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Food and Agriculture
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Advancing data collection efforts for *sustainable queen conch fisheries* and *conservation management* in the WECAFC region.

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A Final Report presented by the
Gulf and Caribbean Fisheries Institute

GULF AND CARIBBEAN FISHERIES INSTITUTE

To the

Food and Agriculture Organization
of the United Nations

Food and Agriculture Organization of the United Nations

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Summary of components used in this report to estimate landings and fishing effort

Fishery statistics on landings and fishing effort are difficult to obtain in artisanal fisheries because of the large number of fishing operations carried out by numerous small boats that land products at many sites along the coast. Standard fishery statistical systems, such as those applied in industrial fisheries, cannot cover the statistical reporting needs of complex artisanal fisheries. Instead, artisanal fishery statistical systems are based on combined census-survey approaches. One such statistical system was developed and implemented in the queen conch artisanal fisheries of Jamaica, which is reported here. The survey component in an artisanal fishery statistical system consists of a randomized sampling design of the landings per fishing trip realized by a few boats from a statistical population of boats (i.e. the entire artisanal fleet) and implemented at a few landing sites from a statistical population of landing sites (i.e. all possible landing sites) and over a few days during a predefined total sampling time period (e.g. one month). Under the randomized sampling design the resulting data are used to estimate average landings per boat per day fishing for the pre-defined sampling period in a defined unit of stock, region or country.

Average artisanal catch per trip for a defined unit stock, region or country needs to be expanded to the statistical population levels, that is to the total number of boats, total landing places and total days of operation during the period. For this purpose, there is a need to have access to fishery census data pertaining to total number of landing sites and total number of boats per location that target queen conch. This information will allow estimation of total fleet size and definition of possible spatial stratifications of fleet operations. Survey sampling designs should be developed considering the possibility of spatial stratifications to obtain estimates with reduced uncertainty (i.e. variance). The census should also collect data on the characteristics of fishing operations (e.g., daily or multi-days trips), seasonality of the fishing operations, and characteristics of the queen conch product types (e.g. in shell, dirty, 50% clean) that are landed.

In absence of recent census data, the surveys should collect pseudo-census data with questions to fishers concerning the number of vessels that operate from the surveyed landing site. This question will capture local fisher knowledge pertaining to size of the fleet's statistical population. Similarly, the survey could include questions to fishers concerning the number of landing sites that are known to them that exist in the region as well as the expected number of fishing trips that they carry out during certain time periods in a fishing season. Total landings estimated in artisanal fisheries will be estimated as the average landings per boat per fishing day times the average number of days fished during a period multiplied by the number of boats and landing sites.

Fishery statistics in the queen conch industrial fisheries are characterized by a census (i.e. complete enumeration) of the reported landings at processing plants. These statistics are obtained from landing receipts and usually corroborated from captain log books. Fishing effort may be measured on a per trip basis (i.e. number of reported landings), or more accurately from captain logbooks and from vessel monitoring systems used in the industrial fleets that allow spatial definition of fishing grounds.

Executive Summary

Queen conch *(Aliger gigas)* resources in the Caribbean region are of significant economic and social importance even though the present status of exploitation of the stocks are not well known and high levels of exploitation are suspected. The population dynamics of the species contravenes the use of most standard fish stock assessment methods designed to evaluate exploitation and to define viable annual catch quotas that are not detrimental to the survival of a species that is listed in Appendix II of the CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora). Of significant concern is that numerous highly heterogeneous fishing fleets exploit the queen conch resources throughout its range and that the necessary statistical fishery information to define exploitation is not always available, or at least is not consistently collected and recorded. In absence of statistically validated data that could be used to depict trends in exploitation, fishery management regulations that could prevent over exploitation become difficult to implement by national and international fishery management organizations.

In 2021 under the advice of the Queen Conch Scientific, Statistical and Technical Advisory Group (QC SSTAG) recommendations, the FAO-WECAFC Secretariat submitted a proposal to the European Union (EU) seeking funds in support of a pilot project to advance data collection efforts for sustainable queen conch fisheries and conservation management in the WECAFC region. The proposal was approved by the EU in June 2022 and the FAO-WECAFC Secretariat entered into a cooperative agreement with the Gulf and Caribbean Fisheries Institute (GCFI) to act as the implementing agency of the pilot project in Jamaica. This country was selected by FAO considering that their queen conch artisanal and industrial fisheries may be representative of queen conch fisheries throughout the WECAFC region. Therefore, findings emerging from the pilot project would be suitable for advising other countries in need of technical support.

The pilot project was implemented in September 2022. Several training steps were necessary to introduce methodologies that could address statistical issues and resolve queen conch data gaps in the industrial and artisanal fisheries while testing feasibilities to expand the results to the national and regional levels. The industrial queen conch fisheries in Jamaica are managed by annual export quotas under CITES export permits. The quotas are based on standing stock biomass estimates and annual trends of relative indices of abundance. Standing stock abundance is obtained through direct visual population density surveys every 3 to 5 years while relative abundance indices are estimated using catch and effort gathered from the industrial fishing fleets. These activities are conducted exclusively for the offshore fishing grounds of Pedro Bank from which the vast majority of conch resources are extracted. However, the National Fishery Authority of Jamaica is concerned with the perceived growth of queen conch artisanal fisheries that operate on the island shelf and for which no statistically validated data collections exist. Therefore, the pilot project focused on the development and implementation of a census/survey approach to secure landings and fishing effort of the large artisanal fleets of Jamaica. At the same time, the pilot project reviewed the industrial fishery statistical system and provided insights on improvements of spatial fishing effort information that may be achieved by way of modeling satellite vessel monitoring information.

National landing statistics are expressed in pounds of dirty weight while queen conch landings reported to FAO are reported in kilograms of live weight. Therefore, conversion factors for semi-processed queen conch

landings were required by the pilot project when estimating landings from artisanal fisheries. For this purpose, conversion factors (CF) for Pedro Bank landings were based on original values found in Tewfik (1997) and for island shelf landings, CF were estimated using individual weights for different percent clean meat categories obtained in artisanal fishery landings. The results are given below where CF for shelf and Pedro Bank queen conchs are noticeable different.

Grade category	Conversion Factors Pedro Bank	Conversion Factors Island Shelf
Dirty	1.00	1.00
50%	1.17	1.06
65%	1.31	1.24
85%	1.47	2.26
100%	1.98	

As a result of applying the experimental sampling designs in weekly field surveys implemented by the project and using the methods developed to estimate landings and fishing effort in artisanal queen conch fisheries in Jamaica, it was possible to obtain average landings, fishing effort per day fishing per week as well total landings per week and for the 5-week project sampling period for artisanal fleets based in five localities selected at random by the project. Results are given below.

Locality	Average Landings (Kg) per day fishing	Number of days fishing per week	Landings (Kg) per week	Landings (Kg) during 5 week sampling period
Top Beach	2.8	10.2	28.2	141.2
Rocky Point	34.7	56.0	1,943.4	9,716.9
Market Beach	5.6	19.2	108.0	540.0
Whitehouse (WM)	86.2	24.0	2,068.4	10,341.9
Whitehouse (SJ)	23.4	3.3	78.0	389.9
		Total landings	**4,226.0**	**21,129.9**

Artisanal landings from Pedro Bank

Locality	Average Landings (Kg) per day fishing	Number of days fishing per week	Landings (Kg) per week	Landings (Kg) during 5 week sampling period
Rocky Point	109.2	131.4	14,355.9	71,779.3

The results portray the importance of queen conch production by artisanal fisheries as well as the viability of nationally adopting the tested survey experimental sampling designs developed by the project.

The discussion and conclusions offer recommendations for improving the experiences obtained during the feasibility (i.e., pilot) study and provide guidance on a few other possible statistical improvements to the industrial fishery data collection system across all fishing grounds.

Introduction

Queen conch (*Aliger* (formally *Strombus, Lobatus*) *gigas*) is one of the most important fishery resources in the Caribbean Sea. The species has been subjected to considerable exploitation since pre-Columbian times evidenced by significant shell middens across the region. At present, there is a significant concern for the long-term sustainability of the species. This is a consequence of the increasing demand for queen conch products in national and international markets as well as the significant over investment in fishing intensity on limited local queen conch resources. The status of exploitation of regional queen conch stocks are not well known; however, over-exploitation is suspected, and Fishery Management Organizations (FMOs) are concerned about the need for proper governance of the species over its habitat range.

Scientific research that employs fisheries data in empirical analyses can dictate the design and implementation of fishery management policies. To provide credible information to decision-makers, FMOs and fishery research institutions are confronted with uncertainty and limitations, particularly related to landings and fishing effort statistics. In the last 25 years, the Western Central Atlantic Fisheries Commission (WECAFC), the Food and Agriculture Organization of the United Nations (FAO), and the Caribbean Fishery Management Council (CFMC) of the US Federal Government have provided guidance regarding stock assessment techniques, the data required for the assessments, and the statistical requirements of the data that could result in effective knowledge in support of queen conch fisheries management.

In response to the Queen Conch Scientific, Statistical and Technical Advisory Group (QC SSTAG) recommendations, the FAO-WECAFC Secretariat submitted a proposal to the European Union (EU) in 2021 seeking funds in support of the pilot project entitled "**Advancing data collection efforts for sustainable queen conch fisheries and conservation management in the WECAFC region**". The proposal was approved by the EU in June 2022 and the FAO-WECAFC Secretariat entered into a cooperative agreement with the Gulf and Caribbean Fisheries Institute (GCFI) to act as the implementing agency of the pilot project in Jamaica. This country was selected by FAO considering that their queen conch artisanal and industrial fisheries may be representative of queen conch fisheries throughout the WECAFC region. GCFI contracted Drs. Nelson Ehrhardt and Alexander Tewfik as consultants responsible for developing training materials, field protocols and analysis methods as well as preparation of this project final report. The National Fisheries Authority (NFA) of Jamaica is the governmental institution that was responsible for the implementation of the field data collection component of the pilot project. Implementation of the pilot project started in September 2022 and completed in July 2023.

Identification of the problem

Queen conch (*Aliger gigas*) is the largest herbivorous marine gastropod endemic to the Caribbean Sea and is recognized for its cultural significance and high economic value to regional small scale and industrial fisheries. Queen conchs occupy mostly shallow coastal areas in both soft (e.g., seagrass, sand plains) and hard bottom (e.g., coral reef) habitats. Shell size at age is influenced by localized environmental conditions and associated food resources. The species exhibits internal reproduction, and mating success is a function of gender reproductive population densities. Therefore, recruitment of juveniles could be density dependent as well as being significantly

affected by varying larval drift. As such, sustainable regional fisheries management and conservation, including data collection, need to incorporate complex biological, spatial and temporal population dynamic characteristics of the target species and their fisheries. For this purpose and in response to queen conch being listed in CITES Appendix II, the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch (i.e., the Working Group) was established in 2012.

