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DELIVERABLE 4: A FEASIBILITY ASSESSMENT OF DEVELOPING VALUE ADDED PRODUCTS TO PROVIDE INCENTIVES FOR RESPONSIBLE FISHING IN THE COLOMBIAN PACIFIC

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Executive summary

Catch data from fisheries monitoring programs in the Northern Chocó collected by Marviva and Valle del Cauca and Nariño collected by BIOREDD were summarised and analysed to explore opportunities to add value to artisanal fisheries in these areas of the Colombian Pacific.

First we reviewed the data to provide a rapid assessment of the fisheries of the region and then used this information evaluate the feasibility of developing strategies for different communities based on briefs produced by Dr Stephen Box from the provisional assessment. We aim here to provide specific context for how these strategies could be implemented and, based on the current catch data make recommendations as to which communities or fisheries sectors these strategies could be applied. A brief summary is provided at the beginning of this report followed by the technical analysis upon which the recommendations are based.

<u>Feasibility of Brief 1</u>: Developing sushi grade tuna

Landings of yellowfin tuna (*Thunnus albacares*) were analysed using size and weight data to evaluate the proportion of landings larger than recommended minimum sizes set by Marviva, and the catch volume of tuna according to location and season. Tuna make up 18% of landings in Buenaventura, and 11% in the Northern Chocó, indicating that with appropriate capacity building of fishers there is good potential for significantly increasing the value of tuna fisheries around the Bahía Solano and artisanal fishing communities throughout the Northern Chocó.

In the northern Chocó region 23% of the tuna captured are above minimum size recommendations (no size information was available from other regions), indicating that if minimum size limits were enforced, yellowfin tuna would need to fetch approximately 5 times the current value in order to provide a meaningful incentive to local fishers to adopt these minimum size recommendations.

Based on estimates calculated from catch per unit effort data, this 23% represents a mean annual catch of ~ 84 tons of yellowfin tuna. Current prices for 1kg of tuna is around COL$6000. A new price of ~COL$30,000 per kg for "sushi grade" whole tuna would provide sufficient economic incentive to offset losses of adopting best practices through the release of the undersize fish.

The current price for sushi grade tuna loin in Bogota (which is currently imported from Thailand) is US$90 per Kg (approx. COL 180,000). The rendition rate for whole tuna to tuna loin is 3:1. So for sushi grade tuna loin sourced from Pacific coast fishers the market price would need to would to be COL 90,000 (plus transport costs and other costs). These figures are encouraging as the final market price would be around half the current price of the imported alternatives whilst providing sufficient income to the fishers to offset losses due to adoption of minimum sizes.

<u>Feasibility of Brief 2</u>: Artisanal Canned Tuna

Landing data for yellow-fin tuna suggest that production is sufficiently high to support the supply of an artisanal cannery for the parts of the fish not used for the high value sushi market. This would be specifically appropriate for the municipality of Buenaventura and augmented by tuna sourced from Nuqui.

Landings of tuna represent 18% of the Buenaventura fisheries. Two Buenaventura fishing communities, Pital and Punta Bonita divide the total annual catch of tuna for the area between them (48% and 52% respectively). Fisheries around the southernmost Colombian department of Nariño show no catch of any tuna species so this area is not recommended for these fisheries concepts.

In addition to yellowfin tuna, data on landings of black skipjack *Euthynnus lineatus* from the Northern Chocó suggests peak season falls between December – April, with El Valle in Bahía Solano showing the highest catch in January. The largest catch proportion is landed, however, in fishing communities of the Nuquí municipality such as Termales, Coquí, Nuquí, Partadó and Panguí. This municipality also exhibits the highest Catch Per Unit Effort (CPUE) for black skipjack in Tribugá and Arusí, so the artisanal fisheries throughout the Gulf of Tribugá and the municipality of Nuquí should be targeted for development of a supply chain for black skipjack to support a high end sushi direct to Bogota and supply an artisanal tuna cannery based in Buenaventura.

Feasibility of Brief 3: Vacuum packed frozen fish fillets

We analysed the catch assemblage from Buenaventura fisheries and investigated potential candidate species for development of value added, single portion, fish fillets aimed at competing with Tilapia. We assessed species based upon their species ecology and vulnerability to fishing pressure using available literature.

The catch assemblage in the Buenaventura area is diverse (~80 species), with a mix of pelagic species and inshore, coastal and estuarine fish species. Sea catfish species (such as barbinche, ñato and canchimalo) and bass (pelada) are abundant species of a medium price category with moderate vulnerability and medium resilience. These would make good options to develop as fillets. Higher value species like the blackfin snook (Gualajo), would also make a very good candidate for filleting, given its low vulnerability and high resilience. Diversifying the focus to a range of inshore species allows for supply chain continuity as a number of similar fillet products can all provide similar products in terms of size, flesh texture and flavor.

We recommend these fisheries be developed with fishers that are not able benefit from off shore pelagic tuna fisheries because of their limited access to off shore areas. The reduced fishing costs of the inshore fisheries means that fishers will not need to significantly upgrade fishing gears or increase fuel expenditure in order to supply these potential "new" products. These recommendations would also be extremely pertinent for fisheries in the department of Nariño, where high volume catches of mangrove and estuarine species are exhibited, and where access to pelagic fisheries such as tuna would be limited.

Introduction

This report analyses the combined fisheries landings datasets from Marviva and BIOREDD programs in the Colombian Pacific. The aim is to evaluate as far as practicable the state of the fishery, apparent health of important fisheries species and the current fishing pressure by coastal communities on different marine areas. The objective is to provide guidance for fisheries and market diversification as a tool to improve the sustainability and income potential of the area's fisheries resources.

Initial fisheries stock assessment analysis was carried out using fisheries dependent catch per unit effort (CPUE) data from fisheries in the Northern Chocó (collected by Marviva), in order to estimate theoretical maximum sustainable yields and estimate values for original stock biomass. Errors and inconsistencies related to utilising CPUE data are reduced somewhat by using single species catches where possible, rather than attempting to analyse the entire mixed stock represented by regional landings. However, in the absence of fisheries independent data, CPUE analysis should still be treated with caution due the natural variability inherent in fisheries catch data and the *catchability* of species changing over time and space (Maunder et al. 2006).

This report provides a review of the fisheries in the area describing geographical trends, gear types in use, and catch composition with special reference to current species-specific size recommendations set by Marviva. In sections 2 to 4 of the report we provide an analysis to determine if the existing fisheries have the potential to support the recommendations made in the technical brief by Dr Stephen Box, as concepts to help restructure local fisheries.

In **Section 2** the analysis focuses on landings of yellowfin tuna to evaluate the potential for developing a niche fishery to provide high value, sushi grade tuna to national markets, competing with imported tuna from Asia (Technical brief 1). **Section 3** evaluates landings of skipjack tuna throughout the Pacific coast to identify potential source fisheries that could supply an artisanal canned tuna brand developed in the Colombian Pacific and produced through an existing cannery in Tumaco (Technical Brief 3). **Section 4** describes and analyses the species assemblage of the Buenaventura fisheries to suggest potentially underutilised species with more resilient life history traits that could be processed into fillets, frozen and vacuum packed to add value to the species and the fishery, and potentially compete with aquaculture-raised tilapia (Technical Brief 4).

Section 1: General Summary of Artisanal Fisheries in Colombian Pacific

Fishers & fishing gears

According to the combined data sets, there are 2,165 fishermen recorded in the Colombian Pacific. This is likely to be an underestimate and building a complete fisher register would be a useful step forwards. In Northern Chocó (Marviva data) there are 1,477 active fishers recorded in sampling, however only the owner of the boat is recorded along with the number of additional fishers. Given the average number of fishers on a typical fishing trip of 1.6, the number of fishers of likely to be nearer ~2400. Recorded fishers from Buenaventura total only 17, and Tumaco 671. So there are at least 3,000 fishers that can be inferred from the existing data sets.

Fishing Gear Types

Hand line (*Linea de mano*): Monofilament fishing line, normally wound around a reel held by hand, with one baited hook per line. Fishers would carry numerous reels per person.

Drum line (*Espinel*): Consists of a thick nylon rope to which monofilament line leaders are tied, spaced approximately 5 m apart. Each leader supports a number of baited hooks attached by gangions (see figure 1), or terminates in a single baited hook.

Gill Net (*Red de enmalle*): A fishing net made of fine monofilament line, weighted on the bottom and with floats on top to hand vertically in the water column, designed to entangle fish by the gills as they swim into it (figure 2).

Beach Seine (*Chinchorro*): A net used to sweep an arc from the shore to capture fish from seagrass and beach shallow habitats.

Cast net (*Atarraya*): A circular net weighted around the perimeter that is thrown from shore or boat to capture small fish.

Purse Seine (*Boliche*): Net that encircles a school of fish and is then tightened to close it at the bottom to catch the school.

There are 7 main gear types in use in the Northern Chocó, the most important of which, by mean weight of annual landings is hand lines (251.7 tons ± 18) (mean ± Standard error) followed by long lines (espinel) and gill nets (see Table 1). The remaining four gear types (spear gun, cast net, beach seine, manual collection) make up less than 1% of total catch (<14 tons) in Northern Chocó.

In BIOREDD program areas in the departments of Nariño (Tumaco) and Valle de Cauca (Buenaventura), the main gear type used is gill nets, representing >30% of the total catch. However, the gear information is missing from many of the landing records from this region, recorded only as 'artisanal' or 'other' and so it is not clear what the actual important gear types are for this area. An additional gear type used in Tumaco that is not recorded from the northern Chocó is the purse seine (*Boliche*).

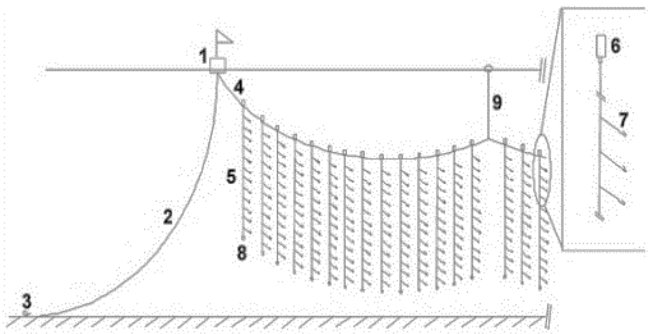


Figure 1. Diagram of a drum line. 1) Buoy; 2) Buoy rope; 3) Anchor, 4) Lift line; 5) Main line; 6) Float (bottle); 7) Gangion and hook; 8) Weight (sinker); 9) Buoy line (from Queirolo & Ahumada 2009).

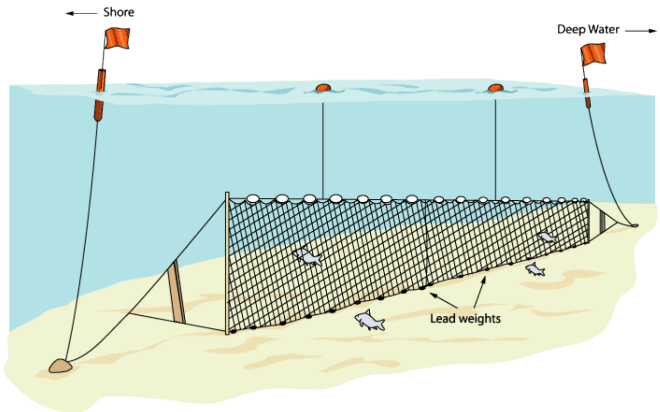


Figure 2: Diagram of a gill net.

Summary of available data

The Marviva data from the northern Chocó represents 4 years of sampling from 19 communities (see figure 3). The data are divided into two main sets:
1) Catch weight & fishing effort and
2) Fish sizes.

Table 1. Mean annual catch (± SE) for all communities in the Northern Chocó across 4 years (2010-13)

Gear Type	Mean Annual Catch (Tons)	Standard Error
Hand line	251.7	18.0*
Long line	114.2	18.7
Gill Net	73.8	7.1
Spear gun	1.6	0.7
Manual Collection	1.2	0.8
Beach Seine	0.8	0.4
Cast Net	0.1	0

*The variance of the mean weight of annual landings is large due to limited data from 2010 when sampling started.

Dataset 1 (Catch weight and effort data) consists of 128,998 records (including 922 fishing trips with no recorded landings). 1,871,143 individual animals were captured across all species, of which 1,564,539 were fish. 8,142 sharks and rays were landed, representing a combined weight of 37 tons landed over four years in all fisheries combined.

Note:
In the Marviva data, size and weight records were taken from different fish. The size or s the weight was recorded but there are not many records that have both size and weight measurements for an individual fish.

Dataset 2 (Fish Sizes) contains 16,383 records, representing 57,918 individual fish of 121 species, measured using total length in centimetres.

Data from the BIOREDD program span 15 months (Oct 2012- Dec 2013), and was collected in two departments of Colombia: Nariño and Valle del Cauca in the southern and central Colombian Pacific respectively. The data are from 20 localities in Tumaco, Nariño (1,858 records), and 9 localities in Buenaventura, Valle del Cauca (1,561 records). Sampling from Buenaventura contains weight and some size data, whereas only weight data are available for Tumaco.

