REVIEW OF THE DATA COLLECTION AND MANAGEMENT SYSTEMS OF THE MARINE FISHERIES IN THE COMMONWEALTH OF THE BAHAMAS

FINAL REPORT

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Recommendations

1. Objectives of the Data Collection

Fisheries Policy Workshops: It is necessary to decide upon the objectives of data collection to ensure that the system is efficient and that information is used. The objectives depend upon the government policy towards its renewable resources and fisheries. The specific objectives need to be decided by managers, fishers and other stakeholders and requires consultation. In the first instance, this consultation should be undertaken formally through workshops.

It is necessary to consider information required to implement the current policy and how that information should be presented so that it can be used in decision-making. Although the decision on how to approach this remains with the Bahamas Government, the following are recommended:

- A simple catch-per-unit-effort index should be chosen as a basic performance index of all fisheries.
- For all fisheries, a recovery programme needs to be defined which will come into force when the fishery passes into an overfished state. The overfished state is defined by a precautionary reference point.
- A precautionary reference point can be developed for all types of fisheries from historical data, current research programmes, interviews with fishers and the scientific literature. The precautionary reference point will have to be agreed with decision-makers to ensure it is consistent with policy.
- For spiny lobster, special consideration must be given to policy and objectives of the management of condominiums (condos or casitas).

Data collection should include consultation with stakeholders. Data fields completed by the enumerator can include references to problems and issues being faced by the community. To be successful, there must be feedback. That is, stakeholders must receive some reply to the issues they raise, through reports or personally through the enumerator.

2. Develop the National Data Collection System

The data collection system needs to be adapted to meet the objectives decided upon above. In general, more detailed information may be required and enumerators require training to ensure they are recording information correctly.

The trip interview system needs to target less well developed fisheries. The trip interview needs to obtain:

- **Better estimates of effort**: Effort targeted at different species needs to be recorded separately. Some gears need effort recorded in a different way, which may require the implementation of a logbook system. More gear details, such as depth and soak time, may need to be recorded.
- **Estimates of catch not going through processing plants**: Landings passing through processing plants are accurately monitored. There is no estimate of the amount not passing through processing plants and not being picked up by the trip interviews.
- **Wider coverage**: A number of islands are not covered by the trip interview system.

To achieve these aims without a dramatic increase in costs, the trip interviews need to be based on a firmer statistical basis through development of a sampling programme. This will allow sampling to be spread across islands and estimates of unobserved variables, such as unmonitored landings.

Given the relatively advanced development of some fisheries, notably the spiny lobster fishery, there should be greater emphasis on the responsibility of fishers to complete and return logsheets of fishing activities. In this context, the co-operation of fishers is very important and some agreement with them needs to be obtained. Reliance on legislation will not be adequate.

2.1 Growth, Fishing Mortality and Discards

Mortality and growth cannot be estimated with current routine collected data. A stock assessment on conch has been completed and a stock assessment is currently being undertaken on spiny lobster and Nassau grouper. Both have undertaken their own data collection programme to provide adequate information for the assessments.

Data collection needs to include a biological data sampling programme in the processing plants for the main commercial species. Data should be obtained particularly for spiny lobster, but also other species if possible. This would take measurements on sex, length, weight and maturity of sub-samples of the catches. Ideally, samples should be linked to individual vessel landings and exported product. This would provide a complete picture of each vessel's landings of spiny lobster and allow very high quality analysis and mointoring.

Given the main gears used, discards are probably not a major issue in these fisheries. Discards can be estimated dependent upon the fishery. 1) Interviews should be carried out to get fishers to subjectively estimate their discards or discards required in logsheets. 2) Full catch and discards should be obtained by gear and area by either using a research vessel simulating commercial fishing (appropriate for larger vessels), or by requiring a sample of fishers to land everything they catch (appropriate for the small scale fishery). 3) An estimate of total discards extrapolating the sample to all landings using both 1) and 2) above. However, there are other environmental effects, which should have higher priority than discarding. Some concern has been expressed over the impact of the condos placed on the banks, for example.

2.2 Economic Data

A sample of trip interviews should record a cost form. With the exception of prices, economic variables are not currently recorded. Costs in particular are lacking, and any interest in monitoring profits (resource rent) or earnings is currently not possible.

There is an investment database, which was maintained to provide permits for importing fisheries equipment. This has been taken over by the Customs Department, but there is an apparent fall in quality of the information provided. This needs to be addressed.

2.3 Develop Sampling Programme

The current sampling procedure does not follow a statistically rigorous method. In this report, a robust sampling method has been proposed based on the 1995 census. Staff will need some training in learning to use this method.