The Working Group adopted the Regional Queen Conch Fisheries Management and Conservation Plan in 2017, a document that prioritized 14 management actions (9 short-term) needed for the sustainability of this internationally shared resource and for the health of the queen conch fisheries and the livelihoods of the more than 20,000 artisanal fishers in addition to many more people involved in processing, retail and export activities. Two of the nine short-term prioritized activities call for the improvement of fishery statistics on the usually semi-processed landings by fishers supplying important local and export markets. Such landings need to be expanded to live weight by applying conch meat conversion factors for several levels of processing, depending in market demands, followed by establishing a well-organized database so that more accurate and precise, regionally comparable landing statistics can be generated. These efforts will facilitate the introduction of precautionary approaches to establish exploitation thresholds needed to secure sustainable queen conch fishery performance and long-term conservation of the species.

At present, no more than 25% of the countries benefiting from these queen conch fisheries have developed national conversion factors. FAO, through the WECAFC, and the Caribbean Fisheries Management Council (CFMC) have invested time and effort to develop such conversion factors (Ehrhardt and Pérez 2019). Conversion factors are modifiers of processed or semi-processed meat products landed or reported as exported products according to processing categories. However, few of the countries have good estimates of national production by processing categories and their use (domestic vs. export), which are necessary to estimate overall exploitation. These limitations have posed a challenge for overall queen conch stock assessments, management and conservation.

In its continuing efforts to address fisheries sustainability and conservation, the Queen Conch Working Group at its 3rd Meeting held in Panama City, Panama, on 30 October-1 November 2018 and funded in part by NOAA Fisheries and through the EU-funded project "Support to the Implementation of the Regional Plan for the Management and Conservation of queen conch (*Strombus gigas*) in the WECAFC Area (Recommendation WECAFC/16/2016/1)" addressed the critically important need to move forward with activities addressing conversion factors and landing statistics. This resulted in significant progress on conversion factor estimations by re-analyzing existing data (e.g., Ehrhardt and Perez 2019). Similarly, Ehrhardt (2021a,2021 b), with funding from the CFMC, developed training materials to provide guidance on how to properly estimate queen conch total national production and annual queen conch non detrimental catch quotas.

A regional data analysis training workshop (July 30 – August 1, 2019) on queen conch population assessments brought together key government officials of six countries. The countries conducted field surveys to analyze and provide recommendations on a harmonized method to conduct population density surveys that would

be non-detrimental to the species populations. Data collection was addressed to better understand the conch reproductive changes, impacts from climate change, and population connectivity patterns, among other priority research needs. The workshop was conducted with EU funding.

All of these efforts were summarized and presented at the 17th session of WECAFC (2018) and at the fourth meeting of the Queen Conch Working Group (2019) to catalyze the improvement and implementation of proper catch and fishing effort data collection efforts, a topic that continued to be recognized as a very high priority. Given the ongoing efforts relative to conversion factors, and the imperative need for improved data on landings and fishing effort, the pilot project "**Advancing data collection efforts for sustainable queen conch fisheries and conservation management in the WECAFC region**" focused on the catch and fishing effort actions identified by the CFMC/OSPESCA/WECAFC/CRFM Working Group to facilitate the sustainable management and conservation of queen conch.

Initial meetings with the NFA of Jamaica suggested that the queen conch (QC) industrial fishery statistics are well developed. However, there was a need to review the existing industrial fishery statistical system to incorporate any additional recommendations to improve estimation of fishing effort of industrial fishing operations on Pedro Bank. In addition, the NFA indicated that during the last decade, significant development of artisanal conch fishing operations on the island (i.e. insular) shelf have taken place and that QC landings from such fisheries are not being recorded. As such, it was requested that special emphasis be put on addressing the design and development of a pilot QC artisanal landings and fishing effort program that the NFA could implement country wide, including independent artisanal operations on offshore banks.

Pilot Project Objectives

1. To enhance the technical and strategic capacities of the NFA of Jamaica regarding the adoption of processes that are statistically valid when collecting information about spatially and temporally complex fishery landings and fishing effort data of the queen conch, a species listed on Appendix II of the CITES

2. To generate a formal understanding on how to incorporate key queen conch population dynamic characteristics in sampling experimental designs that could generate unbiased information about fishery statistics of the queen conch populations.

Pilot Project Design and Implementation Strategies

The pilot project considered two major stratifications based on expected differences in operational characteristics of the fisheries: (a) artisanal and (b) industrial. The last general fishery census carried out in Jamaica was in 1999 and the existing information, although dated, served to identify important spatial landing locations as well as island shelf and offshore QC fishing grounds. An analysis of a QC production chain found in the Jamaica National Marine Fisheries Atlas (CFRAMP 2000, page 52) served to identify key nodes where sampling for catch and fishing effort should be allocated during the pilot project. Furthermore, a review of the existing QC industrial fishery statistical system at the NFA allowed development of the field activities for the pilot project.

The pilot project was designed as a feasibility study to generate results and experiences on QC landings and fishing effort estimates based on experimental statistical sampling designs that could be expanded to the national level and potentially to other countries in the region. In order to accomplish the different tasks of the project, a work plan was developed following a sequential flow of components and activities as shown in Figure 1.

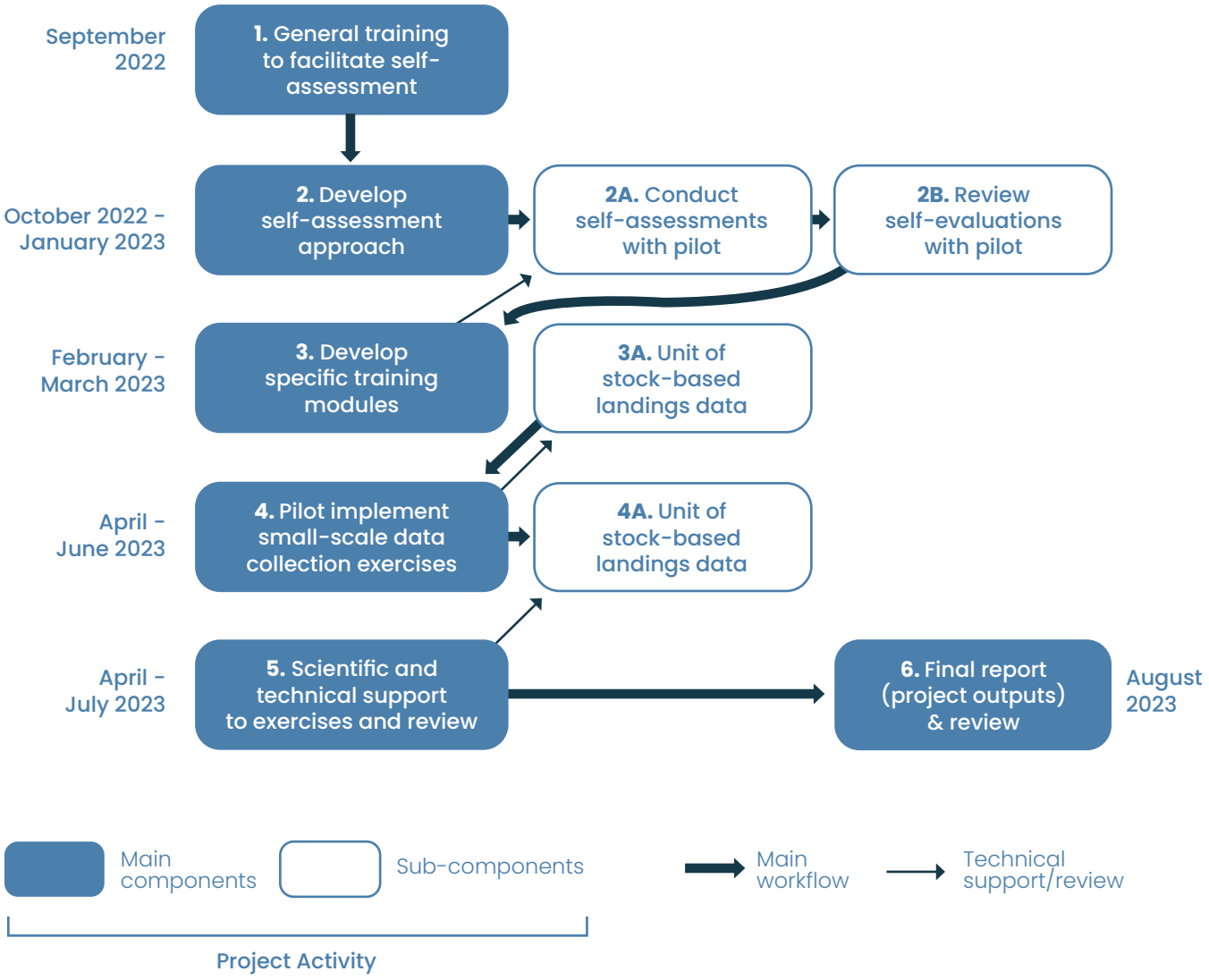

Figure 1: Sequential implementation of the Pilot Project Components in Jamaica

The initial general training component (Figure 1) implemented in September 2022 was necessary to harmonize statistical concepts and provide guidance on the planned project ahead of a self-assessment on existing NFA fishery statistical systems. The self-assessment included a description of the QC fisheries and the existing activities regarding QC fishery data gathering. Based on the self-evaluation results the pilot project further developed a series of three specific training modules to guide small-scale field data collections. The resulting databases were subjected to review for accuracy and subsequently used in the statistical estimation of total landings and fishing effort of the QC fishery components in Jamaica.

Training components: Generic, country self-evaluation, sampler training, and field visit

The initial generic training component (Figure 1) was developed using a queen conch catch and fishing effort training module developed for the Caribbean Fishery Management Council by Ehrhardt (2021a, b). A Power Point presentation in English was prepared to train the NFA personnel involved in the pilot project. This training took place during two days in September 2022 with the participation of 14 individuals from the NFA (Annex 1). A pdf version of this document is found in Annex 2. This generic training included discussions on the concepts and assumptions required for industrial and artisanal landings and fishing effort, as well as statistical estimation procedures applicable to queen conch and of the data to be obtained through experimental sampling designs offered by the project. Such sampling designs will generate statistically valid data to estimate unbiased landings and fishing effort. The samplings were designed to keep variance of the estimates under control because of the method samples are to be selected in the field. Therefore, the sampling experimental designs covered in the generic training components were important regarding the accuracy and control of precision of the estimates.

The generic training also emphasized queen conch population dynamic concepts including spawning and feeding migrations, resulting habitat use, and the seasonal allocation of fishing intensity (i.e., fishing effort per unit of area) exerted on predefined units of stock (defined in the training). In this way, the sampling design addressed an important aspect of fishery statistics that landings should carry population exploitation signals, and as such, they can be used to assess the status of exploitation of the resources. The statistical procedures contained in the generic training distinctly addressed industrial and artisanal queen conch fisheries. Because queen conch landings present different levels of processing, a considerable effort was allocated to the presentation of new and innovative regression estimation procedures to obtain conversion factors for different levels of percent clean meat categories. Consequently, the generic training pointed to the statistical requirements of the data needed for estimating catch and fishing effort and raising the percent clean meat landing estimates to the "dirty" (uncleaned mass out of the shell) and "live" (whole mass with shell) weight classifications as required in national fishery statistics and international FAO Queen conch fishery statistics, respectively.