Main fishing grounds

Six fisheries regions catch 70% of the total catch of the Northern Chocó, Nuquí, Bahía Solano, Jurubirá, Cabo Marzo, Arusí and San Felipe-Castellano-Paja (Table 2 & Figure 3).

In Valle del Cauca, the 3 fisheries of Punta Bonita, Guayabal and Pital around Buenaventura catch 89% of the catch. Around Tumaco in Nariño, the fisheries in Teheran, Pueblo Nuevo and Bajito Vaqueria land 64% of the total landings (see figure 4).

Catch per unit effort (CPUE) is a measure of relative abundance and can be used as a proxy for fish abundance, providing that fishing gears are the same across time and space. CPUE is the amount of fish caught within a specified unit of effort, which relates to the time spent fishing (e.g. one hour) and the 'amount' of the gear type used (e.g. number of hooks, length of net etc.). In mixed stock, mixed gear fisheries this is often simplified using only time for each type of fishing gear. CPUE relies on the assumption that fish at higher densities are easier to catch meaning they require less effort to catch the same amount of fish.

Note: CPUE cannot provide a calculation of absolute abundance. Given sufficient time a depletion method could use CPUE to assess theoretical original stock biomass using the cumulative catch over successive years. However, to more accurately obtain a value for the size of a certain fish stock, mark recapture techniques using fish tagging should be conducted.

Catch per Unit Effort

We defined CPUE as the kilograms of fish caught by one fisher per hour. CPUE was highest in Piña (0.73 kg.fisher^{-1}.hr^{-1}), however data exists for only one year. Arusí has the highest average CPUE across 4 sampling years with 0.63 kg.fisher^{-1}.hr^{-1} ± 0.14 (SE) (Table 2).

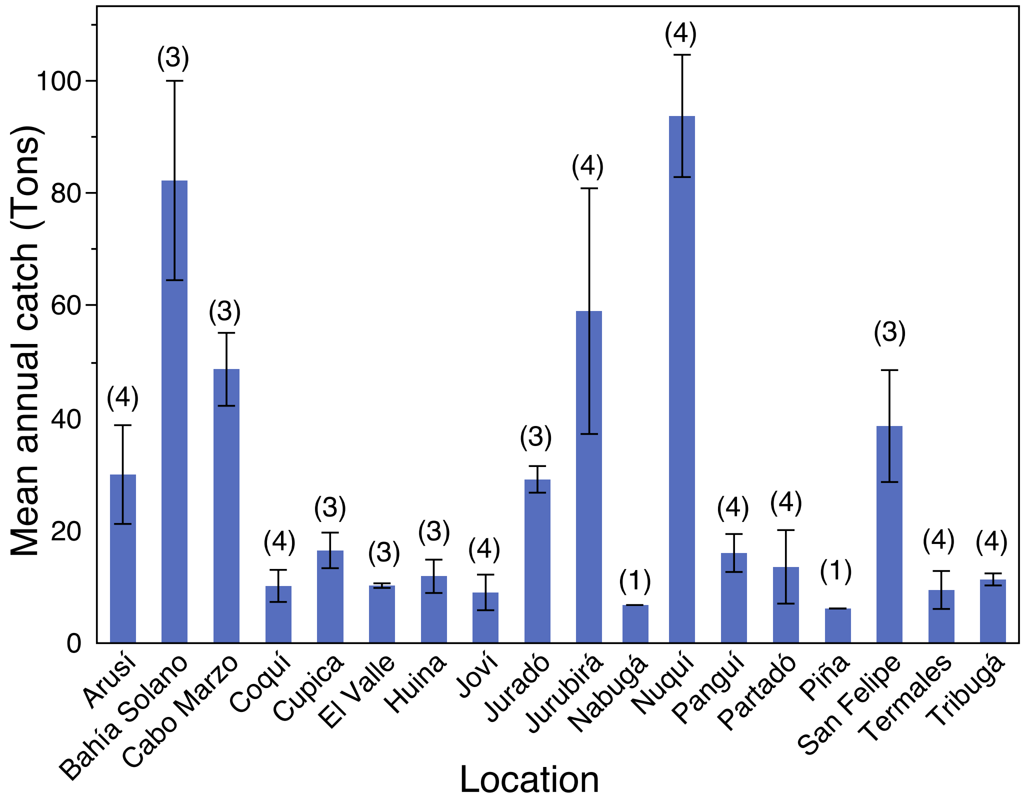


Figure 3: Mean annual catch weights of all artisanal fisheries in the Northern Chocó, Colombian Pacific. Error bars represent the standard error across the years. The number in parentheses represents the number of years sampled.

Table 2. Mean catch per year in tons for 18 fishing communities in the Northern Chocó, Colombia detailing percentage of total catch, and catch per unit effort according. Highlighted communities have the highest mean annual CPUE (kg.fisher^{-1}.hour^{-1})

Location	*N* years	Mean catch tons/yr	± SE	Mean % of all community's catch	Mean annual CPUE (kg/man hr)	± SE
Nuquí	4	93.8	10.9	18.2%	0.25	0.08
Bahía Solano	4	82.3	17.7	16.0%	0.63	0.07
Jurubirá	4	57.5	22.6	11.2%	0.51	0.08
Cabo Marzo	4	48.7	6.5	9.45%	0.40	0.08
Arusí	4	30.0	8.8	5.82%	0.63	0.14
San Felipe CP	4	38.6	10.0	7.49%	0.36	0.04
Juradó	4	29.1	2.37	5.65%	0.41	0.02
Panguí	4	16.0	3.38	3.11%	0.20	0.03
Partadó	4	13.6	6.54	2.63%	0.26	0.05
Cupica	3	16.5	3.16	3.20%	0.48	0.04
Tribugá	3	11.3	1.08	2.20%	0.09	0.01
Coqui	3	10.2	2.85	1.97%	0.14	0.02
Termales	3	9.5	3.37	1.83%	0.19	0.06
Joví	3	9.0	3.17	1.75%	0.21	0.03
Huina	3	11.9	2.98	2.30%	0.45	0.10
El Valle	3	10.2	0.42	1.98%	0.31	0.05
Nabugá	1	6.4	-	1.21%	0.58	-
Piña	1	6.2	-	1.19%	0.73	-

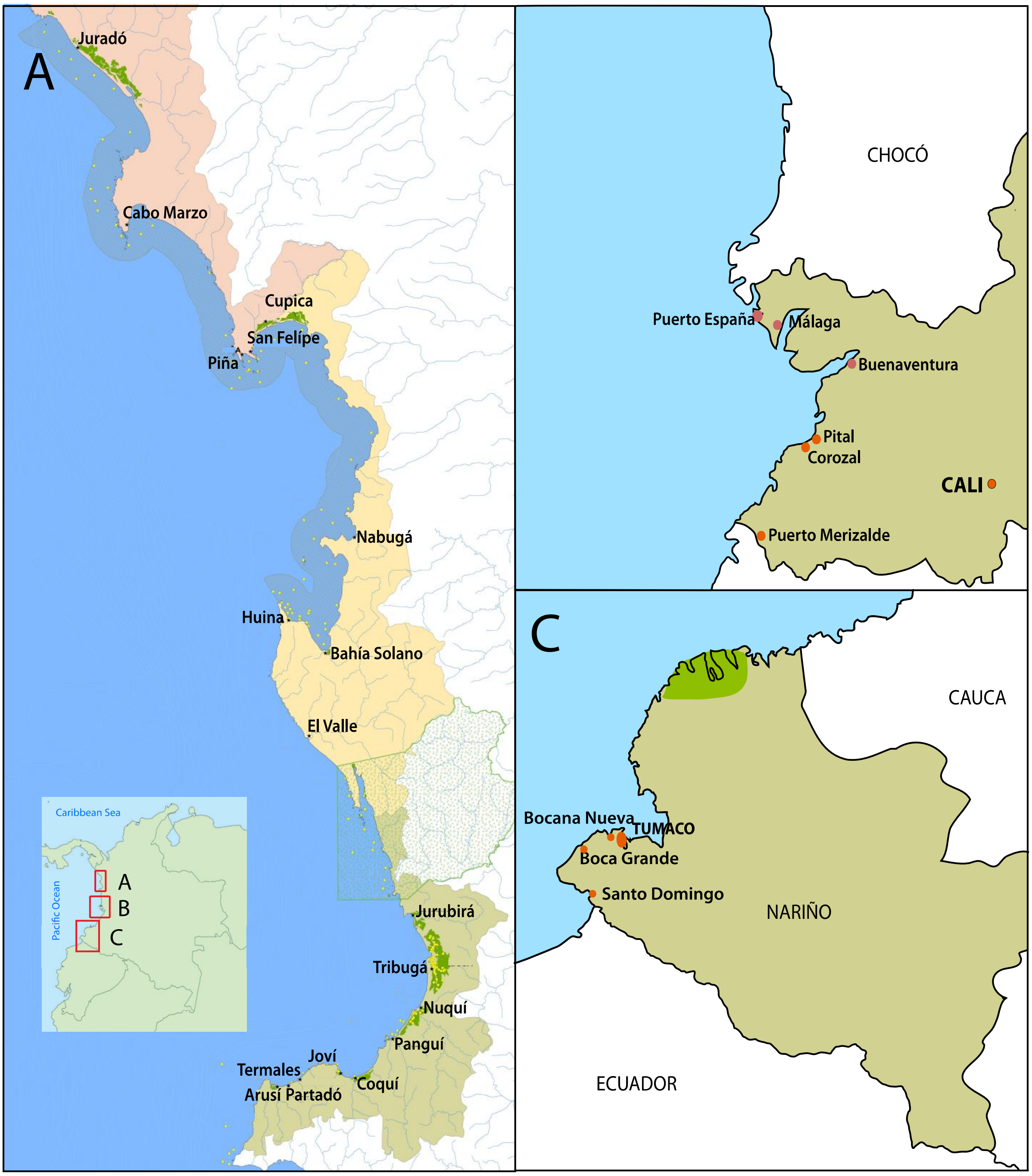


Figure 4 (A, B, and C). Maps of program regions and artisanal fisheries locations of the Colombian Pacific. A) Northern Chocó (Marviva), B) Valle del Cauca (BIOREDD) C) Nariño (BIOREDD)

Catch composition

The catch composition of fisheries throughout the entire Colombian Pacific is made up of ~350 species, the largest proportion of which is bony fishes, but also includes molluscs ("piangua" - arc clams, *Anadara* spps), sharks, rays and marine turtles..

A large part of the artisanal fisheries in the Northern Chocó focuses on pelagic species, particularly scombrids including true tunas, skipjacks, jacks and sierra mackerels, with the largest catch by weight being yellowfin tuna *Thunnus albacares* (see Section 2). In addition fishers target slightly deeper dwelling coastal species such as brotulas (*Brotula clarkae*), red and spotted snappers (*Lutjanus peru* & *L. guttatus*), with less targeting of inshore brackish or mangrove obligate species.

The fisheries of Buenaventura are also dominated by yellowfin tuna *Thunnus albacares* and Pacific sierra (Wahoo - *Scomberomorus sierra*) in terms of landings weight (32%), however the catch composition is also characterized by much larger numbers of inshore and estuarine species such as catfish (*Bagre spp*.) and snook (*Centropomus spp*.).

The southernmost fisheries around Tumaco have catches composed of 36 identified species, however the data are dominated by landings of an unidentified mix of species of lower commercial value called "pescadilla" that make up 63% (106 tons) of all landings. There are only data available for 5 months of the year (May, June, July, October and November), and a lack of detailed species information and length data. The top 10 species landed in Tumaco are detailed in Table 3.

Table 3: Top 10 species landed by weight and percentage of annual catch in the Tumaco fishery, Colombian Pacific.

Common Name	Scientific name	Weight (kg)	% Of Annual Catch
Pescadilla	Group of Mixed fish	106,737	61.8%
Pelada	*Cynoscion reticulatus*	17,849	10.3%
Pargo	*Lutjanus sp.*	13,191	7.6%
Cubo	*Caulolatilus affinis*	7,045	4.1%
Picuda	*Istiophorus platypterus*	5,239	3.0%
Merluza	*Brotula clarkae*	5,045	2.9%
Sierra	*Acanthocybium solandri*	3,456	2.0%
Bagre	*Bagre sp.*	3,163	1.8%
Zafiro	*Cynoponticus coniceps*	2,500	1.4%
Cherna	*Epinephelus acanthistius*	1,771	1.0%

Minimum Size Limits

Marviva and the *Red de Frío* program initiated the introduction of recommended minimum size limits for certain fisheries to encourage responsible fishing. This aims to prevent growth overfishing, of which one of the causes is harvesting fish before they reach maturity. In many fisheries however there is also a maximum size limit as well. This "slot" fishery is based on the understanding that large fish produce more eggs which are more competent and so by protecting larger individuals there is a greater benefit to the overall reproductive output of the population. This has not been considered yet in the fisheries regulations for Colombia.