2.4 Develop Database

Although the Fisheries Department possesses a large amount of data, it is under-utilised, as much of it is inaccessible. The catch and effort database is poorly designed and difficult to use in any other manner than producing monthly summaries. There are two options:

- Develop a database locally. The database can be adapted from one used in another country. However, the database must be supported locally and will require expertise currently lacking in the Fisheries Department. The fact that the existing database has not been updated for many years questions whether this would be an appropriate option.
- Use a standard regional database, such as the CFRAMP TIP/LRS system. This has the advantage of external support and will require a lower level of local expertise. The main problem with the TIP/LRS system is that, at least currently, it does not cover logbooks or processing plant reports, which are important to the Bahamas system.

The preferred option is to use the CFRAMP TIP/LRS system, as it is more likely to be sustainable. However, the system would have to be adapted. It is currently being reviewed and should be updated later this year.

2.5 Training

Training is central to developing a data collection programme. While enumerators and other staff have learnt how to use the current system in practice, training will improve data quality and allow use of a database.

Training should include:

- Workshops on the objectives of data collection. All staff should be clear on why data is collected and how it will be used.
- Data collection methods. To a large extent, some staff are already familiar with data collection methods. However, widening understanding of formal statistical techniques and regional standards among enumerators will be useful.
- Database use. For most staff, this will be limited to techniques for data entry, although at least two staff members should be able to carry out basic data management tasks.
- Reporting standard information indicating the state of the fishery. Some training in simple statistics and estimation will be necessary.
- Training of fishers in completing logsheets will be necessary.

2.6 Consultation and Education

Organise consultations with the users of the data collection programme, primarily the central and local fisheries administration and the bodies dealing with management and development of fisheries.

Create contacts with local authorities, associations, co-operatives, and fishers representing their communities and organise meetings to discuss data collection and use. Posters and leaflets for distribution may be useful in explaining why the data is needed.

Contents

1. REVIEW OF CURRENT DATA COLLECTION

1.1 Overview

The current review and recommendations are derived from standard approach recommended in the FAO Guidelines for the Routine Collection of Capture Fishery Data (FAO 1999). It is strongly recommended these guidelines are used in developing the data collection programme in the Bahamas.

The data collection system implemented in the Bahamas is a mix methods based mainly on processing plants reports, and monitoring using trip interviews when vessel land. This reflects the types of fishing, from semi-industrial vessels targeting the main commercial species of lobster for export to small vessels landing a diverse catch for the local market.

Although the Fisheries Department possesses a database, it is poorly constructed and difficult to obtain information other than the monthly summaries defined in the reports. Therefore, there is considerable information that is collected but not used.

1.2 Fishery Structure

The fishing activities can be divided into semi-industrial and small scale fisheries. The semi-industrial fleet would include larger vessels which go out on trips longer than one day. The small scale fisheries are small vessels which will typically go out for a single day. The 1995 census found 646 vessels greater than 20 feet in length and 3433 vessels less than 20 feet in length. Although the division will not be clear cut in practice, it will be important to separate fleets for purposes of data collection.

Vessels larger than 20 feet in length are required to register with the fisheries department. These vessels include those that stay out on trips for 3-5 weeks catching lobster which are stored as frozen tails on board the vessel. Other larger vessels use traps to catch fin fish to depths of 200 m. These vessels tend to sell to processing plants which consolidate and process the landings for export.

Vessels between 10 and 20 feet are, in theory, required to register with the port authority. These vessels include day-boats, which catch and sell fish locally. However, they will also supply processing plants. Fish targeted include lobster, conch, Nassau grouper and other finfish. The key difference a smaller vessel makes is to limit the range of fishing activity from the home port.

In terms of value and volume of landings, the fishery is dominated by spiny lobster. Lobster are now mostly caught using condominiums (condos or casitas). They attract lobsters, which require shelter from predators during the day. Fishers periodically visit the condos, free diving and catching the lobster using hooks or spears. In 1995 approximately 650 000 condos have been placed on the shallow water banks. However, the placement of condos has been largely unmonitored.

Fishers associations exist, but do appear to be very active. The fishers association in Spanish Wells has declined in activity due to disillusionment as it failed to achieve its objectives.

The main exports are lobster and Nassau grouper to Miami. However, there is a large local market for finfish, conch and lobster, due to a local interest in eating fish, and the development of tourism. Apart from a small licence fee and a small tax paid on exports, local fishers do not pay for access to the resources.

There is a large recreational fishery, which is related to tourism. A significant number of sports fishing vessels were recorded in the 1995 census. These are unmonitored, but will mainly target tuna, billfish and bonefish.

1.3 Policy and Legislation

Current policy concerns in the Bahamas broadly fall into two areas:

- Optimal sustainable use. This is the key policy for all fisheries and needs to be promoted with the Bahamas Government, public and fishing communities.
- Fisheries development. Development of fisheries has to be undertaken with care, as policies can lead to irreversible over-investment and chronic overfishing.

Although 'sustainable use' is a reasonable objective, it of little use by itself in setting management controls. Policy objectives need to be precisely identified and quantified to ensure this aim is achieved. This can be done by specifying controllable performance indicators which represent the required policy.