Following the activities in the general training component, the project required information on the present status of the queen conch fishery statistical system in Jamaica. For this

purpose, the consultants provided guidance to the NFA personnel regarding possible options to summarize preliminary information. This summarized information helped in the final development of the experimental sampling design necessary to estimate landings and fishing effort for queen conch fisheries in Jamaica. A self-evaluation primer was prepared and is found in Annex 3. The primer briefly describes potential steps on how queen conch catch and fishing effort data are being collected such that: (a) conceptual statistical frames presented during the generic training stage could be incorporated to advance data collection efforts; (b) identify new data requirements and improve the statistical requirement of the data; and (c) strategize for the most effective ways to obtain updated fishery census data as well as define sample survey designs.

Information from the self-evaluation allowed a re-interpretation of the queen conch production chain (Figure 2). The new production chain characterized fishing trip operations in time and space and how these operations were carried out so that days operating, and fraction of days effectively operated may be determined. The self-evaluation identified information that could be used to define the historic evolution of institutional and operational structures of the queen conch fishery statistical system at NFA. These documents were the Jamaica National Marine Fisheries Atlas (CFRAMP 2000) including data from the last fishery census; the 2015 Conch Fishing Season Report (Murray 2015); and Jamaica's Non Detrimental Findings for Queen Conch (Kong 2021).

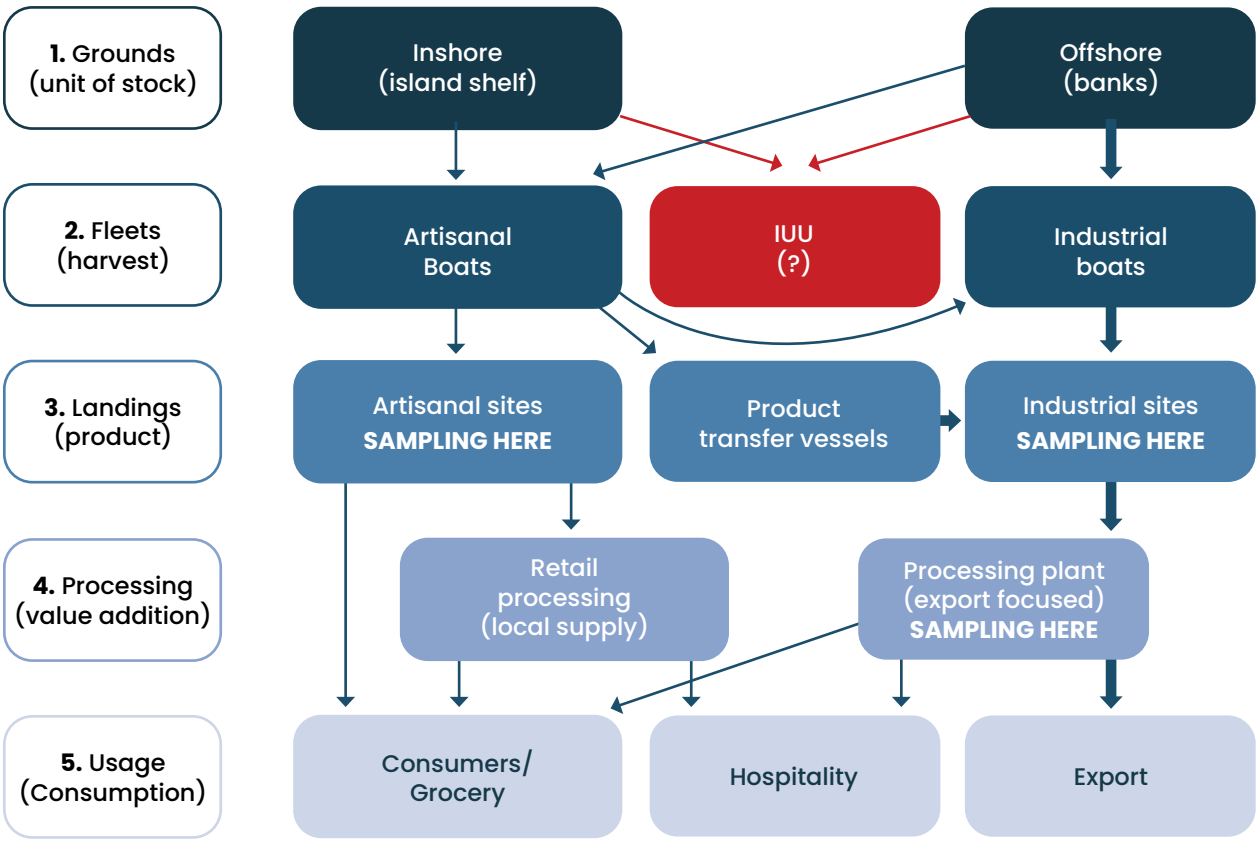

Figure 2: Queen conch production chain elaborated with data from self-assessment. Arrow thickness indicates relative volume of product flow. Red arrows indicate unknown flow.

The third training component was the module on field sampling QC landings and fishing effort (Annex 4). This was used to summarize the core elements in the extensive generic training (Annex 2) as well as incorporating the experimental sampling designs for artisanal and industrial queen conch fisheries samplings in Jamaica described in the self-evaluation primer (Annex 3). The field training component identified the importance of using different sampling methods dictated by (a) different units of stock (e.g., shelf vs. bank) under (b) different operational fishing technologies (i.e., artisanal vs. industrial). This training component addressed the specific procedures required by the field sampling plans. Therefore, emphasis was on the theoretical principles and implementation details that were needed to comply with basic assumptions of the field samplings.

In order to efficiently implement the third level of training, a field visit by one of the consultants (Dr. Alexander Tewfik) occurred during the first week of field sampling (25 April 2023). This was the first direct participation of the pilot project with NFA regarding sampling implementation details, answering questions and providing clarifications on the sampling methods and linking of the field activities with the theoretical aspects of the proposed samplings. A field trip report is found in Annex 5.


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Statistical Sampling Design Components

The pilot project used different statistical sampling design methods dictated by operational fishing technologies according to artisanal and industrial fishery subsectors.

1. Artisanal fisheries

The nature of these fisheries in Jamaica (i.e., large numbers of fishers, highly heterogeneous fleets, large number of landing sites, multi-species catch, varied QC product types from whole live animals to various % clean meat categories, etc.) makes it impossible to register all landings (i.e., via census) all the time. This is due to the high costs needed to maintain a large group of experienced NFA small-scale fishery samplers that could effectively intercept such a large number of landing events over a wide area, sometimes with difficult access by land and marine transportation elevating operational costs.

Therefore, small-scale QC fishery statistics on landings and fishing effort can only be estimated from: (a) average landings by fishing trips estimated from statistically designed surveys carried out in few randomly selected localities or landing sites, with interviews of a few randomly selected fishers, and at randomly selected days during certain periods of the fishing season, and (b) average landings per trip estimated from the survey data are expanded to total landing sites, total fleets in each landing site, and for given time periods. For this purpose, expansion factors are needed that use information previously collected through sporadic (i.e., every 3 to 5 years) fishery censuses. In this pilot, statistically designed landing surveys follow a weekly time frame with an initial random selection of landing sites and boats/fishers to be sampled. Therefore, a general formulation used by the pilot project for estimating landings in artisanal fisheries is given as

Landings =

Average landings per unit of effort
(estimated from periodic landing surveys)

x

Total units of fishing effort
(estimated from sporadic census)

(a) Average landings per unit of effort

Landing surveys were implemented to draw random samples (i.e., unbiased) to estimate average landings per unit of effort; therefore, there was a need to define the statistical populations that were subjected to random sampling to obtain this average. Secondly, there was a need to define how often the statistical populations should be sampled.

The operational characteristics of the QC artisanal fisheries in Jamaica define the statistical populations and the random sampling sequence that needed to be adopted. Each statistical population represented a stratum level, and all strata was functionally tied in a sequential estimation procedure. That is, artisanal fishing trips are mostly daily activities; therefore, landings per day fishing was the variable of interest. Consequently, the statistical populations of weeks, days during the weeks, and landing sites constituted the first three stratification levels. It follows that within such stratifications, there was a need to further stratify by boat types as a function of boat's fishing power heterogeneities, and by QC products landed classified by percent clean meat as well as whole weight. The last two classifications were identified as second level stratifications.

(b) Total units of fishing effort

In the formulation to estimate total landings, the component of total units of fishing effort was estimated according to the following general formulation:

Fishing effort =

Number of boats

x

$$\frac{\text{Work days}}{\text{Week}}$$

x

$$\frac{\text{Fraction of work days effectively operated}}{\text{Boats per week}}$$

Where "number of boats" (NB) must be a complete enumeration of boats fishing for QC in each of the localities linked to a unit of stock. It is the result of a fishery census where localities are also fully enumerated. Note that given the daily character of the fishing trips and the limited navigational capabilities of small boats, most of the time, localities correspond to landings sites (note that some boats from one locality might occasionally land at another locality). Generally, fishery censuses are carried out every 3 to 5 years to corroborate the number of boats by locality and the characteristics of their operations. In Jamaica, the last fishery census was carried out in 1999 (CFRAMP 2000). Since the variable number of boats in a location is directly proportional in the formulation for landings, it was a variable that needed to be obtained as exact as possible (i.e., with high accuracy and precision). The project included a question in the questionnaire to fishers regarding how many boats were fishing for QC in the locality where the survey was being implemented.

Survey questions were also used to obtain details on number of work-days (WD) corresponding to total days in a week minus statutory holidays and average weekends not worked by fishers, and days when fishing was suspended due to weather conditions or mechanical problems.

Fraction of work-days effectively operated (FWDO) corresponded to an average number of days that fishers in the different localities opt to go fishing, or days operated (DO) out of the total WD. Hence, FWDO=DO/WD and it was estimated as an average from information in questionnaires during weekly landing surveys. This variable may be rooted in social and behavioral aspects of the fishers, and the volatility of the local market demands.

Weather factors that may affect "fraction of work-days effectively operated" (FWDO) and therefore total units of fishing effort were considered on historic seasonal weather patterns as observed in figures 3, 4 and 5 for wind speed, wind direction and rain, respectively. Such data was found in

https://weatherspark.com/y/150241/Average-Weather-in-Jamaica-Year-Round.

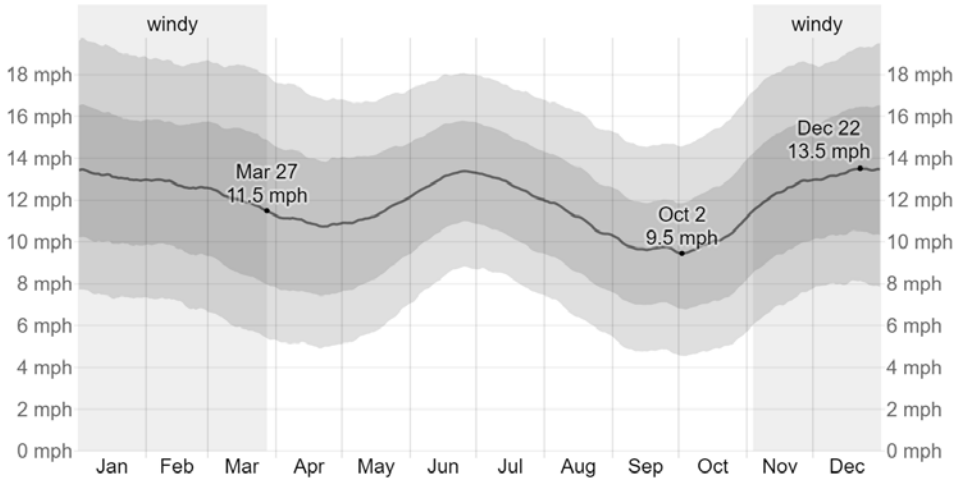


Figure 3:
Average monthly wind speed. The surveys were carried out during the last days of April and all month of May 2023 when an average wind speed is between 11 and 12 mph.

