1	1	1			5
1	1	1	1			1	5
1	1	1		2			5
2	1	1	1				5
1	1	1	1	1			5
1	1	1	1	1			5
1	1	1	1	1			5
1	1	1	1	1			5
1		1	1	1	1		5
1	1	1		1			4
1	1	1		1			4
1	1	1	1				4
1	1	1		1			4
1	1	1		1			4
1	1	1	1				4
1	1	1		1			4
1	1	1	1				4
1	1	1	1				4
1	1	1	1				4
1	1	1	1				4
1	1				1		3
	1	1	1				3
	1	1		1			3
1	1	1					3
1	1				1		3
1				1	1		3
1	1				1		3
1	1				1		3
33	**31**	**26**	**20**	**18**	**9**	**2**	**139**