While the Department of Fisheries is currently monitoring landings and value, it has been unable to set meaningful targets or limits or suggest appropriate management controls. While the stock assessments now being undertaken may address some of these concerns, it is unlikely that they will cover all issues. Policies (Table 1) could address:

- **Fisheries impact on the ecosystem.** A fishery will decrease the population size below that of the unexploited stock. This may not only affect the exploited population, but also predator, prey and competing species. It is therefore important to monitor changes in the fish community and detect potential problems before they occur. As well as collecting data on catch, effort and discards, other environmental and biological monitoring may be necessary to track changes in the ecology.
- **Fisheries contribution to food supply.** It is essential to be able to quantify the dependence on fish as a food source so that fisheries policy-making and management takes due regard of the needs for conservation of resources, their sustainable use and sufficient access to the resources for dependent communities.

  No data exist on consumption. The importance of fish in the diet as a source of protein, and culturally as a traditional food, remains anecdotal. However an important policy objective is to improve the quality of supplied fish, and lower its price (amount supplied). No management activities are in place to achieve these objectives.
- **Fisheries contribution to the economy.** If managed effectively, fisheries are able to generate substantial benefits to the national and local economies. Assessments of the economic contribution of fisheries need to take into account the generation of income in the local community, generation of returns to the broader community and possibly the generation of foreign exchange from export earnings.

Table 1 Current policy objectives and suggested indicators needed to implement policy. Indicators are estimated from the data collection programme and guide management in implementing policy objectively.

Policy	Indicators
Optimum sustainable use of fisheries resources	Stock size, stock structure, employment, investment, subsidies, Gross Fisheries Product, resource rent (profits)
Availability of fish for local consumption	Prices, landings and exports, fish consumption
Improve well-being of the local fishermen	Earnings distribution, employment, socio-cultural, communities dependence on fishing
Promote development of local fisheries	Vessel operations, investment, subsidies
Protect environmental conservation	Stock assessment, species compositions
Diversify fisheries	Vessel operations, investment, landings

Apart from these general policy objectives, it is important to listen to the concerns of fishers and if appropriate address them as part of the data collection programme. An important issue identified by the fishers was the unauthorised use of condominiums. However, as there is no legal basis for registering condominiums, it presents a problem for management. One approach would be to register condos to fishers which would allow monitoring condos as well. With fisher support, it may then be possible to enforce ownership rights on condos and control their distribution.

Based on decisions of policy objectives, legislation may need to be reviewed in relation to data collection. The current legislation is orientated towards non-industrial fisheries and places few requirements on fishers to provide data. The possibility of placing a legal requirement on larger vessels to complete and return logbooks would be an advantage. However, placing too great an emphasis on legislation rather than obtaining majority stakeholder support for such initiatives will make them hard to implement.

1.4 National Data Collection System

Currently data collection is limited to trip interviews and processing plant reports. Although some vessels keep their own log, it is not a requirement that vessels submit a log of their vessel activities to the Fisheries Department. Until recently, information on imports of gear and other equipment was maintained by the Fisheries Department for the purposes of tax exemption. This was useful for monitoring investment in the fishery. Unfortunately Customs Department has taken over management of the database and it has become apparent that they have a number of problems with recording these data, so most recent estimates are unreliable.

Trip interviews record standard data variables, including the vessel, effort, landings by commercial group, gear and price. Importantly, the area fished is also recorded. With the exception of effort, these data variables appear of good quality. Effort is recorded as days fishing, which is adequate for many, but not all fishing gears. There are two significant problems:

- For traps, condos and fish aggregation devices (FAD), days fishing is not strongly related to fishing mortality. A better variable would be some indication of the time since these gear were last fished (soak time), or assuming an average soak time, simply the number of gear pulled or searched. An improved effort variable would greatly improve monitoring the spiny lobster stock in particular.
- In many cases, fishers will target more than one species during the trip. Currently, effort directed at different species is not recorded separately.

Although the trip interview surveys aim to cover all landings, it is likely that some, particularly smaller, landings are missed. Furthermore, landings on other islands, such as Long Island, are not monitored (except through processing plants). This means that considerable landings, which do not pass through the processing plants, are not included in the fisheries statistics. As there is no sampling scheme as such, it is not currently possible to estimate how large these might be.

The trip interview system currently depends upon particular skills of the enumerator and his relationship with fishers. If the enumerator is replaced (becomes ill or retires for example), the sampling system will lose continuity and the monitoring system will fail.

Vessels over 20 feet in length are registered by the Fisheries Department. The Port Authority are supposed register vessels over 10 feet in length, but unfortunately have been assumed that fisheries vessels are exempt. As such vessels are only registered with the fisheries department, there is an important gap covered only by the fisheries census. Registration information is similar for both the Port Authority and the Fisheries Department, although the Fisheries registration requires a description of the gear to be carried. Apart from registration, sports fishing vessel activities are unmonitored.