We carried out an analysis of catch composition in terms of fish size by species, to estimate the current state of fish populations and their size structure within the fished population. In addition we assessed the feasibility of trying to enforce these size limits onto fishers based upon the abundance of fish over the size limit currently being landed. We evaluated this based on the impact this would have on catch levels and income if only fish over the minimum size were landed and sold.

We assessed the proportion of the fishery currently exceeding minimum size limits established by Marviva (Table 4 and Figure 5). Some species exhibit extremely low numbers of individuals exceeding these thresholds (e.g. *Thunnus albacares* the yellowfin tuna (9.1%) and *Epinephelus acanthistius* the rooster hind (6.4%)), potentially indicating that either the size limit is not suitable for this species (be it taken from a geographically and morphologically distinct stock, or from a smaller sub species from the same range), or that the species is overfished and so there are very few larger individuals in the population. Rooster hind and yellowfin tuna are both hook fisheries caught predominantly with espinel and hand line (Rooster hind 87% espinel, 12% hand line;

yellowfin 96% hand line, 3% espinel). The low levels of large fish for these species could indicate that the gear type is not suitable for selecting the larger individuals of a fishery, so perhaps larger hook sizes could be beneficial in increasing the mean size of individuals caught. A fishing experiment using larger hook sizes should be conducted to investigate if this increases the average size of the fish being caught.

Table 4. Comparison of minimum size limits of key fisheries species targeted by Marviva and the *red de frío* program, with Length of 50% maturity (Lm50) (data from fishbase.org), maximum recorded length (Lmax) and the proportion of the catch above this size (%> min size). Empty cells are where no data is available for this species. Cells are shaded for their percentage over minimum size, with green being good (>80%) and red being poor (<10%).

Scientific Name	Common Name	Min Size Limit (Marviva)	Mean fish size	± SE	% > min size	Lm50	Lmax
Centropomus robalito	Snook	30 cm	53 cm	2.1	97.8%	-	34.5
Lutjanus peru.	Pacific red snapper	35 cm	47	0.71	66.4%	22	95*
Katsuwonus pelamis	Skipjack tuna	40 cm	56 cm	2.22	100%	40 (40-45)	110
Scomberomorus sierra	Pacific sierra	45 cm	52 cm	0.17	68.2%	26 - 32	99
Brotula clarkae	Pacific bearded brotula	62 cm	73 cm	0.2	82%	62.3	115
Coryphaena hippurus	Mahi mahi	65 cm	88 cm	0.53	99%	65 (35-55)	210
Caranx caninus	Pacific crevalle jack	70 cm	41 cm	0.47	38%	-	101
Lutjanus novemfasciatus	Pacific dog snapper	70 cm	66 cm	1.53	59%	-	170
Epinephelus acanthistius	Rooster hind	72 cm	46 cm	1.61	6.4%	-	100
Seriola rivoliana	Almaco jack	80 cm	97 cm	0.88	82%		160
Thunnus alalunga	Albacore tuna	85 cm	-	-	-	103 78-158	239
Thunnus albacares	Yellowfin tuna	75 cm	65.5 cm	0.11	23%	78-150	239

*Thirteen values in the data set are for *L. peru* are larger the reported maximum size of this species. These could potentially have been misidentified or measured incorrectly, or maximum size differs from recorded values found in fishbase.org

Conclusions and recommendations

Results show that for some species, more than 82% of individuals captured were larger than the minimum size limit established by Marviva (snook, mahi mahi, almaco jack, brotula). However, other species exhibited proportions of concern, such as the rooster hind (6.4%), yellowfin tuna (23%), Pacific crevalle jack (38%), and Pacific dog snapper (59%). The low levels of large fish for these species could indicate that the gear type is not suitable for selecting the larger individuals of a fishery, so perhaps larger hook sizes could be beneficial in increasing the mean size of individuals caught. A fishing experiment using larger hook sizes should be conducted to investigate if this increases the average size of the fish being caught.

Minimum size regulations (the smallest size at which a particular species can be legally retained if caught) emerged as a strategy for fisheries management in order to protect juvenile fish until they reach sexual maturity and 'recruit' to the spawning stock (Hill 1992). Minimum size limits have the advantage of being a logical and clear regulation to understand and follow. However, in certain cases their application can have some limitations which relate to species biology (i.e. sexual maturity is attained at a particular age, not to a specific size; minimum size is below the size at maturity in species that change sex); or to management (i.e., significant mortality of individuals because discards of undersized catch; species misidentification; minimum size below the size at maturity; difficulty to comply if several similar species have different size limits).

An alternative and likely scenario is that despite rules in place, fishermen ignore fish size. It has been shown that success can be more easily achieved if there is a clear economic benefit in landing animals above the minimum size. Market demand can have important effects on biological populations as it drives selective harvest (exploitation favouring a particular stock, species, or size). This is the case of the Pacific red snapper (*Lutjanus peru*) fishery around La Paz, Mexico and Chocó, Colombia, where "plate-sized" fish are sold to restaurants at premium price. A recent study in the red snapper fishery around La Paz (Mexico) showed that market preferences for a "plate-sized" fish (20-35cm) increased fish biomass (28%) and fishermen's revenue (22%) if institutional constrains led to small improvements in size selection (Reddy et al. 2013).

Other approaches to fish size regulations
Harvest Slot Limits: Permit the harvest of fish within a specific minimum and maximum length range.
Protected Slot Limits: Permits the harvest of small fish and larger adults while restricting the harvest of the intermediate reproductive fish size.

Recent research has shown that *harvest slot limits* that restrict harvest to intermediate lengths (between a minimum and maximum size), contribute to a more natural age-structure in the fished population while maintaining high harvest numbers and conserving reproductive biomass (Gwinn et al. 2013). The case of the red snapper fishery in La Paz, Peru, suggests that "plate-sized" fish preference, which acted as an informal slot limit (as buyers did not want fish that were either too small or too big for the plate), has been beneficial for the stock and the fishermen (Reddy et al. 2013). Other examples of the use of harvest slots limits are seen in the snook fishery in Florida, where slot limits have been in place since 1990 (snookfoundation.org). In Florida, other species such as snapper, black drum, permit, redfish, sea trout, and pompano are also regulated using harvest slots limits.

It is important to note that the success of size limit regulations depends on the fishery status, the species biology, and the institutional and governance context of the area. Correct fish identification is essential when complying with size regulations. Increased local capacity in species identification may be needed in species that are difficult to distinguish and have very different sizes at maturity. Additionally, it is essential to develop more research in the Colombian Pacific regarding fish species biology, such as growth, mortality, and reproduction, since literature size limits might not be suitable for certain fish, and discrepancies have been seen in these data.

The effectiveness of size restriction to protect small sized fish as a mechanism of enhancing stocks depends on its combination with other management methods. According to the obtained results, it is recommended that the fisheries with a significant proportion of fish exceeding the size thresholds, combine regulations with the following techniques:

- Gear restrictions: Use of size-selective fishing gears, such as hook and line, with careful consideration of hook size.
- Closed seasons: Prohibiting fishing in the reproductive or spawning seasons of overfished species (usually more suitable for species with short recruitment periods).
- Closed areas: Protecting areas that are of importance to juveniles or reproductive stages, such as nursery ground habitat (mangroves and estuaries).
- Quotas: A total allowable catch quota encourages fishers to maximize the value of their landings by focusing on catching larger more valuable fish, rather than smaller lower value fish in larger volumes.

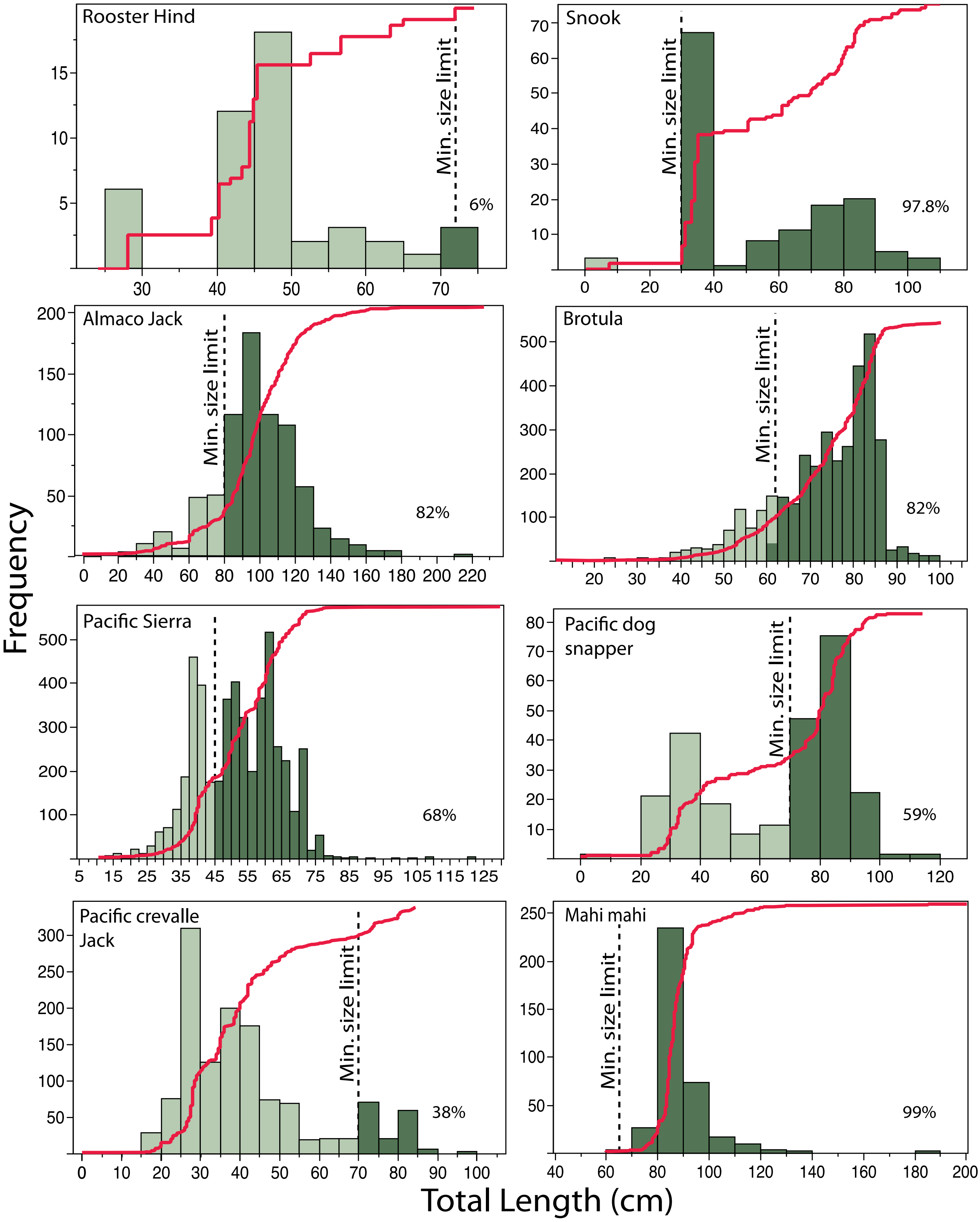


Figure 5: Frequency distributions of size (TL) of 8 key fisheries species caught in artisanal fisheries of the Northern Chocó, Colombian Pacific between 2010-2013. Dark green bars represent fish larger than the minimum size limit set by Marviva. Percentage values represent the catch proportion that is over the minimum suggested size.

Section 2: Biological feasibility of Brief 1 – High value tuna fishery

Data Description & Analysis

High value tuna species used in sushi and sashimi belong to the true tunas, genus *Thunnus*. These are further divided into two sub genera, yellowfin tuna and bluefin tuna. According to species ecology and distribution, three *Thunnus* species are distributed in the tropical eastern Pacific, one yellowfin *Thunnus albacares* (Yellowfin Tuna) and two bluefin species *T. alalunga* (Albacore Tuna) and *T. obesus* (Bigeye Tuna).

Note: There is some confusion over species nomenclature in the region, as both yellowfin (*Thunnus albacares*) and albacore (*T. alalunga*) tunas can be known locally as 'Albacora', yet each have an alternative local name 'Aleta amarilla' for yellowfin and 'Atún blanco' for albacore respectively. Identification at the species level is lacking, with yellowfin tuna appearing in the Marviva dataset, using the local name of 'Albacora' but then classified as Yellowfin tuna, *Thunnus albacares.* Only 4 records of 'Atún blanco' exist across the 4 year Marviva dataset, and no records of the bigeye tuna (*T. obesus*) despite the Colombian Pacific being in the range for this species.

Buenaventura (BIOREDD data)

In the area of Buenaventura, only limited data are available to evaluate tuna landings. Two localities divide the total catch of tuna with Pital (2.9 tons, 48% of annual catch) showing peak abundance in March, and Punta Bonita (3.1 tons, 52% of annual catch) peaking in November, similar to the pattern seen in Jurubirá fishery of Northern Chocó (Figure 7). However, it is not known what species of tuna are being captured, as these are listed in datasets only as "Atun". No tuna landings were recorded for fisheries in Tumaco.