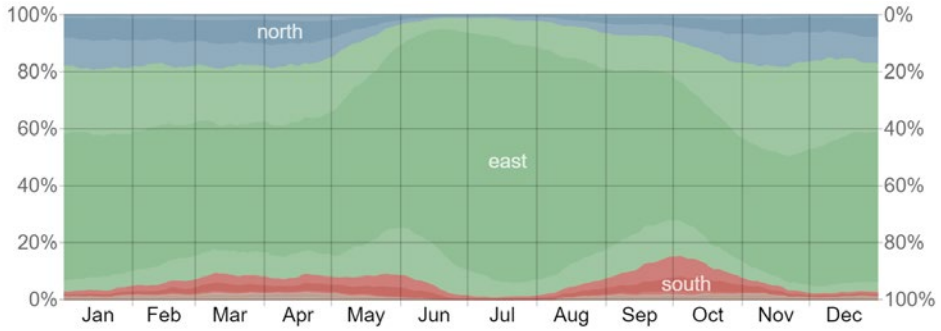


Figure 4:
Percent monthly probability of wind direction. The surveys were carried out during the last days of April and all month of May 2023 when an average probability of wind direction was from East.

Figure 5:
Percent monthly probability of rainfall. The surveys were carried out during the last days of April and all month of May 2023 when an average probability of rainfall is 0.33.

Field sampling: forms, sites visited and times.

The consultants and the NFA personnel assigned to the pilot project exchanged ideas and discussed the type of information that should be recorded from the surveys. The list of variables included in the survey are in Table 1. Appropriate forms were developed for the field interviews and the collected data was digitized in Excel sheets. The surveys were carried out in the five locations as indicated by arrows in Figure 6. The locations were visited once a week for a total of six weeks.

Table 1: Questionnaire headings pertaining to surveys to artisanal fishers.

Data collection date
Parish
Home Port
Fishing Beach
Fisher ID
Main fishing grounds fished during this fishing trip
Type of vessel
Size of vessel (ft)
Size of enige (HP)
Gear
of tanks used
Cost to fill tanks (JMD)
Average length of fishing trips (hours)
Number of trips this period (out of 7 days)
Did you fish during weekends and holidays? No = 0, yes/sometimes = 1
How many days in this period you could not fish due to weather?
How many days in this period you could not fish due to mechanical problems?

Approximate times of departure
Approximate times of arrival
Total crew
No. of divers
% clean meat
Weight (kg)
Number of pieces
Total landed this week (kg)
Total landed this week (kg) DIRTY
Landings/trip (kg)
How many boats do you know are fishing for QC from this fishing beach?
How many boats from this fishing beach did you see fishing for QC in today's fishing trip?
How many boats are fishing for QC from neighbouring fishing beaches (i.e., beyond this fishing beach)?
What is your usual fishing range (i.e., distance from landing site) (miles)
What is your usual fishing range (i.e., distance from landing site) (km)
Do you land QC at other fishing beaches [ ] or transfer boat [ ] ? No = 0, yes = 1

Figure 6: Map indicating interview sites (arrows) on mainland Jamaica. Whitehouse (SJ = St. James Parish), Whitehouse (WM = Westmoreland Parish).

2. Industrial fisheries

Prior to the industrialization of the Jamaican queen conch (*Aliger gigas*) fishery in the late 1980s, queen conch exports from Jamaica were less than 50 MT per year (Mahon et al. 1992, Aiken et al., 2006) even as the levels of local consumption were poorly understood. The conch fishery on the south coast and southern banks, including Pedro Bank, involved only artisanal fishers with an expansion in the early 1980s through the establishment of collector/ supply boats to offshore cays where artisanal fishers were based (Tewfik 1997). However, a rapid expansion of the queen conch fishery was reported on the south coast and offshore banks of the island by the late 1980s with the increased catch coming mainly from the Pedro Bank (Mahon et al. 1992, Tewfik 1997). This large expansion of the conch fishery in the late 1980s was a direct result of the entry of several industrial scale vessels (20 – 28 m) operating on Pedro Bank over multi-day trips with each vessel employing as many as twenty SCUBA or Hookah equipped foreign divers (Aiken et al. 1999).

The Jamaican Statistical Institute indicated that conch landings for 1990 and 1991 were 1500 and 2300 MT respectively while the potential sustainable yield based on other areas in the region was between 600 and 800 MT annually (Mahon et al. 1992). The significant export

revenue from conch meat (9 million USD annually – early 1990s), local sales to tourist facilities and local communities and earnings by artisanal and foreign fishers, vessel crews and processing plant staff necessitated an urgent need for detailed information on conch populations and fishing activities on Pedro bank to facilitate long-term sustainability. This included potential sustainable yield calculations, detailed studies of morphometrics of shell and soft tissue and population structure in various habitats, calculations of growth rates using tagged juveniles and cohort analysis, the first calculations of conch conversion factors at processing facilities as well as the first full visual survey of the Pedro Bank for queen conch (Tewfik 1997). By 1993, the commercial conch fishing fleet operating on Pedro Bank consisted of at least 12 vessels ranging in size from 17 – 60 m with as many as 60 divers on the largest and a mean of 22 divers per vessel (Tewfik 1997).

By the late 1990's Jamaica was largest producer and exporter of the queen conch in the region (Aiken et al. 2006). Landings of 1800 MT with a landed value of over J$500 million (US$15 million) made Jamaica's conch harvest its most valuable fishery. The conch fishery maintained its' focus on the south coast with the vast majority, then thought to be ~99% of the catch, coming from Pedro Bank. The fishery was divided into industrial and artisanal sectors. The 11 companies in the industrial sector continued to operate large (greater than 20 metres) steel-hulled vessels under foreign charters using many divers equipped with either Hookah or SCUBA gear. The industrial sector plants also bought conch from artisanal fishers operating from the Pedro cays. The artisanal sector traditionally harvested conch by breath-hold diving but switched to Hookah and SCUBA as shallow water stocks became depleted. In addition to the divers and captains of the artisanal vessels there was also a network of carrier boats, middlemen and artisanal processors who provided financing, supplies and transport of conch for the fishers based on the Pedro bank's offshore cays.

Since 1994, Jamaica has relied on fishery-independent research surveys conducted every 3 to 5 years to determine conch population abundance and distribution on the Pedro Bank (Kong 2021). Trends of mean densities and population biomass from the first survey in 1994 to 2018 suggests that the conch population size seems to modulate at around 150 conch per hectare for the fishable biomass (i.e., juvenile conch larger than 200 mm shell length through to old adults). This would suggest that the quota management regime in place for the fishery has been effective in keeping the conch population relatively stable and harvest sustainable. The most recent estimate done in December 2020, of the QC population size on the Pedro Bank is 182 conch per hectare for the fishable biomass (NFA 2021), which is very close to the 1995 estimate of 152 conch per hectare. In addition, details on industrial landings, through pre-off-loading inspections of product by both NFA and the Veterinary Services Division (VSD), and estimations of effort, using Captain's logbooks, are collected (Kong 2021). The use of VMS data in the future will improve the fishing effort calculations. All this information including population surveys and fisheries dependent understanding of catch and effort has been used to calculate the National Total Allowable Catch (NTAC) and allocate individual quota allocations and works in conjunction within a strictly monitored export system under CITES export permits, food security protocols and associated health certificates (Figure 12).

Generally, industrial fishery census approaches are used in Jamaica to classify all landings (i.e., total industrial vessels, all industrial landing

places, all processing plants, and across the fishing seasons). A census approach is used by the NFA to collect landings of queen conch by industrial fleets that fish offshore on Pedro bank fishing grounds. The census approach uses several point interceptions identified in the production chain (Figure 2). Landing receipts by fishing trips and Vessel Monitoring System (VMS) associated with vessel track trajectories of each fishing trip are used to log catch and fishing effort by the NFA. Time framed Captain logbooks from some (but not all) the vessels to express catch per day fishing by dinghies fishing for the commercial vessel, and several checks of exports quality controls by veterinarian laboratories, and export weight checks are among the many instruments, tools, and actions used by government institutions in Jamaica.

At the start of the project NFA of Jamaica authorities commented on the opportunity to dedicate special efforts of the pilot project on artisanal fishery statistics over the existing well developed industrial fishery statistical system. The queen conch artisanal fisheries are perceived by the authorities as growing rapidly while there is not an official functional artisanal fishery statistical system in place. As a result, two different approaches were needed: (a) development of concepts, strategies, and sampling methods necessary for designing the implementation of a feasibility project on an artisanal fishery statistical system based on census and surveys, and (b) a review of the existing industrial fishery statistical system identifying possible avenues for improvements regarding fishing effort estimation.

Results

1. Artisanal fisheries

The fisher interviews were conducted by National Fisheries Authority of Jamaica personnel following training and discussions with the consultants. Staff collected data for 6 weeks (April 25th - June 2nd, 2023) at five previously selected fishing beaches sites on the northeast, southeast and south-central coast of Jamaica (Figures 6 and 7). A total of 49 interviews of fishers and 1,336 associated biological measurements of landed products (i.e., individual meat weights) were obtained through the field sampling activities of the pilot project. The data gathered during the surveys (Annex 6) contribute to an integral part of this final report. The raw data from interviews were subjected to reviews for accuracy of annotations as well as for interpretation of answers in the questionnaires. A small number of interviews could not be utilized in the overall analysis of fishing statistics due to missing data from unanswered questions.

The interviews were split into two main operational categories: (a) artisanal fishers that operate on the coastal shelf of mainland Jamaica (N = 42) and (b) artisanal fishers that operate offshore on Pedro Bank (N = 7) who may also operate on the shelf (Figure 8). All shelf fishers operated from motorized boats (most common 40 hp, 15 – 60 hp) ranging from 6 m (18 ft) to 18 m (60 ft). These boats were crewed by between 1 and 8 men (mean = 4) including between 1 and 7 divers (mean = 2.5). Overall diving operations, often combined with either line or trap fishing, were conducted between 1 and 6 days per week at distances between 0.16 to 25.9 NM (0.3 to 48 km) (mean = 9.99 NM, 18.5 km) from landing sites using Free-lung (43%), Hookah (31%) and SCUBA (24%) gear with considerable variation between fishing beaches (Figure 9). Most landings were of "dirty" (all or part of viscera attached) conch with a small number of other meat grades including 50, 65 and 85% clean (Figure 10, Table 2). Landings of conch meat ranged between 0 and 158 kg per trip (mean = 19.6 kg). Fishers operating offshore on Pedro Bank constituted a significantly smaller set of interviews (N = 7). These fishers would spend many consecutive days based from the Pedro Cays, tended to use Hookah over SCUBA, and had similar configuration of vessels and crew as the Rocky Point shelf fishers but had higher catches per trip and landed product at a higher level of processing.