A fishery census was conducted in 1995. Unfortunately, the resulting database is undocumented and the final report remains in draft form. This illustrates a need for clearer structured data collection and data management. Apart from a lack of technical support, the main problem is such information is not used routinely in decision-making. If information were routinely supplied from the census and data collection programmes, the system would not be so neglected.

In addition to the routine data collection, data have been collected on a number of projects with the University of Miami. They cover environmental projects, and resource assessments of conch, Nassau grouper and spiny lobster. The Nassau grouper and spiny lobster projects are on-going and still in the stages of collecting data. Spiny lobster includes sampling for biological data in processing plants. These data are likely to prove valuable and could easily form part of the routine data collection programme.

Processing plants return monthly reports to the Fisheries Department giving a purchase record of the products bought from fishing vessels. The report gives the commercial group, gross amount in weight and the price of the purchase. Thus, all landings that go through processing plants are recorded. This system appears to be accurate and probably gives a very good estimate of the landings of spiny lobster.

Processing records for Nassau grouper includes no size structure, but lobster is graded into tails. Export forms for lobster report size grades, which are currently not used. These data are important monitoring information, but are not maintained on a database.

The relationship between Government and fishers could be improved. It is claimed Government is ineffective at dealing with poaching, a key concern. However, fishers pay no fees and very little tax, so their expectations in terms of Government support appears to be a little high. These issues should be addressed through meetings between the Fisheries Department, fishers and the processing industry.

The main problems that need to be addressed are:

Analysis and use of information in decision-making: No enough use is made of routine data in decision making. This is mainly because the data collection is not directed to supplying information to decision-makers in the form they would find most useful. This will require improvements in recording certain variables such as fishing effort.

Logsheets: Logbooks or a similar system needs to be developed and implemented for vessels on long trips.

Sampling: The sampling methodology needs to be improved to avoid bias and improve efficiency.

Data storage and retrieval: Data is stored on a database with limited capabilities. The data set could provide a great deal more information for management advice. The only way to obtain this information is to develop a new database for data collection.

1.5 Summary

Table 2 A summary of the strengths and weaknesses of the current data collection programmes.

Strength	Weakness
The current system is sustainable	Fishery is not well covered by enumerators for obtaining trip interviews.
Landings data are well covered by processing plants	No statistical sampling system has been implemented.
Trip interviews record most important variables well, with the exception of fishing effort.	Enumerators have not been formally trained
Stock assessments are being undertaken through collection of additional non-routine data	Database inadequate for raw data storage and retrieval
	Effort variable inadequate for many trips
	Very little routine economic or biological data is recorded
	Data not used explicitly in decision making

2. DATA AND DECISION-MAKING

2.1 Overview

The standard approach to managing fish stocks has been to carry out periodic assessments and then give general advice to management on their options. This approach has generally not been successful, for the following reasons:

- Disagreement among stakeholders with the assessment
- It is often unclear among different groups on the decision to be made

- Risk assessment is poor, so often the most optimistic forecasts are chosen even though this is bound to lead to overfishing in the longer term.
- There is improper interpretation of scientific information, as reports are too technical and can be misunderstood.
- The older approach has not been pro-active. The assessment focuses on the current state of the fishery rather than considering what might happen and what would be an acceptable response.

While these problems have been addressed in a number of ways, an approach using reference points is rapidly becoming the standard, being applied among fisheries throughout the world. It addresses these issues by focusing decisions on indices, which summarise information on the state of the fishery. The indices are based on the objectives of management, and hence measure something about the fishery that is of interest to decision-makers. Indices are estimated based on a data collection programme, which should produce data that objectively represents the state of the fishery.

2.2 Management Units

Before considering indicators, we must consider what makes up a complete fishery, the unit to be managed. Assessments and management deal with single stocks as the appropriate unit of control. The biological definition of "stock" is complicated and difficult to define in practice. A living stock could be defined as a group of animals from one species, which share a common gene pool. For the management of fisheries, however, this definition is academic rather than practical, and it is the concept of “management unit” rather than stock that is useful. A management unit is a resource, which we choose to management as a single unit. For this to be meaningful, the unit must possess a way to measure its status and predict how that state might change under different levels of exploitation. In practice for the Bahamas, management units will be defined by species or commercial group and the Bank on which the catch was made.

As they are pelagic, larvae of most species probably spread over many shallow banks. However, for many species, once the larvae have metamorphosed into the adult form, they will not migrate over deep water. Spiny lobsters and conch are an example of this. The following are the locations defining the main management units:

- Little Bahama Bank
- Cay Sal Bank
- Great Bahama Bank
- Crooked Island Bank

Other smaller banks which should strictly speaking be managed as separate fisheries, are: Conception Island, San Salvador, Samana Cays, Plana Cays, Mayaguana, Great Inagua.