Northern Chocó (Marviva data)

Total catch of *Thunnus albacares* in the Northern Chocó region over 4 years sampling (2010-2013) was 200 tons. Mean annual catch for last 4 years (duration of data collection) across all regions was 50 ± 14.4 tons (± SE), however over the 2012-2013 sampling period this rises to 74.5 ± 2.5 tons (because the increased sampling effort during these years) (Table 5 & Figure 6).

Table 5: Catch and effort information for the yellowtail tuna (*T. albacares*) fishery in the Northern Chocó, Colombian Pacific.

Year	Catch (kg)	Effort (man hours)	CPUE
2010	18,942	22,776	0.83
2011	32,221	58,920	0.55
2012	77,003	86,616	0.89
2013	71,999	67,488	1.07

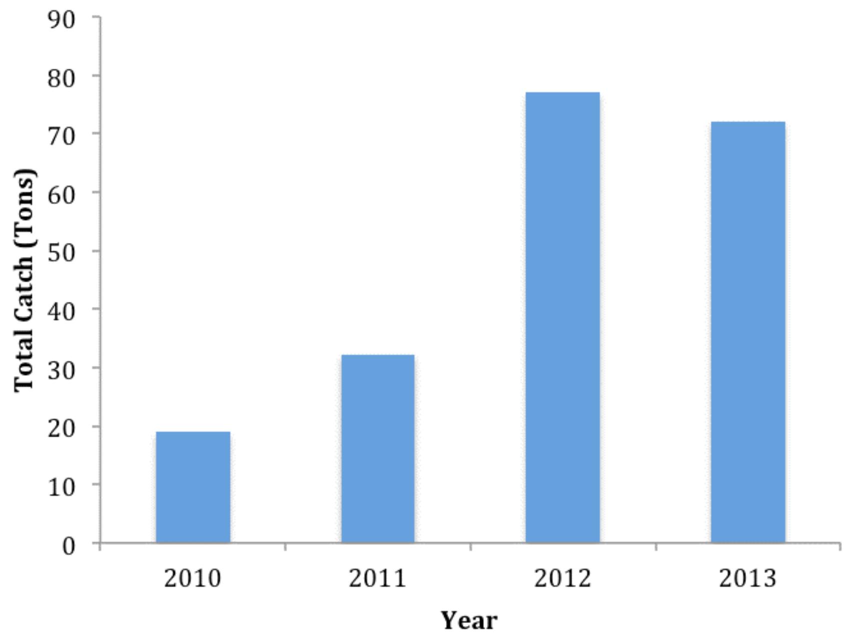


Figure 6. Annual recorded catches of yellowfin tuna *Thunnus albacares* between 2010-2013 in the Northern Chocó, Colombian Pacific.

The data sets include 641 boats, 43% of all the boats active in the Northern Chocó (total 1,477), recorded as landing yellowfin tuna *Thunnus albacares*. Using a mean catch per unit effort (CPUE) value by month in kg^{-1} $boat^{-1}$ day^{-1} and multiplying it by 641 boats*17 days (~4 days per week), we calculate an estimated total annual catch of ~366 tons, or ~1.8 tons of yellowfin tuna landed per day. It should again be noted that CPUE analysis is extremely unreliable however, due the natural variability inherent in fisheries catch data and the *catchability* of species changing over time and space (Maunder et al. 2006), so this figure should be used with caution. However, this calculation provides an approximate value for the total productivity of this fishery, given that only a fraction of the total catch landed is sampled by observers.

Between 2010-2012 catch of yellowfin tuna increased markedly across the region, rising to its highest point in 2012 of 77 tons. This heightened catch could be for a number of reasons, though it is more likely due to greater sampling efficiency rather than increasing tuna abundance. The total catch decreased in 2013, however this corresponded with a decrease in recorded fishing effort, so CPUE was highest for this latest year of sampling. Approximately 1,025 fishers in 641 boats are recorded as catching tuna in the Northern Chocó (based on the average of 1.6 fishers per boat).

Total mean annual catch of yellowfin tuna in Northern Chocó is 50 tons ± 14.4. Six local fishing communities land ~82% of this total catch (Bahia Solano 32.7%, Arusí 20.4%, Huina 8.7%, Cabo Marzo 7.4%, Partadó 6.8% and Jurubirá 5.8%). In the two years sampled (2012-2013), the Bahía Solano fishery has landed an average of 50.6% of the total tuna catch for the region (see figures 7 and 8).

The two largest tuna fisheries based around Bahía Solano and Huina, representing ~80% of the mature catch of *T. albacares*, actually show positive catch per unit effort trends over the past three years, from which we can only conclude that the fisheries are supporting existing fishing pressure. The other key fisheries of Arusí and Jurubirá show mean annual catches of 6,669 kg and 1,639 kg respectively.

These trends may also be related to a reduction in fishing pressure on the tuna stock from the industrial fleet in recent years. A genetic study comparing catch from industrial and artisanal fleets would be extremely useful in management, to ascertain if they are targeting the same stock, as this information is crucial in calculating quotas and maximum sustainable yields.

A calculation of Maximum sustainable yield (MSY) for tuna in the northern Chocó would be extremely unreliable without further work on stock identification. Given the potentially very high value this fishery holds, work to ascertain the stock structure should be prioritised (i.e. do captured tuna in this region belong to the same large stock, or are there overlapping stocks utilising the same area periodically?). This work can be done in a variety of ways, involving tagging studies of tuna (mark-recapture or movement tracking), however genetic sampling of catches would be the most efficient and accurate way of comparing variability among catches by location and season.

Seasonal Variation

In the northern Chocó yellowfin tuna is landed year round, but does show seasonal variation in abundance and CPUE levels. There is slight variation in seasonal catches by location, with a peak in landings in November from Jurubirá that does not appear in data from other areas. The most productive tuna fishery in Bahía Solano consistently lands higher catches throughout the year than the other 3 areas, and shows strong peaks in abundance in April & July. 56% of the annual catch comes in the 5 months between March and July, with April showing the highest overall catch rates across 3 years of sampling. (See figures 4 & 5).

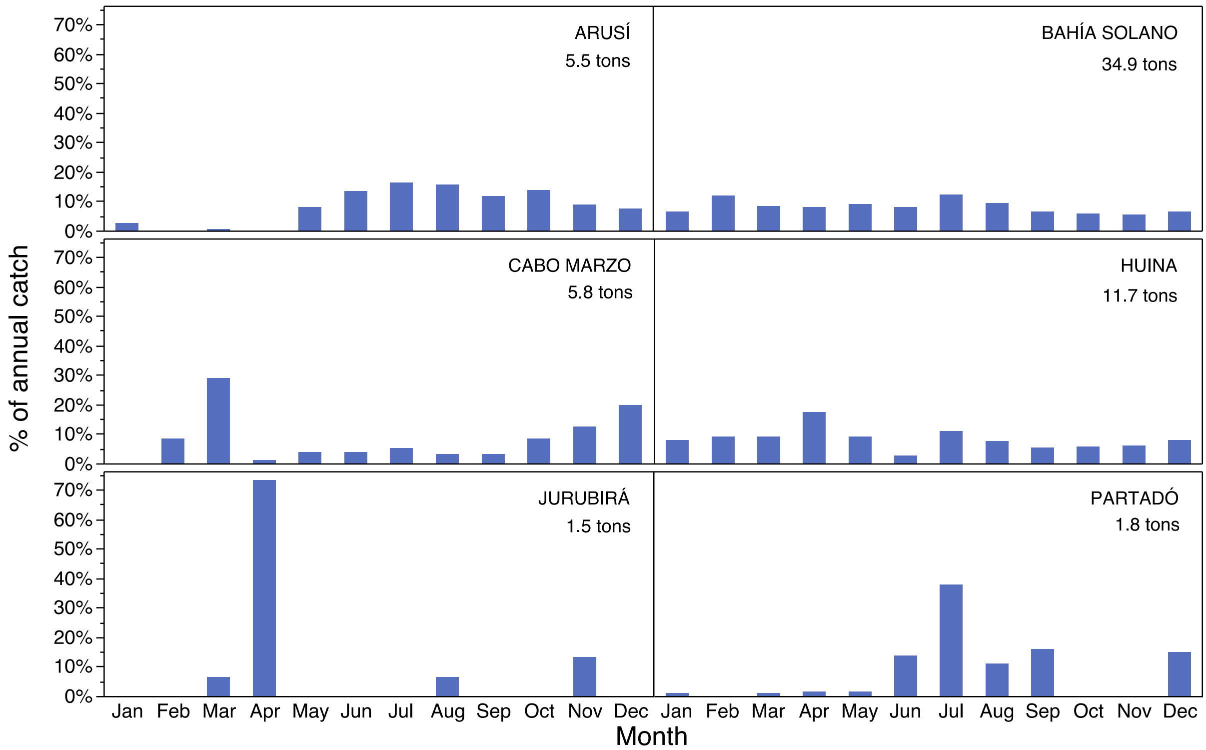


Figure 7: Monthly catch of yellowfin tuna *Thunnus albacares* in 2013 as a percentage of total annual catch in 6 key artisanal fisheries of the Northern Chocó, Colombian Pacific. Figure under location name represents total catch of 2013 in tons.

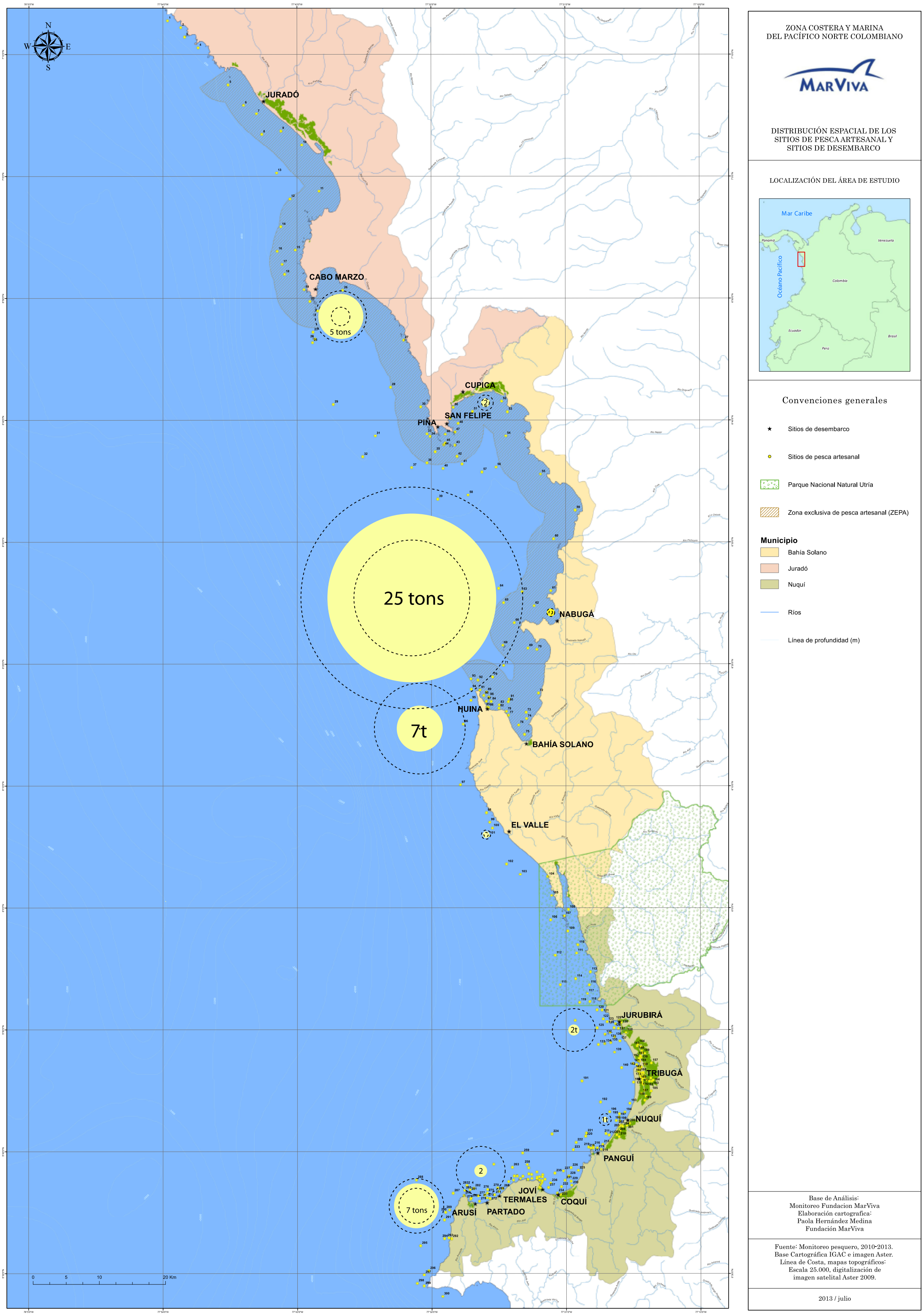


Figure 8. Map of the Northern Chocó region of Colombia depicting the tuna landings from each fishery. Yellow circle size represents the mean annual catch in that area. Dotted black lines represent standard error of the mean.