Figure 7: Sample of boat types, interviews being conducted, and meat mass data sampled at the five selected fishing beaches.

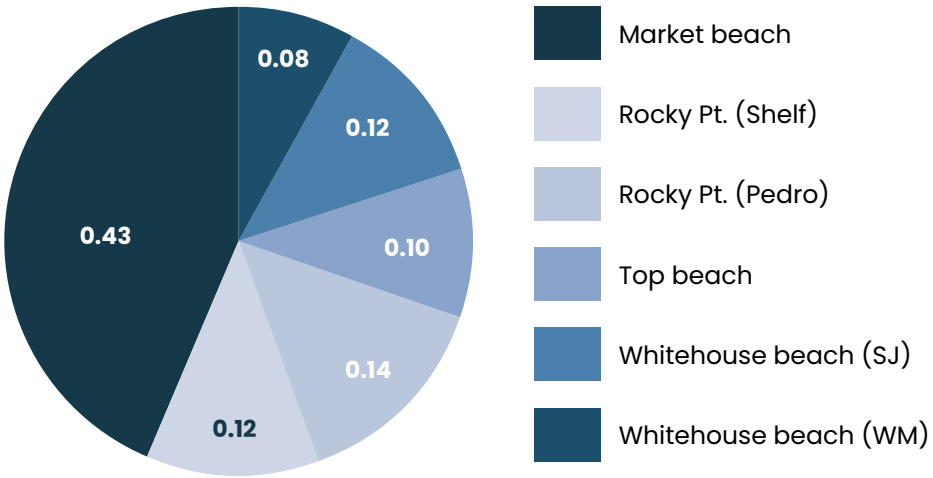


Figure 8: Proportion of interviews conducted at each fishing beach (N = 49).

Note that fishers from Rocky Point operate both on the southern shelf and offshore Pedro bank. Note that Market beach is a very busy commercial area in the large town of Savana-la-Mar which afforded a larger than usual sample size.

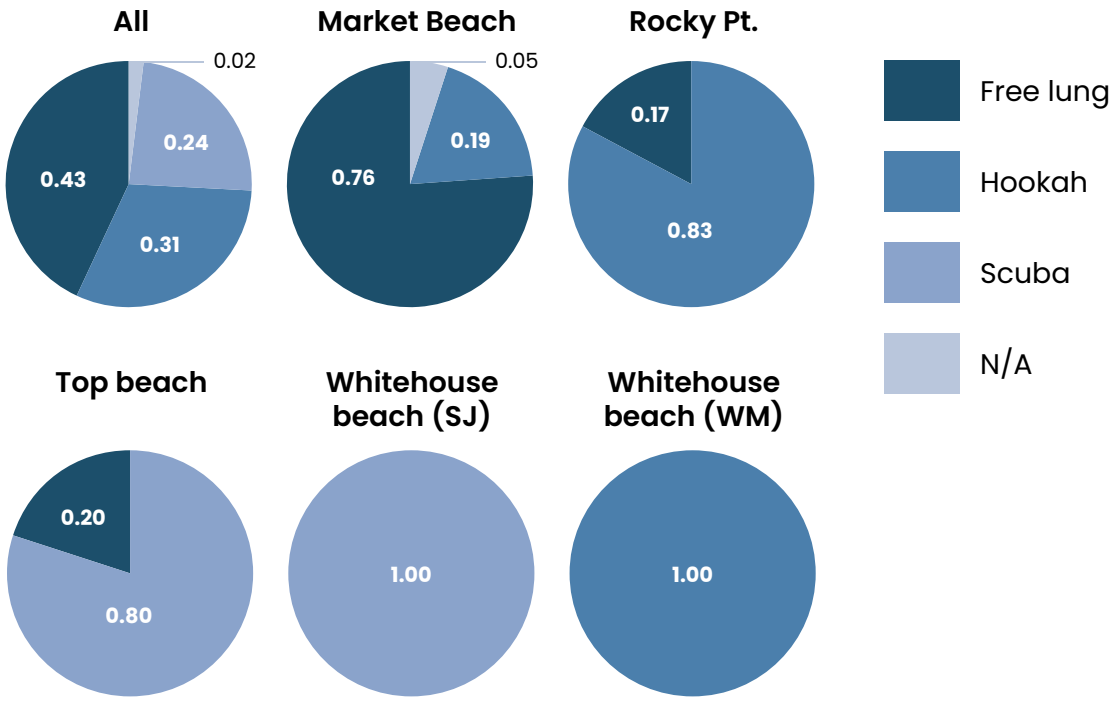


Figure 9: Proportion of diving gear utilized to harvest queen conch globally (i.e., all) and at each of the selected fishing beaches.

Note that fishers from Rocky Point mostly use hookah for operations on the southern shelf and Pedro bank. SJ = Saint James Parish, WM = Westmoreland Parish – see map Figure 6.

Conversion factors for % clean meat categories

Conversion factors (CF) are necessary to standardize queen conch landings by different percent clean meat categories to dirty and live weights. A thorough statistical evaluation of queen conch conversion factors for Jamaica have not been completed. There are indications from field data (Tewfik 1997) and observations (Tewfik, personal observation, April 2023) that individual queen conchs are smaller in size in the Pedro Bank region than those found on the island shelf. The dominance of older individuals on Pedro Bank at relatively high densities was likely related to a build-up of biomass dominated by small adults (see conversion factors) and relatively low levels of exploitation when compared to other areas in the region. However, the small size of many adults and low shell length growth rates observed in juveniles suggested possible food limitations across the mostly sand dominated habitats (Tewfik 1997). Ehrhardt and Perez (2019) found out that edible meat yield of juvenile conch is not directly proportional to yield among larger individuals; therefore, it was necessary to estimate conversion factors for island shelf conchs separately from the existing conversion factors existing for Pedro Bank landings (Tewfik 1997; Smikle 1997 in Thiele 2001). In this pilot project CF for Pedro Bank was re-standardized from the data found in Tewfik (1997) where dirty weight was made the base standard (i.e., 1.00) rather than the previous 50% clean which constituted the major landed product monitored at processing plants between 1992 and 1993. The resulting CF for Pedro Bank landings are based on the original values in Tewfik (1997):

Grade category	Conversion Factors
Dirty	1.00
50%	1.17
65%	1.31
85%	1.47
100%	1.98

In the case of semi-processed queen conch landings from island shelf grounds, indirect CF were obtained from data on average individual weights within different percent clean meat categories collected by the pilot project. A total of 1336 individuals were measured across all the categories observed and their weight size distributions are presented in Figure 10. Descriptive statistics for the samples in the weight categories are given in Table 2. Use of the mean values and defining dirty (complete) as the standard base category (i.e., 1.00), CF for all other categories were estimated as the simple ratio between their mean values and that of the standard. It should be noted that "dirty" conch meats in the samples came in two forms, dirty (complete – all viscera intact) and dirty (broken – part of the viscera remains in the shell). As the definition of the first processed meat grade (50% clean) is defined as the removal of all viscera we used dirty (complete) as the best base category. The resulting CF for queen conch caught on the island shelf and used in our calculations are provided in Table 3.

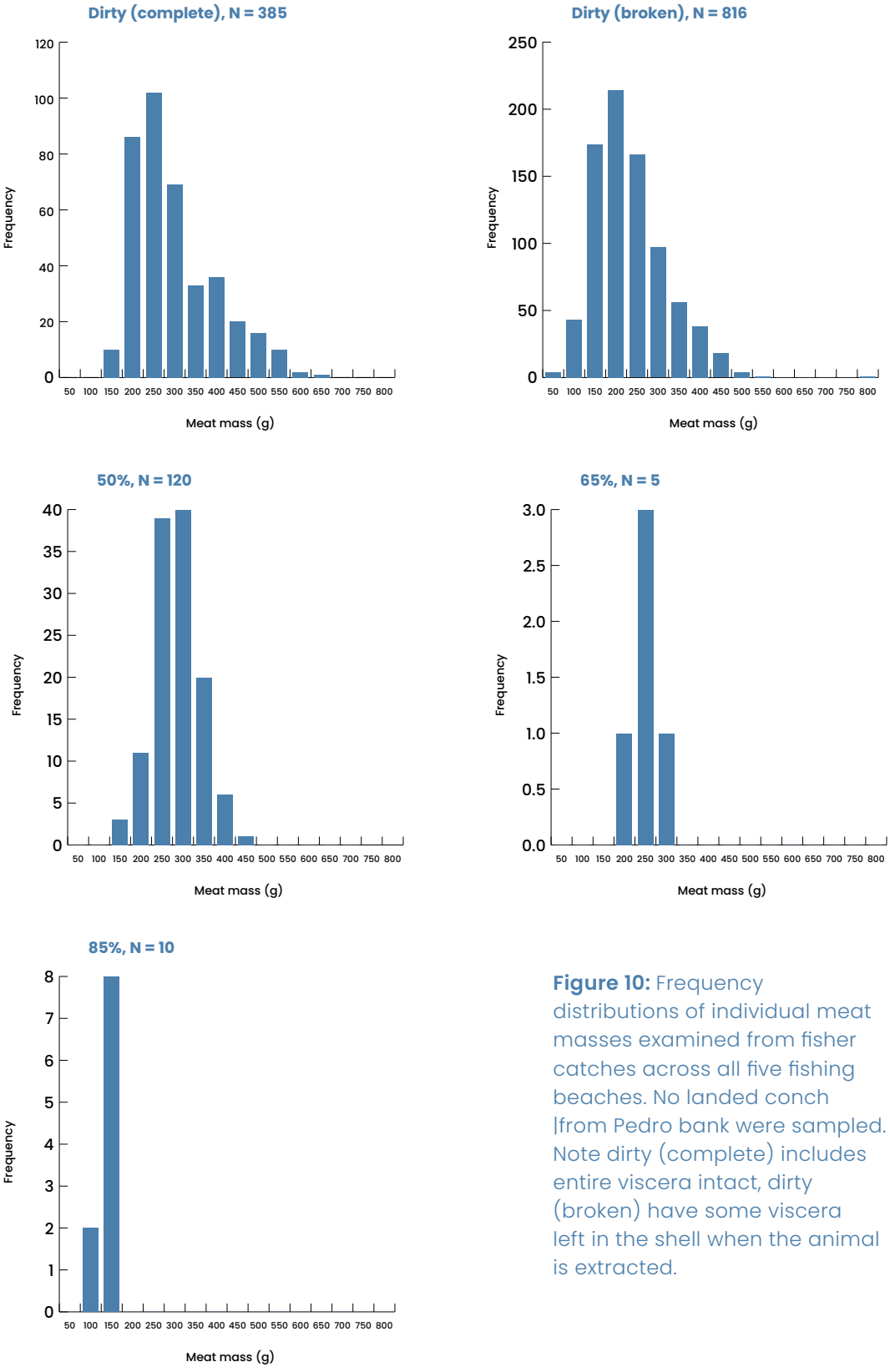


Figure 10: Frequency distributions of individual meat masses examined from fisher catches across all five fishing beaches. No landed conch |from Pedro bank were sampled. Note dirty (complete) includes entire viscera intact, dirty (broken) have some viscera left in the shell when the animal is extracted.