Sharing resources among countries remains an issue, and it is likely long term management of recruitment will require sharing data and co-operation with other countries. It is also likely that Nassau grouper breeding aggregations should ideally be managed as separate units. Further research may identify better management units for all species.

As in the case of the resource, the vessels can be allocated and managed in fleets. A fleet is a group of similar vessels, which are approximately the same size and have the same construction. The vessels of a fleet use the same type of gear and fishing techniques and most often, they share fishing grounds. Identifying fleets is also important in simplifying data collection and analysis.

In the Bahamas, larger should be dealt with separately from smaller vessels. Particular types of fishing, such as the spiny lobster fisheries based in Spanish Wells, may need to be treated as a separate fishery with its own methods of data collection and management controls. Such groups need to be identified.

2.3 Performance Indices and Reference Points

'Performance indicator' is a general term for any quantifiable value that gives some idea of how well a fishery is doing in some respect. For example, the total annual landings gives some indication of how well a fishery is doing. Assuming they are sustainable, high landings may be better than low landings as they imply greater economic output. However, interpretation of indicators is not necessarily simple. If total landings are low, we do not know whether this is because the resource is small, the fishery is in a chronically overfished state or the fishery is undeveloped. To help interpret an indicator we use reference points.

Reference points indicate a target we might want to achieve or a limit we might not wish to cross. For example, the total annual landings may be compared against a reference point, the Maximum Sustainable Yield (MSY), which marks the point beyond which landings are thought to be unsustainable. Although MSY indicates the potential size of the resource, it still does not automatically determine the current state of the resource. Often several indicators are required to manage a fishery effectively.

The main attributes of performance indicators and reference points is they reduce complex information into forms which are relatively easy to interpret. Therefore, they are an important aid to decision-makers in simplifying scientific information and focusing decisions on the important aspects of the fishery.

Decision rules may also be considered. Once we define MSY, we may require a management action to maintain or reduce catches below this figure. A decision rule can be proposed and negotiated that achieves this aim well before the problem arises. This ensures the fishers and the fishing industry are aware of what might happen, making implementation of fishing controls much easier.

Table 3 Some examples of the types of indicators and reference points used in fisheries. Empirical indicators do not have a strong dependence on underlying models, although implicit relationships are assumed. Non-empirical indicators depend directly on the choice of analytical model, which must fit the data, and generally require a scientific research programme.

Performance Indicators / Reference Points		Minimum Data Variables Required
Empirical	CPUE	Catch and effort
	Vessel Profit	Catch, prices and costs
	Average Fish Size	Catch composition; Age-at-first-maturity
Non-Empirical	Yield-per-recruit	A long time series of catch composition and effort
	Biomass and	A long time series of catch and effort
	Maximum Sustainable Yield	
	Net Present Value	A long time series of costs, prices, catch and effort

2.4 Examples

To illustrate the approach, two examples of performance indices are given. In both cases, performance indices are calculated or estimated from the available data. These indices are compared with reference points, which represent a decision rule. The approach has several important attributes.

The complex information is reduced to a relatively simple form that summarise the state of the fishery and the associated decision-making process. This clarity helps management and industry understand what is going on with the fishery.

The decision rule ensures management and industry have considered their options should the fishery be threatened with overfishing. This focuses the fishery on future options than simply react to current assessments.

2.4.1 USA

In the North East USA, decisions are standardised and encapsulated into a decision rule based on fishing mortality and the spawning stock biomass. Both these performance indicators are estimated using stock assessment. Fishing mortality is closely related to the proportion of the stock that is removed each year by the activities of the fishing fleets. The spawning stock biomass is closely related to the numbers of mature females that provide eggs and therefore recruits in future years.

The decision rule encapsulates two principles (Fig. 1). Firstly, the rate of exploitation should never go above some maximum level. If the fishing mortality is found to be above this level, then the TAC or fishing effort should be reduced. Secondly, if the spawning stock falls below some precautionary level, then fishing mortality should be reduced to rebuild the stock. If the spawning stock biomass falls to a level that endangers the stock, the fishery will have to be closed for the stock to be rebuilt.

The reference points are set according to what is known about the biology of the stock and its past behaviour. In general however, this approach is sophisticated and requires an in depth knowledge of the stock and has limited application in areas which do not have a long tradition of scientific research. However, this or similar approaches may form the ultimate aim of a data collection programme which aims to generate information indefinitely into the future.