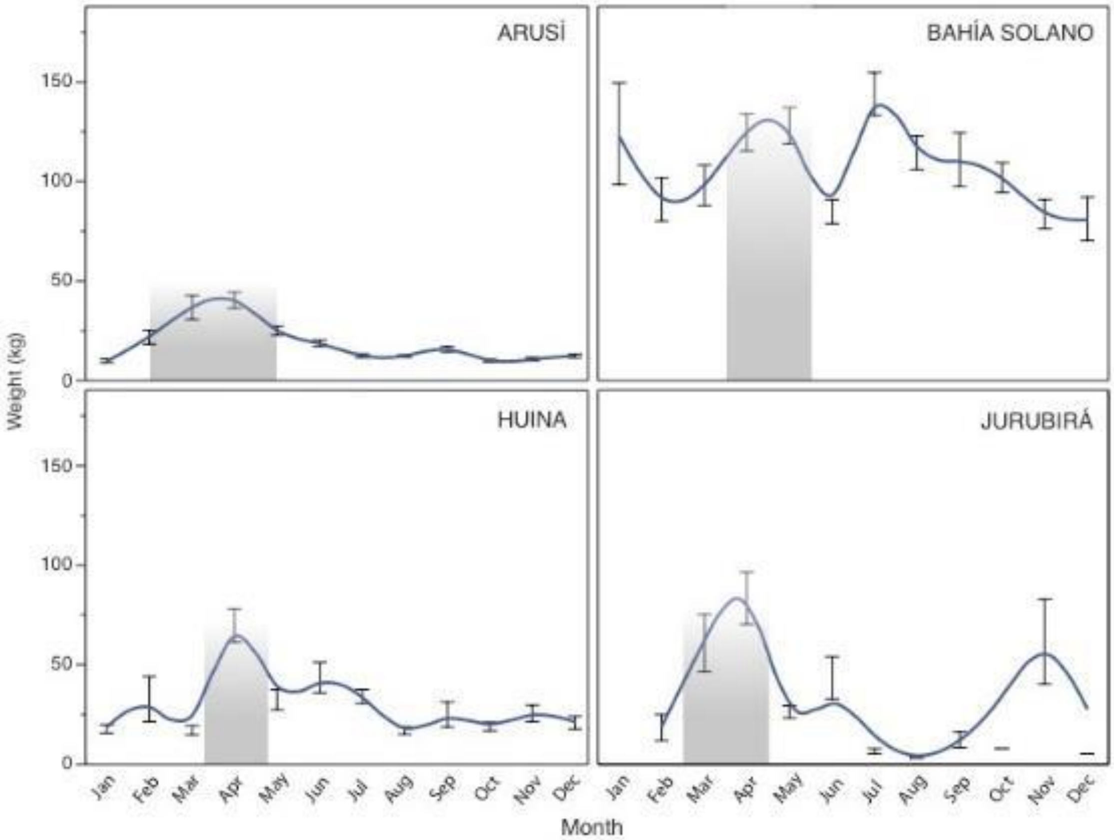


Figure 9: Mean boat catch weight of yellowfin tuna *Thunnus albacares* by month in four key artisanal fisheries of the Northern Chocó, Colombian Pacific. Blue line indicates average catch in kg. Grey shading represents peak fishing season. Error bars represent standard error.

Tuna size & maturity

In the Northern Chocó, 14,159 tuna were measured in 2010-13 sampling. Mean total length was 65.5 cm ± 0.13 (mean ± SE); equivalent mean fork length was 59.1 cm ± 0.11. However, the far more frequently collected catch weight data from the same region indicates a mean fish weight of 4.9 kg ± 0.3 (N = 41,168) equating to a fish size of ~65.5 cm FL based on standard conversion factors available for this species at fishbase.org, however, these figures are estimates from length-weight curves compiled from various regions, so more confidence should be placed in actual measured fish data.

The largest individual captured between 2010-2013 was 238 cm in Jurubirá in March 2011. Size at maturity for the Colombian Pacific tuna stocks has not been conducted, however Marviva are in the early stages of collecting the necessary data to estimate this. Other data from the Eastern Pacific reports *T. albacares* reaching a maximum size of ~239cm (fork length) and weighing up to 200 kg (Froese & Pauly 2000). Published length at maturity (*Lm*) for *Thunnus albacares* from Indonesia ranges between 78-158 cm FL (Mardlijah & Patria 2012). Given large variation in *Lm*50 values according to location, this should be treated with caution. For calculations of the catch above minimum recommended size we use the length suggested by Marviva of 75 cm.

Note: Length data for all species in the Marviva database uses Total Length (TL), from the snout to the tip of the tail. However, tuna is typically measured using Fork Length (FL), to the middle of the "V "of the forked tail. This is because the length of tail is highly variable for fish of similar length bodies. A conversion factor of 1.108 was used to convert TL to FL ("Randall's tank photos. Collection of 10,000 large-format photos (slides) of dead fishes. Unpublished." 1997). Training with data collectors should be conducted to measure

The published length at maturity for the two other true tunas with overlapping distributions are 78 cm FL (male *T. alalunga),* 83 cm (female *T. alalunga)* (Chen et al. 2010) and 102.4 cm (*T. obesus)* (Farley et al. 2006), however these values were calculated in the western Pacific, so should be treated with caution (figure 11).

Using the Marviva suggested minimum size of 75 cm TL for *T. albacares,* only 23% of the total catch recorded should be retained (figure 10). Of this, 40% were captured in Huina, 31% Bahia Solano, Cabo Marzo 7% and San Felipe-Castellano-Paja 6%. All other communities combined catch less than 17% of the tuna above this recommended minimum size (figure 12).

Table 6. Mean fish weights and mean fish lengths from separate Marviva data sets. *Data from Cabo Marzo in 2013 contained 4.6 tons of tuna with no associated frequencies, so a frequency of 1 was used. Hence, figures for Cabo Marzo are likely to be underestimates and should be used with caution.

Location	Mean fish weight (kg)	± SE	*N*	Mean fish size (cm)	± SE	*N*
Jurubirá	10.6	0.45	617	76.4	0.87	214
Bahía Solano	6.0	0.12	12,446	68.1	0.24	3,006
Piña	5.2	0.23	37	76.0	1.60	66
Joví	4.9	0.37	256	49.0	2.88	13
Cabo Marzo*	4.6	1.19	3,227	60.0	0.32	1,393
Arusí	4.5	0.03	5,984	59.5	0.15	3,549
San Felipe CP	4.5	0.11	410	75.0	0.33	404
Termales	4.4	0.15	696	63.1	0.59	372
Huina	4.3	0.12	4,767	75.6	0.15	2,663
El Valle	4.0	0.18	968	69.9	1.61	76
Partadó	4.0	0.06	1,908	57.1	0.48	219
Nuquí	3.5	0.32	1,676	87.6	1.46	323
Nabugá	3.3	0.38	214	72.8	1.38	29
Cupica	2.7	0.07	1,791	-	-	-
Juradó	2.7	0.12	1,240	57.4	0.23	1,281
Panguí	2.5	0.06	817	49.1	0.47	251
Coqui	2.2	0.34	839	56.6	1.00	275

Mean size of fish varied significantly between locations (Wilcoxon, $X^2 = 4648.56$, df = 15, $P < 0.0001$), however no location was significantly greater than all other locations (Steel-Dwass Each Pair test – Appendix 1).

Mean monthly catch weight varied significantly between locations (Wilcoxon, $X^2 = 103.36$, df = 16, $P < 0.0001$), with Bahía Solano being significantly greater than all other locations (Steel-Dwass Each Pair test with Control – Appendix 2).

Note: The landing volumes are approximate due to length and weight information being gathered separately (at different times, from different catches). An improved data collection process would gather length and weight information from the same catch to provide better estimates, and also to investigate aspects such as condition factor.

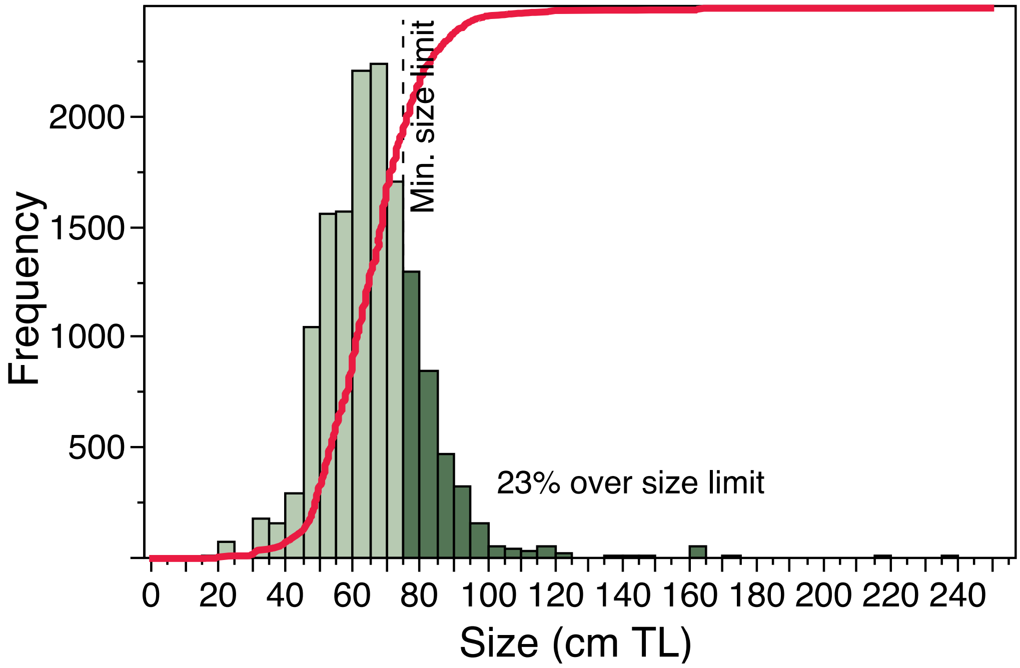


Figure 10: Frequency distribution of size (TL) of *Thunnus albacares* caught in artisanal fisheries of the Northern Chocó, Colombian Pacific between 2010-2013. Dark green bars represent fish larger than the minimum size limit in reported landings

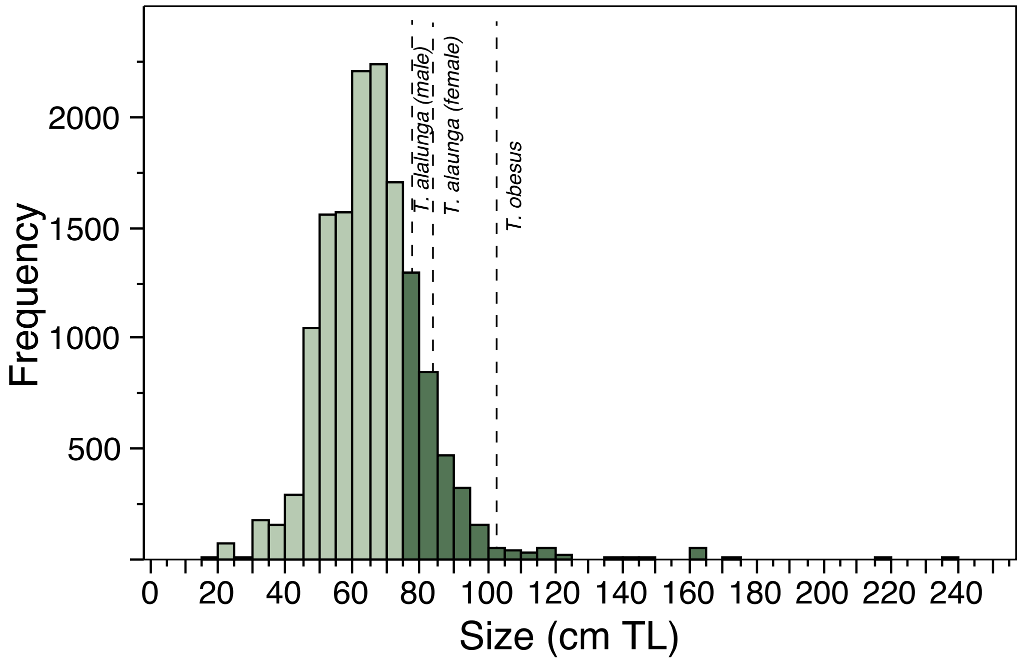


Figure 11: Frequency distribution of size (TL) of *Thunnus albacares* illustrating the published *Lm*50 figures for *Thunnus alalunga* (male and female) and *Thunnus obesus*.