Table 2: Descriptive statistics of meats examined from artisanal fisher catch. Note conversion to dirty meat mass used the complete dirty category and meats were not individually peeled through grades.

	Meat type (g) - level of processing						
	Dirty (complete)	**Dirty (broken)**	**50%**	**65%**	**75%**	**85%**	**100%**
N	385	816	120	5	0	10	0
Sum	105738	169786	31068	1108		1215	
Mean	**274.6**	**208.1**	**258.9**	**221.6**		**121.5**	
Min	133	47	107	182		85	
Max	628	765	419	268		150	
Sd	99.1	86.1	55.9	32.5		20.3	
Se	5.05	3.01	5.1	14.5		6.4	

Table 3: Conversion Factors for queen conch in several percent clean meat categories landed from island shelf grounds.

Grade category	Conversion Factor
Dirty (complete)	1.00
50%	1.06
65%	1.24
85%	2.26

CF data for QC fisheries in Jamaica do not include information to raise landings expressed as "Dirty weight" to "Live weight" as requested by the FAO. The pilot project did not have access to live queen conchs necessary to estimate such conversion factors. However, it was noted that a report regarding a regional review of QC conversion factors carried out in 2018 and 2019 (Ehrhardt and Pérez 2019) was available through funding by the Caribbean Fishery Management Council. The report includes analyses pertaining to the validation of the statistical databases used to estimate conversion factors by the countries. Countries were requested to submit their databases and regression and covariance analyses were used to classify the information used in QC percent clean meat conversion factor estimations. The analyses regarding estimation of an average by country and regional CF to estimate "live weight" (i.e., shell + tissue weight) from "dirty weight" to include potential regional stratifications and an overall non-stratified regional mean CF" is shown in Table 4.

Table 4: Conversion factors for Queen conch in dirty categories to live weight category for different countries reviewed and validated by Ehrhardt and Perez (2019).

		CF 95% Confidence Interval	
	Average CF	**Lower**	**Upper**
Nicaragua	5.39	4.82	6.12
Honduras	5.63	4.82	6.76
The Bahamas	5.60	4.41	7.68
Martinique	5.54	5.53	5.55
Barbados	4.66	3.87	5.17
Average	**5.36**	**5.01**	**5.72**

The 95% confidence interval for the average regional CF is narrow generating an estimate with fairly high precision. The CF among the countries is statistically not significantly different indicating that "Dirty weight" is morphometrically correlated with "Live weight", which is a function of biological condition. This argument supports the adoption of the average regional value of 5.36 estimated by Ehrhardt and Pérez (2019) in the "Live weight" landing estimation in Jamaica.

Artisanal landings and fishing effort estimation

The QC artisanal fishery surveys were carried out between April 25th and June 2nd, 2023, and allocated to 5 randomly selected localities (Figure 6) with boats from those localities fishing on the island shelf and Pedro Bank. Data on the characteristics of the fishing operations are summarized in Table 5. Boat size appears to be similar except at the Whitehouse (SJ) fishing beach where boats are larger with higher horsepower (HP) engines. However, these larger boats have smaller crew and fewer divers. Fishing operations from Market beach and Whitehouse (SJ) take place in neighboring fishing grounds with minimal distances of 9.3 and 2.9 nautical miles, respectively. Fishing operations on Pedro Bank are distinctly more distant at 47.3 nautical miles from their landing beach at Rocky Point.

Table 5: Average data from surveys showing characteristics of the fishing operations.

Landing Location	Boat size (ft)	Engine HP	Gear type	Crew size	Number of divers	Time of departure	Time of arrival	Length fishing trips (hr)	Distance from landing site (NM)
Top Beach	26	40	Scuba	4.2	3.2	7:00:00 AM	1:08:00 PM	6:08	16.3
Rocky Point	28.7	40	Hookah	3.5	2	7:56:15 AM	4:22:30 PM	8:26	27.7
Market Beach	24.4	42.3	Free Diving	4.5	3.0	7:56:40 AM	2:00:00 PM	6:04	9.3
White-house (WM)	29.7	40	Hookah	3.8	2.3	7:45:00 AM	2:52:30 PM	7:07	20.4
White-house (SJ)	33.3	60	Scuba	2.8	1.2	6:45:00 AM	11:36 AM	4:51	2.9
Rocky Point (Pedro Bank)	29.4	40	Hookah	4.3	2.3	7:30:00 AM	3:22:30 PM	7:52	47.3

Data on the average results of the fishing operations by those fishers interviewed at each locality are shown in Table 6. The survey question to fishers regarding the number of boats fishing for queen conch in their localities served the purpose of creating a pseudo-census on fleet sizes per locality. This was required given the absence of fleet size information from a fishery census during the last 24 years (i.e., the last fishery census was implemented in 1999). The number of fishing trips per week is generally low (1.3-2.2 trips) excepting for Whitehouse (WM) with 4 fishing trips per week and Pedro Bank with 3.3 fishing trips per week. Data on landings per trip were recorded during surveys in pounds by percent clean meat categories and later transformed to kilograms. In the analyses, landings were converted to dirty (complete) weight using the conversion factors given previously and according to the origin of the landings (i.e., island shelf or Pedro Bank). The average of landings by groups of interviews by locations and their standard errors (i.e., standard deviation divided by the square root of the number of interviews per locality) are given in Table 6.

Table 6: Average results of the surveys on fishing operations with information provided by fishers interviewed during the survey at each of the 5 localities.

Landing Location	Number of boats in your locality	# Boats from your locality you saw fishing	# Boats from other localities you saw fishing	# Fishing trips during this week	Landings in dirty weight per daily trip (Kg)	Standard error landings per trip (Kg)	Operates Weekends and Holidays Yes = 1 No = 0	Days not fished due to weather	Days effectively operated	Fraction of days operated	Fishing effort (Days operated per week)
Top Beach	5.7	4.0	6.0	1.8	2.8	0.8	1.0	0.2	6.8	0.265	10.2
Rocky Point	25.8	1.7	15.0	2.2	34.7	14.3	0.2	1.2	4.2	0.516	56.0
Market Beach	10.6	3.7	4.3	1.8	5.6	1.9	0.3	0.7	4.9	0.368	19.2
White-house (WM)	6.0	3.3	0.0	4.0	86.2	26.3	1.0	0.0	7.0	0.571	24.0
White-house (SJ)	2.5	0.2	0.7	1.3	23.4	5.4	0.2	0.5	4.8	0.276	3.3
Rocky Point (Pedro Bank)	40	12	2.3	3.3	109.2	50.4	1	2.3	4.7	0.704	131.4

The amount of work-days per week given in Table 6 was estimated by subtracting statutory holidays and weekends per week from standard country calendars minus the average number of days that weather conditions impeded fishing and estimated from fisher responses (Table 6) as well as days lost due to mechanical issues. For example, in Table 6 at Top Beach and Whitehouse (WM) fishers disregarded holidays and weekends while at other landings sites, such as Rocky Point and Whitehouse (SJ), fewer number of fishers operated in such days. The total amount of fishing effort in days fishing per locality (i.e., the number of fishing days per boat per week times fleet size at locations) were estimated according to the formulation for fishing days given in figure 11 and presented in the last column in Table 6.

With the information on average landings in kilograms per day fishing obtained from the surveys and the average number of days fishing per week the total landings per week were estimated following the formulation for landings in Figure 11. The results per week and for the period of the surveys (i.e., 5 weeks) are presented in Table 7.

Table 7: Estimated average landings per day fishing, fishing effort in number of days fishing per week and landings per week and expanded to the 5-week period of sampling for each locality surveyed.

Locality	Average Landings (Kg) per day fishing	Number of days fishing per week	Landings (Kg) per week	Landings (Kg) during 5 week sampling period
Top Beach	2.8	10.2	28.2	141.2
Rocky Point	34.7	56.0	1,943.4	9,716.9
Market Beach	5.6	19.2	108.0	540.0
Whitehouse (WM)	86.2	24.0	2,068.4	10,341.9
Whitehouse (SJ)	23.4	3.3	78.0	389.9
		Total landings	**4,226.0**	**21,129.9**

Artisanal landings from Pedro Bank

Locality	Average Landings (Kg) per day fishing	Number of days fishing per week	Landings (Kg) per week	Landings (Kg) during 5 week sampling period
Rocky Point	109.2	131.4	14,355.9	71,779.3

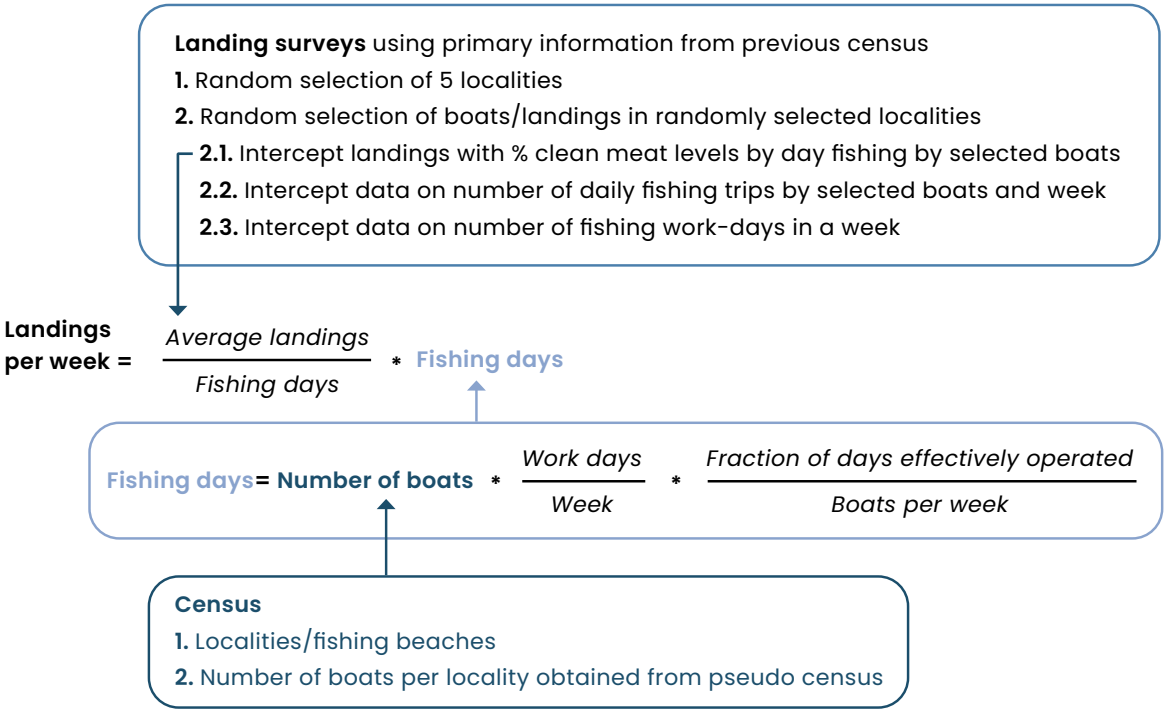


Figure 11: Flow of information in the process of QC landing estimation in artisanal fisheries

It is noted from the surveys that low landing estimates for fishing operations out of Top Beach, Market Beach and Whitehouse (SJ) are the result of artisanal multi-species fishing operations, including spear and traps, in those localities while the larger landings per week estimated for Rocky Point and Whitehouse (WM) are indicative of fishing operations directed to queen conch. The significantly larger landings from Pedro Bank are due to the numerous artisanal fishing boats that operate in the offshore bank (i.e., a total of 40 boats in Table 6 second column). Possibly a significantly high number of such boats may be operating to obtain catch for the industrial fleets that harvest conch on Pedro Bank and do not supply queen conch products to artisanal landing sites. In such a case, landings and fishing effort estimated for artisanal fleets operating on Pedro Bank and landing in Rocky Point may be over-estimated. Therefore, there is a need to obtain information on the number of artisanal boats practicing different arrangements of queen conch deliveries in the offshore queen conch grounds. The pilot project was able to obtain only three interviews with artisanal boats that were transferring significantly high catches from the offshore banks directly to processing plants on mainland Jamaica. As per discussions with NFA personnel, such landings are intercepted through the national statistical fishery statistical system implemented for the industrial fisheries. Despite this, there is a need to estimate the fraction of landings by artisanal boats that fish for queen conch on offshore banks that transfer their catch directly to the processing plants. This will only be possible through a general QC fishery census and dedicated survey operations on offshore fishing beaches such as those on the Pedro Cays.