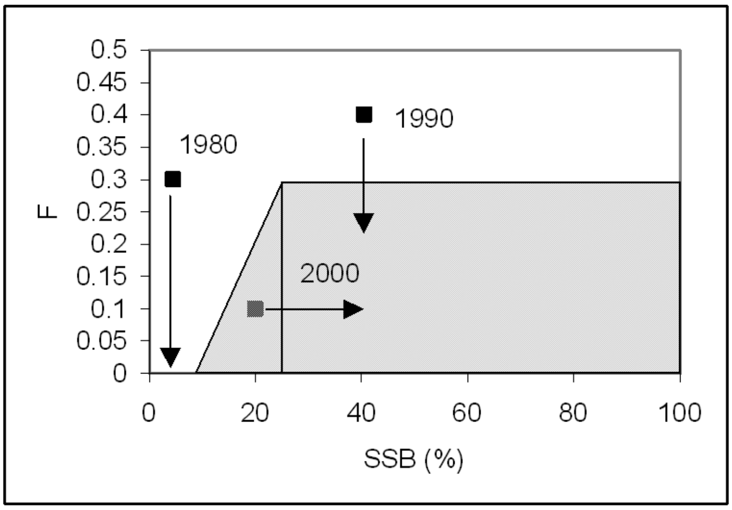

Figure 1 The decision rule indicates the decision to be made based on two performance indices, fishing mortality (F) and spawning stock biomass (SSB) as a percentage of the unexploited spawning stock. The shaded area represents the desirable states in which the stock should reside. In this example, three scenarios are displayed. In 1980, the spawning stock is so low that any reduction in fishing mortality will not automatically drive the fishery into the desirable region. Under these conditions, the rule states the fishery should be closed. The arrow represents the decision, and indicates the fishing mortality should be set to zero (or as low as possible if the species is taken as bycatch). For 1990, the spawning stock biomass is high, but the fishing mortality is also higher than the maximum. If left alone, the spawning stock would be driven to low levels threatening the stock. Again, the decision is to reduce effort or catch quota in line with reducing the fishing mortality below the maximum level. Finally 2000 is in the desirable region. In fact, it lies in the rebuilding area where both fishing mortality and spawning stock are at low levels. The projection, if the decision rule is set up correctly, suggests that the spawning stock will be rebuilt to safe levels as long as fishing mortality is not allowed to increase beyond the limits.

2.4.2 Jamaica

Even where scientific information is lacking, it is quite possible to use the same approach as the USA. With inadequate scientific information, a reference point may be more arbitrary, but can nevertheless guide management in planning actions to maintain the fishery in a desirable state. Reference points in this instance are usually empirical - that is they are based on past observations rather than on any theory.

To illustrate the approach, the shrimp fishery in Discovery Bay, Jamaica is used (from FAO 2001). The objective of the assessment was to decide on a precautionary reference point for an empirical CPUE index. The CPUE index is obtained from a small scale sampling programme. The estimate is subject to a great deal of statistical error, but nevertheless indicates the state of the fishery and resource. The hypothetical decision which management has to make was whether to implement a recovery programme or not. A recovery programme would be appropriate if the stock was declining, otherwise no action is necessary for conservation purposes.

The suggested rule was to test the average annual CPUE against the initial three year average (the data collection programme was three years old). This was considered reasonable as the empirical base line representing a state where the stock is not overexploited. The specific decision rule is: if the average annual CPUE of both gears has fallen below x_{RP}% of the base line (i.e. the reference point), then a recovery programme would be instituted, otherwise it would not. The question is what is an appropriate reference point in this sort of system.

There are two kinds of error possible. We may implement the recovery programme when there has been no decline in stock size (Type I error), or alternatively we do not implement the programme when there has been a decline (Type II error). These incorrect decisions may be made because the CPUE is not an exact measure of stock size and includes significant observation error. Both incorrect decisions introduce a cost. When the correct decision is made we assume that there is no cost as this is the best action we could take (i.e. we have no regrets). In the absence of proper costs (for example, no recovery programme has been proposed, so its potential cost is unknown) a relative cost was assumed between the two types of error. If this method was to be applied, these costs would have to be known, and the recovery programme agreed with the fishers. A recovery programme would include reducing catches of shrimp, but might include some form of compensation, for example.

To find the optimal x_{RP}%, the computer was used to simulate CPUE data with statistical errors consistent with those observed in the real data. Different recruitment trends were introduced to represent possible scenarios.

For each random simulation, the management rule was applied by calculating the average CPUE and comparing it to the base line value multiplied by the reference point percentage. If the average annual CPUE was below the reference point, the recovery programme would be implemented. This simulation was done a very large number of times and the costs recorded.

The optimal reference point was found to be approximately 80% of the average annual CPUE assuming a precautionary cost structure. This cost structure in this case tended to favour implementing a recovery programme, with a relative cost ratio (Type II : Type I) of 1.7 (Fig. 2), although results were robust to this assumption. With real cost information, a true optimal point could be found.

The method illustrates an explicit risk assessment based on the data collection programme. It recognises that the data collection system is not perfect (they never are), and that decisions should be based on the relative costs of making the wrong decision. For small scale fisheries, this is an appropriate approach. It has a low cost of implementation, allows management to plan ahead and uses information that has a clear meaning to fishers. Although the analysis above would take a little research, the application of the method only requires using averaged CPUE, estimated directly from trip interview data. Therefore, once the reference point is known, the decision rule is very simple to understand and apply as part of the decision-making process.