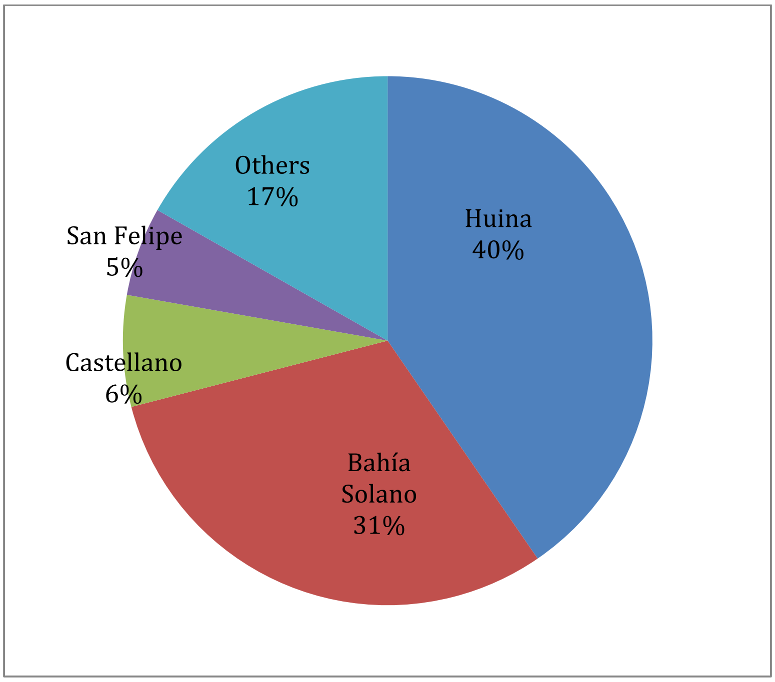


Figure 12: Percentage of catch of mature *Thunnus albacares* (>75 cm FL) by location in artisanal fisheries of the Northern Chocó, Colombian Pacific.

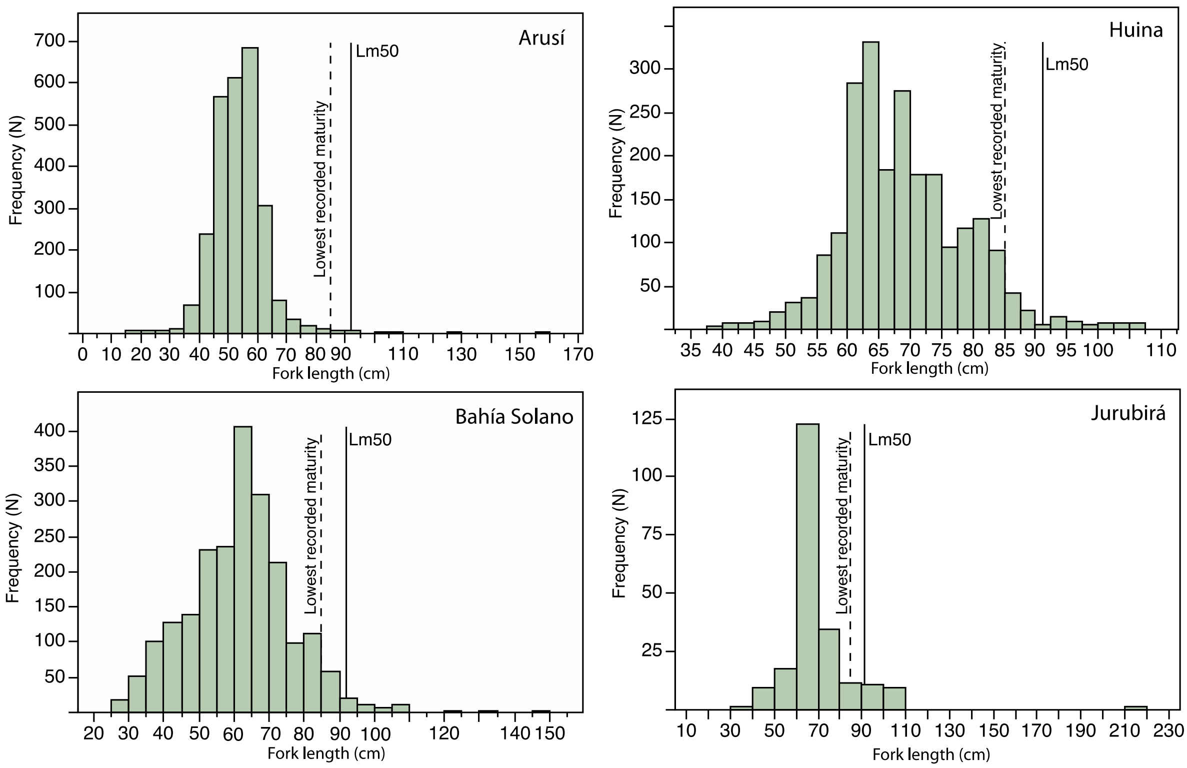


Figure 13: Frequency distribution of size (TL) of *Thunnus albacares* by location in four artisanal fisheries of the Northern Chocó, Colombian Pacific.

Conclusions and Recommendations

Based upon the data available, the true tuna fishery is restricted to yellowfin tuna *T. albacares,* however it is likely that tuna catch is a combination of all three species including *T. obesus* and *T. alalunga* to a lesser extent. Greater care should be taken to identify and record catch to individual species level in order to facilitate accurate catch and effort estimations and improve fisheries management in the future. The four fisheries in the northern Chocó of Bahia Solano, Huina, Castellano/San Felipe and Jurubirá should be targeted for a large enough catch to enable fishers to focus on developing the proposed higher value tuna fisheries for sushi and sashimi. These fisheries exhibit the highest catches of *T. albacares* in the region, as well as the highest proportion of mature sized fish (>75 cm FL).

All tuna landed in this region is caught by drum lines ('espinel') and hand line, representing an already favourable gear type in terms of limiting bycatch, however enhanced minimum size regulations as well as training in post capture release protocols may be necessary to enhance survival post release and overall sustainability. Detailed gear information is not available, however if purse seines are the chosen gear types, this represents an opportunity to select only the fish of large size and release the remainder of the catch. There is currently no information available on the hook sizes used by fishermen in any area. This would be important information to gather in future sampling as a potential transition to larger hooks could be implemented to target the larger individuals in the schools.

Much more data are needed from the artisanal fisheries of the Buenaventura region in order to make informed decisions, however, based upon the catch rates compared with the Northern Chocó where more data is available, it would appear the yellowfin tuna catch is substantial enough to warrant developing the high value tuna fishery with certain fishermen. The skewed distribution of large fish being landed in certain communities (76% landed in the fisheries of Bahía Solano, Arusí, Huina and Cabo Marzo) could be attributed to fishing patterns of certain fishers, rather than certain areas exhibiting greater abundance of large fish.

The total number of boats recorded catching tuna is 641, however, the number of boats landing >0.5 tons/yr is only 40. The 23 boats with the highest catch weights, land 37% of the total catch, all by hand line. This makes the potential training and capacity building program feasible, as it should be highly targeted towards those fishermen, retain the natural diversity within the fishery, and not waste resources on training fishers focusing on other species. No fisheries in the Northern Chocó exhibited mean fish size above the recommended limit set by Marviva (67.7 cm TL), however, the project should focus on increasing capacity of specific fishermen in the following communities in the Northern Chocó, given their high mean catch sizes only ~5 cm less than minimum size: Jurubirá; Piña; San Felipe and Nuquí. See document: Operationalizing Brief 1 - Developing a high value Tuna fishery.

If further focus was needed in other localities, initial data suggest that tuna catches come from only two localities in Buenaventura, Pital (48%) & Punta Bonita (52%), however further sampling over a greater time period would be needed to provide greater resolution on specific species captured in the fishery, the size of individuals captured, and the health of the stock. Further data collection should be year round and be sure to include clear species identification and fork length of individuals landed in order to assess the population structure, the suggested quota to limit annual catch and/or effort, and hence the sustainability of the fishery in the long term. If fork length data were not available or possible, an alternative would be to collect the weight of individual fish in order to evaluate maturity from *post hoc* length-weight conversion calculations during analysis. It is also recommended that tuna length data from the Northern Chocó should be collected using fork length, to avoid unnecessary error associated with conversion from total length.

Across all regions, greater care should be taken to identify true tunas to species level given their extremely high value, as well as the increasing need for responsible labelling of seafood products for consumers. Colombian Pacific fisheries may be losing out on potential avenues for exploitation if all tunas are grouped into the same category as 'Atún' or 'Albacora'.

Section 3: Brief 3 – Artisanal Tuna cannery

Data Description & Analysis

> Note: Marviva's ID guide "*Peces de importancia comercial en la costa Pacífica de Colombia*" lists the 'Patiseca' as *Euthynnus affinis.* According to current knowledge this species has not been found in the eastern tropical Pacific and is found in the Indo Pacific and eastern Central pacific. The identification of skipjack tunas should be carefully confirmed during sampling. It is believed that "Patiseca" is actually the black skipjack *Euthynnus lineatus.*

There are two skipjack tunas distributed throughout the Colombian Pacific, black skipjack (*Euthynnus lineatus)* known locally as 'Patiseca', and *Katsuwonus pelamis* known merely as skipjack, or 'Atún barrilete' in Colombia.

The BIOREDD dataset from Tumaco is limited to March, May, June, August and October from the 2012-13 period, and shows no 'Patiseca' or any other tuna species being landed.

A small amount of black skipjack, *Euthynnus lineatus,* is landed in the Buenaventura fishery, but from the data available this makes up less than 1% of the landings recorded. However, Buenaventura fisheries are landing substantial quantities of yellowfin tuna *Thunnus albacares*, identified only as Atún, which makes up 18% of their mean annual catch (table 9).

The fisheries landing the most skipjack tuna (*E. lineatus*) from all the data available are those in the Northern Chocó (Table 7). Landings of skipjack (*K. pelamis*) in the Northern Choco amounted to only 11 individuals over 4 years, so these were omitted and analysis focused only on *E. lineatus* for simplification.

Utilising CPUE (kg/man hour) as an indicator of abundance, Tribugá and Arusí represent the best fisheries in which to develop a supply for artisanal canned tuna (Table 7). Black skipjack is predominantly caught using hand lines (73%), and to a lesser extent gillnets (26%).

Table 7: Total landings of black skipjack tuna *Euthynnus lineatus* between 2010-1013 in the Northern Chocó, Colombian Pacific, in order of decreasing catch per unit effort (kg/ man hour).

Location	Total 4 yr Catch (kg)	Mean annual catch (kg)	± SE	Effort (man hrs)	CPUE (kg/man hr)
Tribugá	810	202.5	83.8	1,152	0.70
Arusí	893	297.6	265.3	1,416	0.63
El Valle	4,364	1,454.6	692.0	11,016	0.40
Bahía Solano	1,911	637.0	278.3	5,064	0.38
Cupica	1,354	451.4	244.1	4,032	0.34
Coqui	3,094	773.6	285.7	9,720	0.32
Partadó	6,084	1,521.1	426.7	19,128	0.32
Joví	1,138	284.4	138.1	4,296	0.26
Juradó	401	133.7	40.0	1,752	0.23
Jurubirá	1,799	449.7	191.2	8,232	0.22
Panguí	3,528	881.9	263.0	16,944	0.21
Termales	4,659	1,164.8	518.5	25,416	0.18
Nuquí	3,641	910.2	166.7	20,664	0.18
Huina	869	289.7	51.7	5,136	0.17
Cabo Marzo	226	113.0	84.8	2,688	0.08
Piña	2	2.0	-	48	0.04

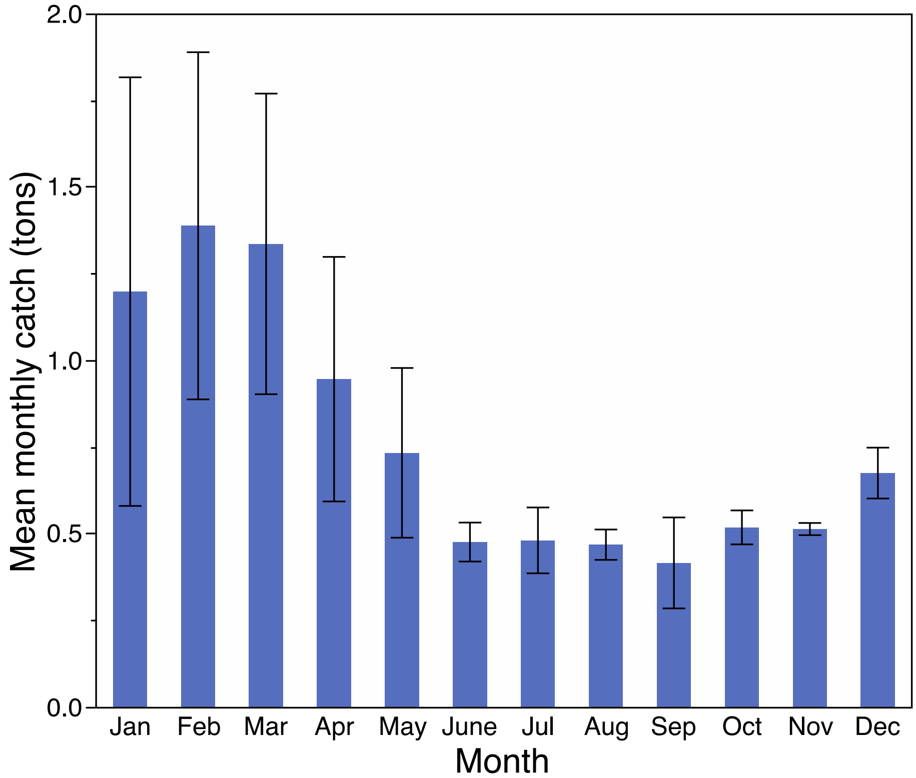


Figure 14. Mean monthly catch of Black skipjack (*Euthynnus lineatus*) between 2010-2013 from the Northern Chocó, Colombian Pacific. Errors bars are standard error.