The 95% confidence intervals for average landings per week in each locality was estimated as

Average Landings per week ±1.96

x

Standard error of the estimate

where standard errors were estimated from standard deviations of the landing observations divided by the square root of the number of interviews obtained during the weekly surveys. The results are shown in Table 8.

Table 8: 95% Confidence intervals for estimates of average landings in kilograms per week

		95% confidence interval landings per week	
Locality	**Average Landings (Kg) per week**	**Lower 95% Confidence interval (Kg)**	**Upper 95% Confidence interval (Kg)**
Top Beach	28.2	26.7	29.8
Rocky Point	1,943.4	1,915.3	1,971.5
Market Beach	108.0	104.3	111.7
Whitehouse (WM)	2,068.4	2,042.1	2,094.6
Whitehouse (SJ)	78.0	67.3	88.6
Total	**4,226.0**	**4,155.7**	**4,296.3**
Rocky Point (Pedro Bank)	14,355.9	14,257.1	14,454.6

2. Industrial fisheries

The industrial QC management regime in Jamaica is characterized by a robust system facilitated by several legislations entrenched in Jamaican law that are administered by several separate government agencies including the NFA (National Fisheries Authority), VSD (Veterinary Services Division), and NEPA (National Environment & Planning Agency). In addition, the CITES Scientific Authority (SA) in Jamaica is staffed by local experts working closely with the NFA (Figure 12) (see Kong 2021 for complete details). The provisions of the legislations enable the various government agencies to implement a wide set of monitoring, management, and conservation measures (Kong 2021) which include:

- Legally mandated joint physical inspections by two independent government agencies (NFA, VSD) of each shipment of QC to ensure consistency with annual Export Quota and Individual Export Quota
- Determination of the annual national TAC based on fishery independent surveys and legally mandated fishery dependent data from 100% of industrial fishery landings.
- Annual TAC subject to consensus between the National Fisheries Authority and the CITES Scientific Authority.
- Annual TAC allocated as Individual Conch Quotas to licensed fishers through a conch quota allocation process administered by a legally constituted multi-agency committee.
- Observation and inspect of QC loading operations of containers for export – Customs officials.
- Reporting of current season export quota (CITES Scientific Authority) and past season annual trade data (NEPA)
- Conch fishers and fishing vessel subject to fishery specific licensing requirements.
- Legal sanctions and fines for fishing QC without a valid license or Individual Conch Quota.
- Annual Export Quota established based on annual catch quota and allocated as Individual Export Quotas to bona fide Individual Conch Quota holders.
- Seven months annual closed season (presently August 1 to February 28 of the following year) unless changed by the Minister.
- Legally mandated requirement for every person to declare the quantity of QC in their possession prior to the commencement of the annual closed season for QC.
- Prohibition of the sale of conch products and by-products after the first 21 days from the commencement of the closed season for QC.
- Prohibition to harvest immature QC.
- Legally defined Conversion Factors (CF) for different degrees of processed conch meats.
- Established Conversion Factor for QC opercula.
- Legally established Fishery Management Areas (FMA) where the fishing of QC may be managed. Any FMA may be opened or closed to conch fishing or subject to specific condition(s) such as prohibiting MFVs fishing conch in any or all designated FMA.

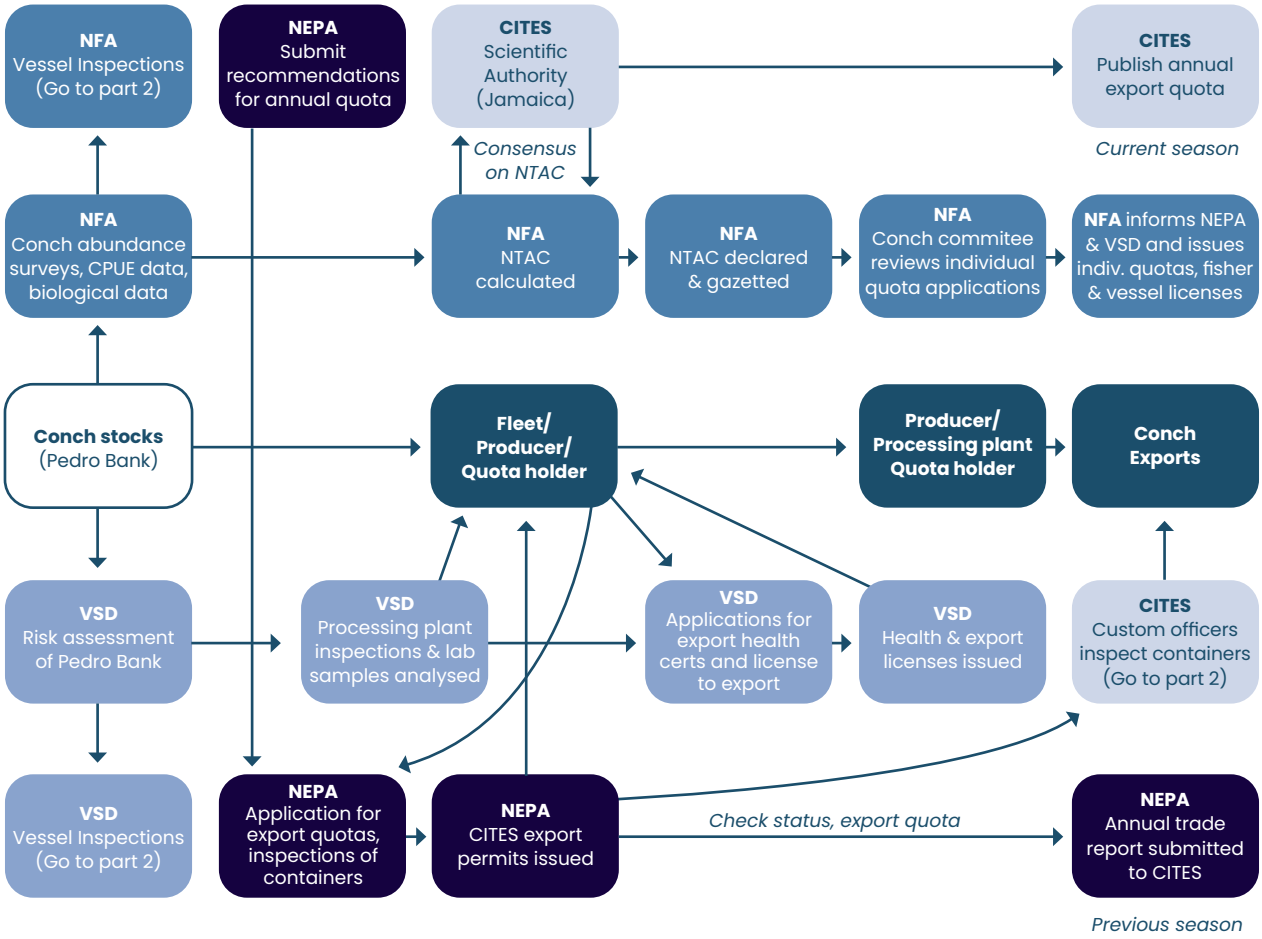


Figure 12 (Part 1): Jamaican Queen Conch Industrial Fishery: Determination of total allowable catch (TAC), individual quotas, export, and trade data. NFA = National Fisheries Authority, VSD = Veterinary Services Division, CITES = Convention in the Trade of Endangered Species, NEPA = National Environment & Planning Agency. Adapted from Kong (2021).