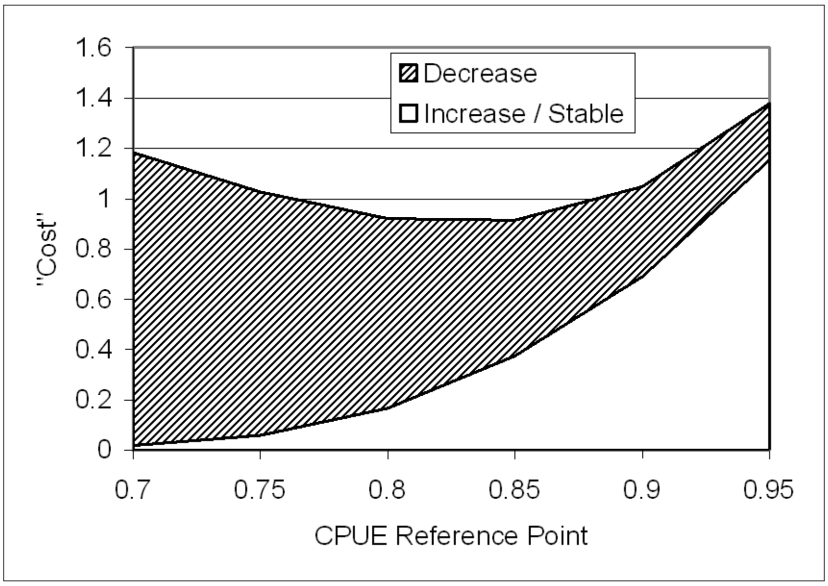

Figure 2 Cumulative two sources of costs from the regret function. The "Decrease" cost is incurred when the population is decreasing but the decrease is not detected by the reference point, so no recovery is implemented. The "Increase / stable" cost is incurred when the reference point method indicates a declining stock when in fact the stock is stable or actually increasing, and an unnecessary recovery programme is implemented. The minimum cost occurs between 80 and 85%.

This system is very dependent on the monitoring of catch per unit effort carried out as part of the continuous data collection programme. It should be noted that CPUEs are more than indicators of just population size. CPUEs are indicative of earnings, profits and economic rent. This makes CPUE or catch rates, interpreted correctly, very useful indicators of the general health of the fishery.

2.5 Recommendations

Based on a review of policy, cost of data collection and consultations between decision-makers and stakeholders, performance indices and reference points need to be developed for the management of resources. This should form the subject of a high-level workshop to agree an approach and initiate the data collection programme.

The performance indices should inexpensive to estimate and simple to calculate. Average CPUE is an obvious choice, and for many of the small-scale fisheries is appropriate. For more highly valued fisheries, such as lobster, indices that are more complex maybe used, perhaps based on size frequencies.

Performance indices should cover the status of the stock and the status of the industry. For this purpose, a minimum of three indices are probably required: CPUE, earnings (or profits) and employment. Whereas CPUE and earnings should be available for each fishery, employment can be calculated overall. Earnings may require information external to the fishery for its reference point (e.g. the opportunity cost for fisher's labour). In the absence of biological information, a reference point for CPUE would probably have to rely on historical data.

3. DATA VARIABLES REQUIRED

3.1 Overview

I assume three performance indices are required. More information may be needed for others, however these represent the basic approaches which may be used to start the monitoring and decision-making process. In particular, at least some fisheries will require biological data collection, and this is covered.

It is important not to overload the system with data. While more data may be collected, it must be born in mind that this involves a cost. Not only will enumerators spend more time, it may be more onerous for the fisher, the encoder, and (less importantly) increase the size of the database. In general, there must be a justification for any data that is collected, but that justification can be scientific research or future monitoring needs.

Some information may well be confidential. For example, fishing location and the quantity caught at different locations most fishers would not like passed on to their competitors. Some negotiation with fishers will be required to make any scheme for voluntarily providing data successful.

3.1.1 Commercial Group Definitions

When landed, the catch is sorted to meet the request from the buyers. The grading of the catch will be dictated primarily by commercial requirements. Hence, commercial groups are related to market demands and often attract different prices.

The commercial groups will also reflect taxonomy. The catch will nearly always be separated at least into fish, lobsters, conch and others.

In the Bahamas, with the exception of the main commercial species, commercial groups are relatively broad. It would be useful to compile a list of species found in the different commercial groups which would aid in identification.

3.1.2 Landings

Landings are estimated through interview and inspection at the landing site, where measurements on numbers and weight of fish can be made. For large catches, this is measured in "kits". Direct measurement of smaller landings weight could be made.