Based upon the published estimated length at maturity of black skipjack *Euthynnus lineatus* of 47 cm FL (Schaefer 1987), only ~4% of skipjack caught in Northern Chocó fisheries are of reproductive age (figure 15).

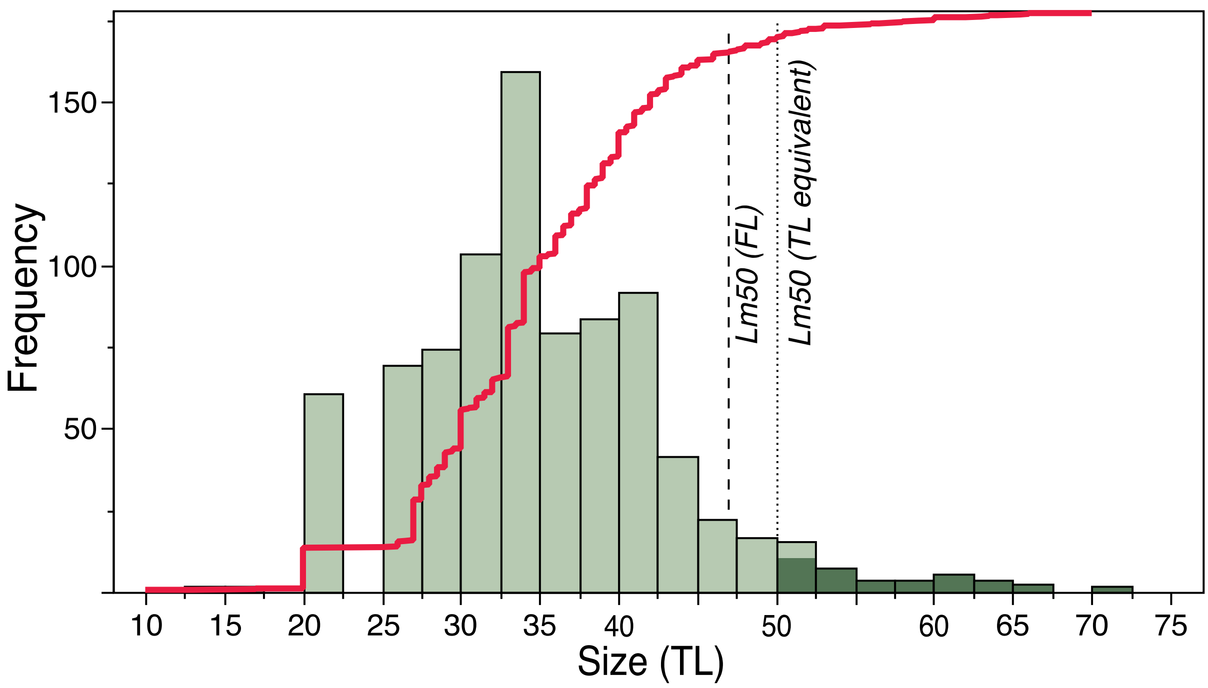


Figure 15. Frequency distribution of size (TL) of *Euthynnus lineatus* caught in artisanal fisheries of the Northern Chocó, Colombian Pacific between 2010-2013. Dark green bars represent fish larger than the estimated length at maturity (47cm FL or ~50cm TL) (Schaefer 1987).

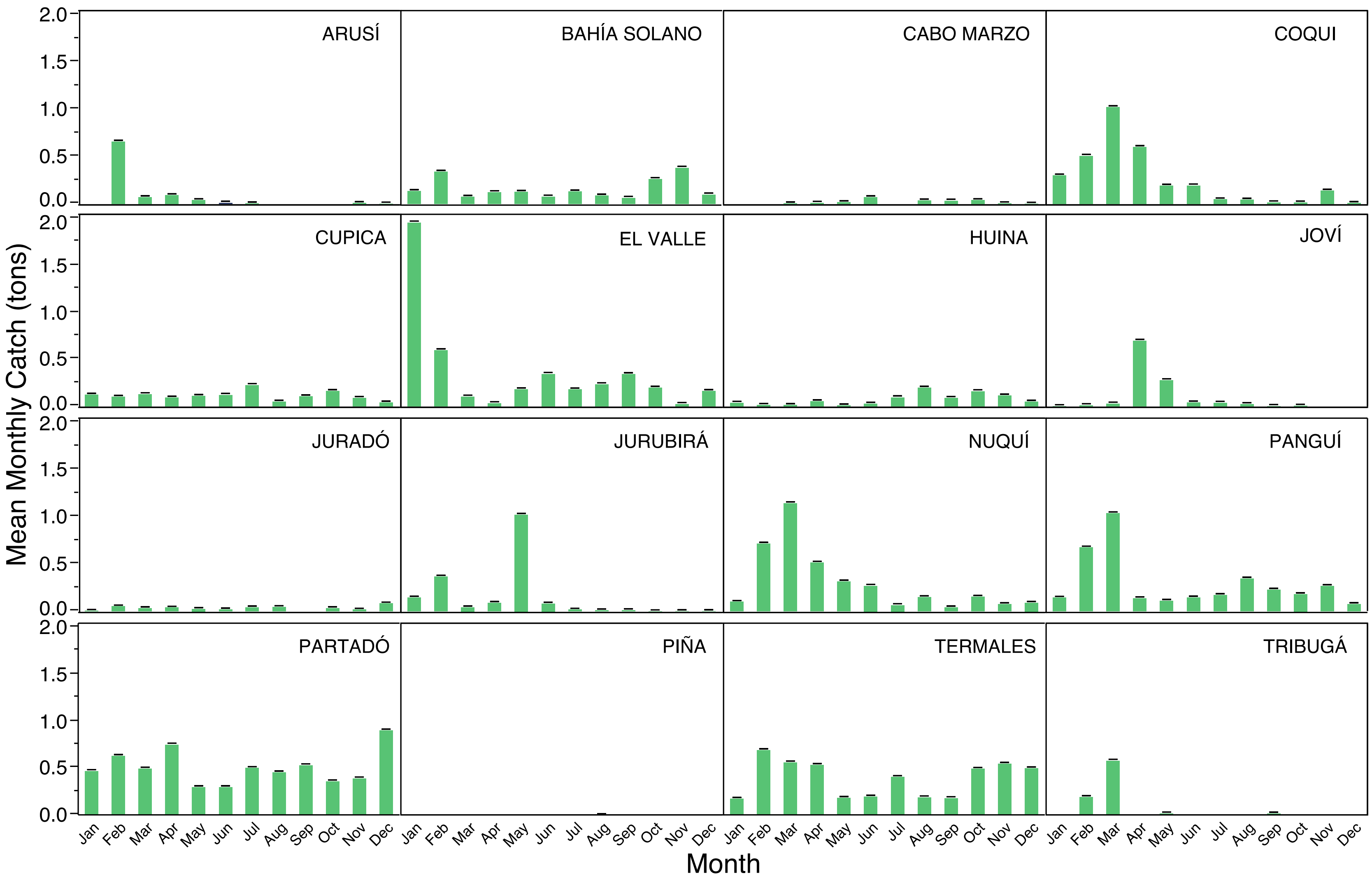


Figure 16. Mean monthly catch in tons of black skipjack *Euthynnus lineatus* from each artisanal fishery of the Northern Chocó, Colombian Pacific.

Black skipjack in the Northern Chocó shows a clear trend in catch volume, with highest catch occurring in January and then declining consistently through the calendar year with the lowest catches in December (Figure 14).

Recommendation for next steps

Black skipjack (*Euthynnus lineatus*) has a low dockside value because Colombian consumers do not like its darker flesh colour and stronger flavour when fresh. However, skipjack is one of the most commonly canned tuna species. Fisher groups who catch black skipjack could be connected to existing canning facilities to produce an "artisanal" canned tuna product.

Canning is one of the most common mechanisms for conserving fish yet has rarely been applied to artisanal fisheries in Colombia. Canning can help smooth the fluctuations between supply and demand enabling communities to use their catch without depressing values.

Data from many locations are only available for 3-4 months of the year, however from existent data it is possible to detect certain trends. In the northern Chocó, peak season for black skipjack appears to fall between December and April. El Valle, in the municipality of Bahía Solano, has one of the highest catches, with a peak in January; however, the largest catch proportion of black skipjack is landed in fishing communities of the Nuquí municipality such as Coquí, Nuquí, Partadó, Termales and Panguí (Table 7). This same municipality exhibits the communities with highest CPUE, Tribugá and Arusí. Given the clustering of fishing communities in the Nuquí municipality with high black skipjack landings, it may be assumed that this municipality is a productive area for this species, and therefore would be an important area to develop a supply chain to a cannery in Buenaventura.

Around Buenaventura, less than 1% of the landings are black skipjack, yet tuna are landed in high quantities, making up to 18% of the mean annual catch (Table 9) (These tuna were only identified as "Atún" in the data set). Buenaventura may have the potential to develop an artisanal cannery given the volumes of tuna present in their fishery, however, to determine if this is a feasible recommendation for the area, it is important to previously identify the species composition of the tuna catch.

According to the data, there is potential for development of a skipjack fishery to supply a cannery in the Colombian Pacific. There is evidence of catch throughout the year in terms of weight, however more data on population size structure would allow estimation of the most sustainable areas and seasons to catch skipjack for this project. There is very little evidence in the data of significant skipjack catches outside of the Northern Chocó, in contrast to what fishers mentioned during site visits (by S. Box).

This program should include similar training programs to the sushi tuna program in terms of handling of the tuna (Section 2) and parallel development of a code of conduct for its members to promote conservation of pelagic species and the designation, by mutual consensus, of minimum sizes and quotas to promote recovery and sustainability of the target tuna population. It should be noted that based upon the published estimated length at maturity of black skipjack *Euthynnus lineatus* of 47 cm FL (Schaefer 1987), only ~4% of skipjack caught in Northern Chocó fisheries are of reproductive age (figure 15), so caution should be taken in setting quotas for a fishery to support a cannery.

Section 4: Brief 4 – Small fish fillet processing – Buenaventura

Data Description & Analysis

Fifteen months of data is available for the Buenaventura fisheries, Oct 2012 - Dec 2013 (BIOREDD). Fishers in this area are generally segmented into an off shore fishery, an inshore fishery and a near shore shrimp fishery. In our analysis we will focus on the inshore fisheries around Buenaventura which utilise estuarine and mangrove habitat, so landings are dominated by catfish species, along with other small-bodied snappers.

Relatively small-bodied fish such as gualajo (*Centropomus medius)*, barbinche (*Bagre panamensis*), small pargos (*Lutjanus* spp.), pelada (*Cynoscion reticulatus*) and ñato (*Cathorops steindachneri*) make up a significant portion of the Buenaventura fishery, and if focusing only on nearshore fishing grounds, these would be the mainstay of landings for small scale artisanal fishing boats. There is a great deal of scope for increasing processing capacity in this area in order to create a higher value product through filleting of these small species.

The catch assemblage of these fisheries is diverse with ~80 species recorded in landings. Tuna, from off shore areas, makes up the largest proportion of Buenaventura landings by weight, representing 18% of the annual catch. But tuna is grouped together under the generic 'Atún', so there is limited scope at this stage in identifying which tuna they are catching.

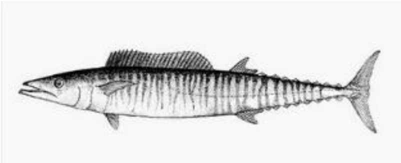
Due to the diversity of the catch assemblage in the Buenaventura area, there are numerous opportunities to orientate the fishery towards the development of "new" products for fillet fish. Catfish and bass (corvina) make up more than 30% of the fishery at the current time. Filleting and freezing individual fillets can help simplify the cold chain as well as adding value to the product. Examples of suitable species for this type of product development include the box sea catfish or Bagre canchimalo (*Ariopsis seemanni*). This fish is an estuarine and mangrove fish that grows to a max length of 35cm and is found in nearshore habitat. Currently this represents 5% of the catch of the Buenaventura fisheries, equating to ~2 tons during the sampled year.