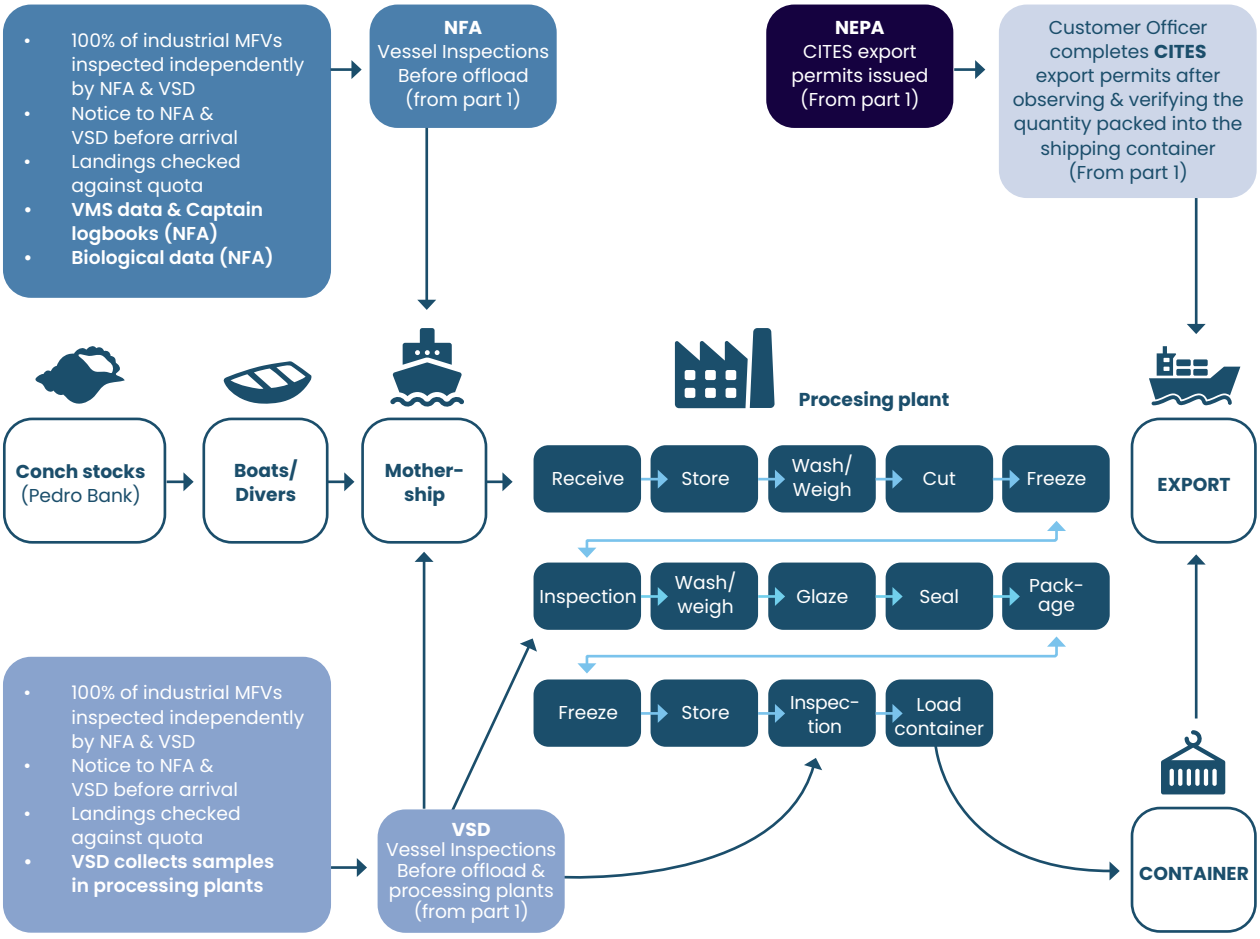
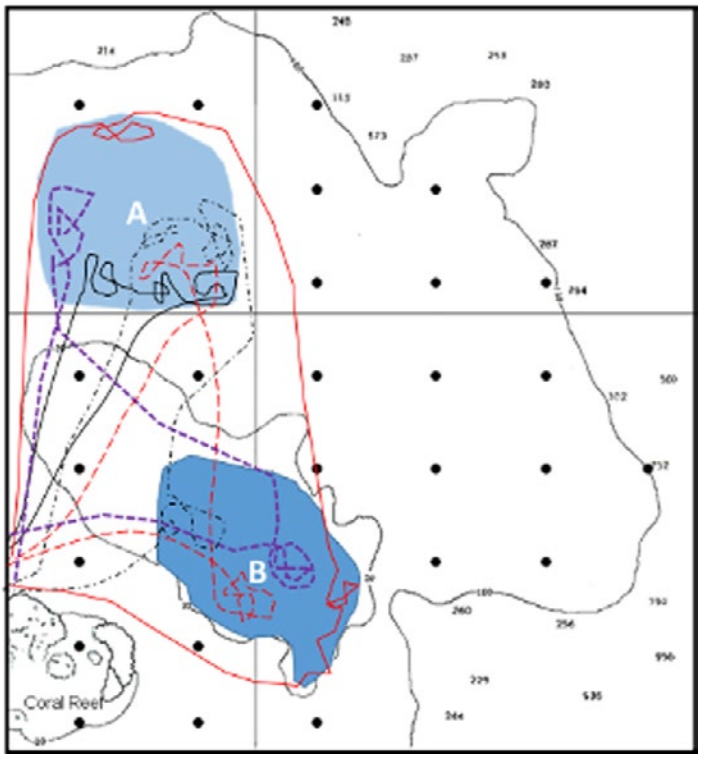


Figure 12 (Part 2): Jamaican Queen Conch Industrial Fishery: Determination of Total Allowable Catch, Individual Quotas and Export. NFA = National Fisheries Authority, VSD = Veterinary Services Division, CITES = Convention in the Trade of Endangered Species, NEPA = National Environment & Planning Agency. Sources: Adapted from Kong (2021) and Prada & Appeldoorn (2016 – processing plant flowchart)

While vessel monitoring systems (VMS) are currently deployed in industrial queen conch vessels the data generated by such systems are not currently being used to determine fishing effort exerted on the queen stocks. The addition of VMS data in the existing industrial statistical system will provide significant improvements regarding fishing effort calculation for industrial vessels that operate their own dories from a mothership. However, VMS data represent an extra investment that cannot be effectively implemented at this time in smaller, independent artisanal boats that may still supply queen conch catch to industrial fishing vessels, carrier vessels, or directly to processing plants on mainland Jamaica. In the generic training module, explanations were provided regarding analyses of data generated by VMS that allow descriptions of fishing trips carried out during a given month and given fishing grounds (Figure 13). Fishing grounds can be identified from vessel tracks as well as days out of port. Days effectively fishing can be estimated from these data and later correlated to landings reported by vessels. Data from VMS may be saved at short time periods less than two hours; therefore, spatial resolution of fishing ground mappings is possible. Such degree of fishery data integration may allow estimation of spatial relative indices of queen conch abundance that may result in more accurate descriptions of queen conch resources use and more precise estimations of annual TAC.

QC fishing grounds A and B



Vessel 1:
Red segmented line

Vessel 2:
Double dotted black line

Vessel 3:
Black segmented line

Vessel 4:
Red continuous line

Vessel 5:
Black continuous line

Figure 13: Tracks of 5 industrial vessels targeting queen conch in offshore fishing grounds, not Pedro bank (Ehrhardt 2021.a).

Conclusions and Recommendations

The objectives of the pilot project were achieved by including (a) several training components on potential experimental sampling designs that could be applicable to queen conch fishery statistics in general, (b) field samplings to secure the necessary data proposed by the project, and (c) application of methods that generate unbiased statistical estimates of landings and fishing effort specifically for artisanal fisheries in Jamaica. Consequently, the pilot project identified the proper data required by the methodologies adopted and the statistical requirements of the data necessary to estimate landings and fishing effort in the artisanal fisheries. Similarly, it generated opinions about fishing effort estimation on the existing well-designed industrial fishery statistical system in Jamaica. The works adopted by the project required surveys with institutional field sampling capabilities to draw samples via questionnaires to fishers. The team from the NFA with technical support from the project consultants was able to secure the necessary planned survey information that resulted in landings and fishing effort estimation for queen conch artisanal fisheries.

The information on artisanal landings per fishing trips during weekly sampling intervals as well as the resulting estimates of days effectively operated out of potential fishing days per week available during the month of May of 2023 allowed estimation of average total weekly landings per fishing site and their respective variances. Landings were classified by percent clean meat categories and collection of biological samples (i.e., individual queen conch weight within categories) allowed estimation of conversion factors for landings in those fisheries.

The results indicate significant differences in the amount of the landings observed among the five landing sites. Such differences are the result of artisanal fishing operations that represent both multi-species as well as directed queen conch fishing operations and dictated by distances to fishing grounds from landing sites. Resulting estimates for monthly landings by localities are indicative that artisanal fisheries may have a significant level of queen conch production that have not been considered in the annual quota definitions.

Fleet size is the most critical data to estimate landings in queen conch artisanal fisheries. These data must be secured by a census that includes complete enumeration of localities as well as queen conch boats operating from each locality. In absence of recent census data on locations and boats per location that are fishing for queen conch, it was necessary to include specific survey questions to artisanal fishers about their knowledge regarding fleet sizes in their locations and their perception on the operations carried out by such fleets. The pseudo census data used in the project analyses need to be corroborated via a specific national queen conch fishery census.

A review of the existing, well-defined industrial queen conch statistical system shows the complexity of this fishery regarding the origin of the products landed and the requirements of permits and checks needed to comply with exported products of a species that is listed in Appendix II of the CITES and of annual NTAC compliance. This review does not offer any changes to the existing landings production chain checks done by several institutions in Jamaica. This conclusion is based on an assessment of the actions and documentation officially created to check for quantity and quality of the queen conch exports and of steps taken by institutions to control and enforce quotas assigned to fisher groups.

Missing information and gaps on industrial fishing effort data appears to be the main concern in the statistical system for the industrial fleets. Fishing effort is a complex variable to measure in these

offshore industrial fisheries due to (a) numerous artisanal boats transferring their catch to industrial vessels under contract, and (b) numerous dinghies operated by the industrial vessels that generate the fishing power of the vessel. Therefore, the project recognizes the possibility and need for obtaining a better identification of spatial considerations regarding the origin of the industrial landings (i.e., landings according to fishing grounds within Pedro Bank and of queen conch caught by artisanal fleets on Pedro grounds and delivered to the industrial vessels). This recommendation specifically refers to the use of the existing data from VMS installed in the industrial fleet.

Tracking of spatial fishing operations using data from VMS information may be possible by transferring VMS information to a specialized analytical group that will need to be specifically created for this task within NFA. Such group will need to operate continuously throughout the queen conch fishing season and permanently within the institution. The possibility exists to develop generic units of fishing effort such as number of trips, days out of port, number of diving sites as well as the possibility to carry out advanced spatial analyses regarding fishing ground definitions and fishing intensity (i.e., fishing effort per unit of area fished, hours of diving operation, economic analyses of the fishing operations).

Fishing intensity can be derived from analyses and spatial modeling of VMS data and correlated with temporal catch annotated in existing or to be implemented captain's logbooks. Several possibilities exist to secure fishing effort from VMS data:

1. Secure a few QC industrial vessels that use VMS and operate small dinghies from the industrial vessel to participate in a catch per unit of effort assessment program.
2. There will be a need to assess the relationship between the amount of time fishing in different areas of the banks to the amount of catch associated to the fishing effort such that the spatial and temporal designation of such data can be identified. Fishing effort could be obtained from a review and analyses of the VMS data registered by the VMS service provider. Permission from the captain and/or vessel owner will be required to use the data. The digitized data regarding time of day, latitude and longitude positions of the vessel should be made available from the provider of vessel tracking, with permission from captains/owner, to the NFA.
3. It should be assumed that captains must keep track of product brought aboard by different suppliers (i.e., own divers vs artisanal fishers). Such logbooks should be implemented and obtained on arrival at port after every fishing trip. Logbooks are not released to samplers; therefore, pictures must be taken of the pages corresponding to the catch brought in the trip being surveyed.
4. NFA personnel that may participate in the industrial fleet catch per unit of effort assessment should also contact processing plants and explain the purpose of the survey and the need to obtain copies of the receipts of landed QC by the vessels selected as samples. These activities must be inserted in the existing landings data collection system.
5. The catch per unit of effort data collected should be digitized as soon as possible for analyses. VMS data should come in the form of digital files as well as a plot of the trip tracks provided by the VMS service provider to NFA.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Annexes

Annex 1:
National Fisheries Authority team members and their positions in the project

Stephen Smikle
Karlisa Black – Point person, Research & logistics, Data Collector
Azra Blythe Mallett – Research & logistics
Rachel Feddis – Data Collector
Nicolette Shaw
Howard Simpson
Othane Parkinson
Deandra Roberts
Anginette Murray – Data Collector Supervisor
Garth Brown
Sashay Tennant – Data Collector
Robert Kenward – Data Collector
Shantol Powell – Data Collector
Kishawna Green – Data Collector

Annex 2:
Generic training PowerPoints (3 parts)
Part 1, Part 2, Part 3

Annex 3:
Self-evaluation Primer PowerPoint

Annex 4:
Field Sampling Training/Review PowerPoint

Annex 5:
Field Trip Report

Annex 6:
Field Data (6 weeks)

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