A detailed analysis of seasonal abundance by species was not possible due to limited data, however, it appears that May, November, and December are important months for most inshore species, with enough variability throughout other months and species to ensure continued supply of small-bodied fish throughout the year for processing and sale (see Table 8).

Table 8. Suggested small-bodied fish species from Buenaventura fisheries with potential for use in developing processed fish fillets. Combined the species below account for the nearly a fifth of the fishery landings. Information was obtained in fishbase.org.

Common name	Latin name	Food	Life Style	Habitat	Max size (cm)	Minimum population doubling time	Resilience	Vulnerability	Mean TL± SE (cm)	% of catch
Gualajo	*Centropomus medius*	Enter freshwaters mostly in large rivers and feeds on fish and crustaceans	Marine; freshwater; brackish; demersal	Adults inhabit bays and estuaries. They also occur in coastal waters, but is more abundant in estuaries of any size.	65	Less than 15 months	High	Low to moderate	35 ± 1.23	3.7
Barbinche	*Bagre panamensis*	Marine catfish feed on benthic crustaceans polychaetes and mollusks (Tilney & Hecht 1990)	Marine; brackish; demersal	Found inshore, usually on muddy bottoms. Enters estuaries	38	1.4 – 4.4 years	Medium	Moderate	42.8 ± 3.57	2.3
Small Pargo (e.g. Pargo rojo)	*Lutjanus peru*	Carnivorous, feeds on big invertebrates and fish	Marine reef associated	Adults are found over hard bottoms in inshore reef areas up to a depth of at least 80 m	95	1.4 – 4.4 years	Medium	Moderate	39 ± 1.44	0.96 all pargos
Pelada	*Cynoscion reticulatus*	Feed on fishes, shrimps and other crustaceans	Marine; brackish; demersal	Adults inhabit coastal waters and estuaries with high salinities	90	1.4 – 4.4 years	Medium	Moderate to high	32.9 ± 1.26	1.8
Ñato	*Cathorops steindachneri*	May feed on benthic crustaceans polychaetes and mollusks (Tilney & Hecht 1990)	Demersal brackish marine freshwater	Found in draining rivers and estuaries.	36	1.4 – 4.4 years	Medium	Moderate	42.1 ± 1.16	8.19
Canchimalo	*Ariopsis seemanni*	May feed on benthic crustaceans polychaetes and mollusks (Tilney & Hecht 1990)	Marine freshwater brackish demersal	Inhabits medium and large rivers to an elevation of at least 25 m	35	1.4 – 4.4 years	Medium	Low to moderate	24.6 ± 1.36	0.5

Table 9: Top 10 species landed by weight and percentage of annual catch in the Buenaventura fishery, Colombian Pacific.

Common Name	Scientific Name	Annual catch (kg)	% of annual catch
Atún  *T. albacares* **©R. Robertson**	*Thunnus/Euthynnus sp.*	6,071	18%
Sierra  **©FAO**	*Acanthocybium solandri*	4,754	14%
Aguja  *T. crocodilus* **©R. Robertson**	*Tylosurus sp.*	3,418	10%
Ñato  *Cathorops multiradiatus* **©R. Robertson**	*Cathorops steindachneri*	2,779	8%
Bagre  **©R. Robertson**	*Bagre sp.*	1,871	6%

Sierrilla  ©R. Robertson	*Scomberomorus sierra*	1817	5%
Alguacil  ©R. Robertson	*Bagre pinnimaculatus*	1634	5%
Barbinche  ©R. Robertson	*Bagre panamensis*	1498	4%
Gualajo  ©R. Robertson	*Centropomus armatus*	1239	4%
Corvina  ©R. Robertson	*Micropogonias altipinnis*	1233	4%

Recommendations for next steps

In Colombia there is growing demand for easy-to-use "fish fillet", and the market is being dominated by cultured tilapia fillet. Main fish suppliers in Bogota were noted as selling a wide variety of filleted fish. Replicating and expanding this strategy would seem opportune as many species such as catfish are currently undervalued whole. If the processing capacity for high quality fish fillets is developed, Buenaventura's fishers will be able to generate higher income as connections with supermarkets, chain restaurants, and hotels in Bogotá can be developed.

In Buenaventura, small-bodied species of snapper, catfish and snook are landed in significant volume, and have the potential to be sold as high quality products in the form of frozen fish fillets. Sea catfish species (such as Barbinche, Ñato and Canchimalo) and corvina (Pelada) are species of medium price category with moderate vulnerability and medium resilience (Table 9) that could be sold as fillets. Higher value species like the blackfin snook or Gualajo, would also make a very good candidate for fillet, given its low vulnerability and high resilience. All these species are found entering estuaries and in coastal waters, so effort and fuel consumption would be at a minimum.

Small-bodied snappers also represent a significant proportion of the Buenaventura fishery. The lack of detailed data to species level however, inhibited further analysis, as most records were identified only as "pargos". From the two snapper species identified (rojo and roquero), red snapper (*Lutjanus peru*) was used in this analysis (Table 9). Given the excellent quality of flesh, red snappers are generally marketed whole, fresh and frozen. For this reason, we do not recommend that snappers be developed as a fillet fish, but rather focus on catfish species of which there are many, allowing for supply chain continuity as a result of having a number of similar fillet products available in terms of size, flesh texture and flavor.

These recommendations would also be extremely pertinent for fisheries in the department of Nariño, where high volume catches of mangrove and estuarine species are exhibited, and where access to pelagic fisheries is limited meaning they do not have the option for the development of a high value tuna product or a tuna cannery.

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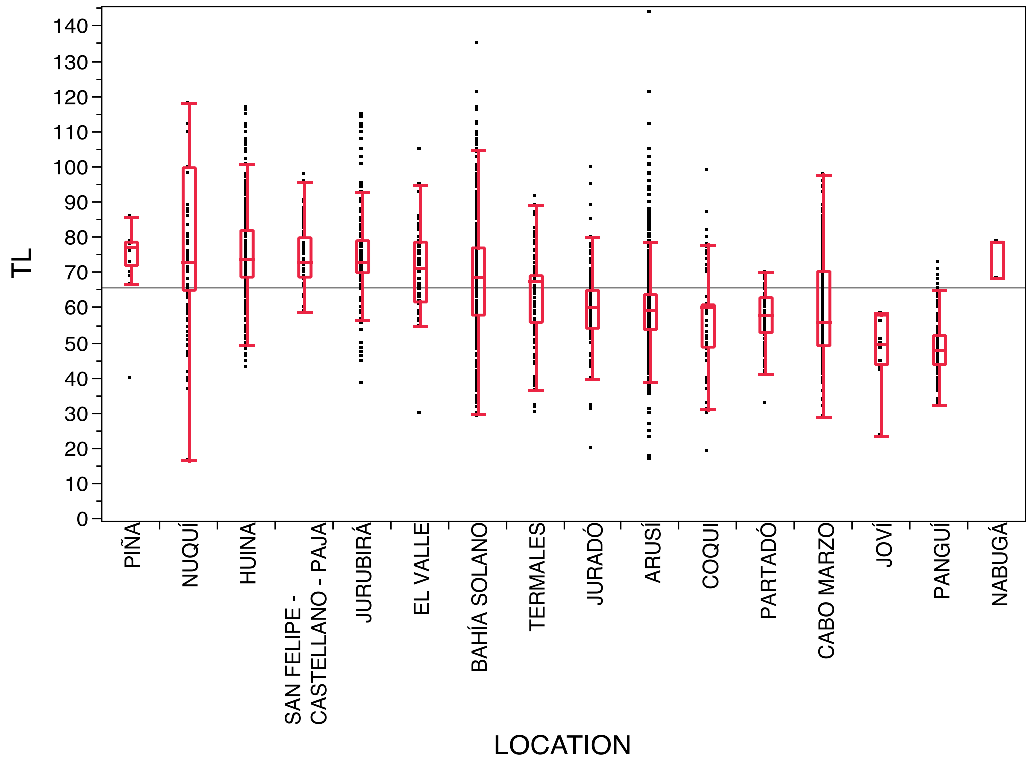
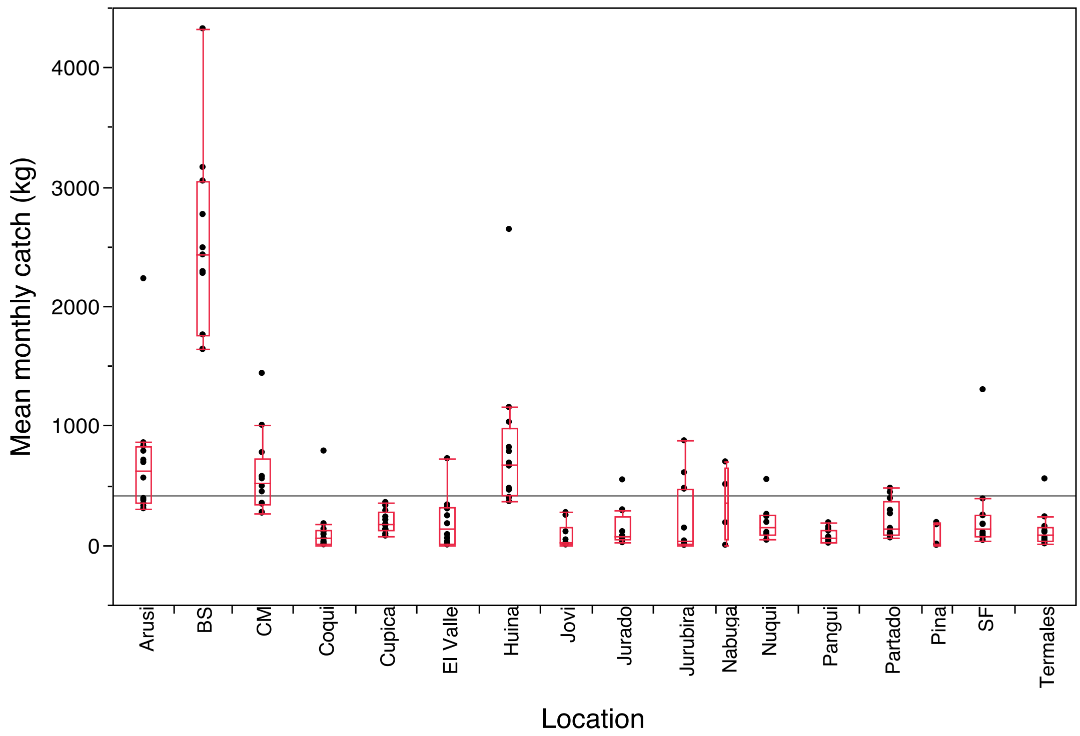
Appendices

Appendix 1. Statistical analysis of fish total length by fishery location in the Colombian Pacific. Boxplots represent lower, median and upper quartiles, with bars depicting 95% confidence intervals. TL represents total length.



Appendix 2. Statistical analysis of mean monthly catch by fishery location in the Colombian Pacific. Boxplots represent lower, median and upper quartiles, with bars depicting 95% confidence intervals. BS = Bahía Solano, CM = Cabo Marzo, SF = San Felipe/Castellano/Paja.



Appendix 3. Table of statistical output from Dwass-Steel Test with control, testing for significant differences between mean monthly catch in Bahía Solano compared to all other locations at alpha level 0.05.

Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Arusi	10.89	2.83	3.85	0.00	1876.54	930.45	2701.03
Nabuga	-7.33	2.61	-2.81	0.06	-2095.23		
Pina	-8.37	2.56	-3.27	0.01	-2309.38	-4314.88	-1470.22
Huina	-10.19	2.83	-3.60	0.00	-1740.71	-2649.03	-855.53
Jovi	-10.40	2.71	-3.84	0.00	-2347.94	-3152.33	-1627.53
Cabo Marzo	-11.41	2.83	-4.03	0.00	-1915.63	-2716.78	-1086.02
Coqui	-11.41	2.83	-4.03	0.00	-2303.42	-3108.58	-1608.78
Cupica	-11.41	2.83	-4.03	0.00	-2208.35	-2988.83	-1508.44
El Valle	-11.41	2.83	-4.03	0.00	-2264.54	-3047.48	-1551.14
Jurado	-11.41	2.83	-4.03	0.00	-2262.60	-3088.08	-1578.47
Jurubira	-11.41	2.83	-4.03	0.00	-2278.28	-3127.33	-1605.22
Nuqui	-11.41	2.83	-4.03	0.00	-2235.63	-3007.61	-1534.49
Pangui	-11.41	2.83	-4.03	0.00	-2348.51	-3100.27	-1603.22
Partado	-11.41	2.83	-4.03	0.00	-2211.29	-3022.50	-1509.59
San Felipe	-11.41	2.83	-4.03	0.00	-2224.51	-3009.05	-1468.17
Termales	-11.41	2.83	-4.03	0.00	-2281.21	-3054.58	-1600.98