The data most easily accessible for the enumerator is the weight by commercial group and the price per kilogram. Sometimes a commercial group is the same as a species, but in general, the enumerator must take a sample to estimate the species composition of a commercial group. If a commercial group is a size class of one species, the total weight of the species must be calculated from the sum of all size classes.

Catch consists of landings, which means the part of the catch that is actually brought to the land, and discards, that which is dumped at sea. Catch is the variable of primary interest to biologists.

3.1.3 Estimation of Discards from Limited Data

The safest, but also most costly, method for estimating discards is to place observers (enumerators) onboard a representative selection of fishing vessels, and then let the observers record the total catch (landings and discards) and take samples from the discards. The use of observers may have many more objectives than collecting discard data, and in general, they would be required to monitor the fishing operations. Observers onboard the vessel during the fishing trip is only recommended if the vessels are large, and the budget and personnel allows for this expensive activity.

Using research vessels to simulate commercial fishing is a sound approach to collecting samples of detailed data. To what degree experimental fishing should be used is very dependent on the resources available to the data collection programme. Extensive experimental fishing is expensive.

A third simpler but less dependable method to estimate discards is to use a sub-sample of hauls of a trip where the discards are retained for examination. These samples allow CPUE, including discards, to be estimated. However, it is unlikely this can be relied upon in artisanal fisheries.

For artisanal fisheries, where the catches are expected to be small in size, a fisher can be asked to land his entire catch, including discards. This may require the data collection programme to purchase the entire catch, use it to gather biological information, then sell on the commercial fish. This will require a revolving fund, which will need to be topped up regularly.

Discards can be estimated inexpensively through trip interview. The approximate proportion of fish returned to the sea dead can be provided by the fisher. By itself, this information may not be accurate, and should be corroborated by other data. However, as a monitoring index of relative discarding, it may be acceptable.

The information collected can be extrapolated to the entire fleet using either linear models (based on auxiliary information) or assuming an underlying species abundance in the exploited ecosystem (Medley 2001).

3.1.4 Fishing Effort

One of the main aims of fisheries science is to link the mortality of fish with fishing effort. For example, we may wish to find the link between the number of vessel-days of each fleet and the proportion of the stock that was harvested. This not only allows the assessment of the state of the fishery, but can also provide advice on how effort should be controlled to protect the stock.

For a bio-economic analysis, effort is often the link between the biological and economic models. It is related to production through fishing mortality, as well as to variable and fixed costs. Effort expressed as fishing days or days away from port is the most important variable for the bio-economic assessment of fisheries, as the number of active days is often assumed to be related to the variable costs of fishing.

Fishing effort can be measured in many different ways (Table 4). The effort measurement may be selected to fit a specific type of vessel and gear. For example, for a trawler you might use the number of trawling hours, for longlines the “number of hooks per line” and for gill nets the “number of gill nets set per night”. What can actually be used as measure for fishing effort, of course, depends on which data are available from the fishing operations.

The usual standard, and the standard adopted in the Bahamas, is to record effort as days fishing. This is a reasonable approximation for many gears, but passive gears such as traps and condos should ideally record soak time, or at least the numbers of gears checked or hauled. In addition, effort should be separated by the species it is directed at. So, if on a trip, a vessel directs some time to hauling lobster traps and the remaining time using handlines to catch groupers, the two periods need to recorded separately. If, alternatively, the grouper is taken as by-catch in the traps, the effort cannot be separated, but these two possibilities need to be clear in the data.

Table 4 List of possible effort measures, in order of priority according to the ability of measure to provide a relationship between fishing effort and fishing mortality.

FIRST	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
Fishing with FAD Fish Attracting Device, including condos/casitas	Number of hours or days since last fished	Number of hours or days in which FAD (Fishing Attracting Device) is left since it was fished last time if cyclical fishing. For trolling, the number of hours trolling around each FAD and number of lines set.
Beach seines	Number of sets	Number of times the gear has been set or shot, and the number in which a catch was made.
Castnet	Number of casts	Number of times the gear has been cast, and whether or not a catch was made.
Trawls	Number of hours fished	Number of hours during which the trawl was in the water (midwater trawl), or on the bottom (bottom trawl), and fishing.
Gill nets (set or drift)	Number of effort units	Length of nets expressed in 100-metre units multiplied by the number of sets made (= accumulated total length in metres of nets used in a given time period divided by 100).
Gill nets (fixed)	Number of effort units	Length of net expressed in 100-metre units, the number of times the net was cleared and soak time.
Traps (uncovered pound nets)	Number of effort units	Number of days fished and the number of units hauled.
Covered pots and fyke nets	Number of effort units	Number of lifts and the number of units (= total number of units fished in a given time period) and estimated soak time.
Longlines (set or drift)	Numbers of hooks	Number of hooks set and time of setting and hauling.
Pole-and-line	Number of days fished	The number of days fishing (24-hour periods, reckoned from midnight to midnight) including days searching. Similar to purse seine, in that schools are searched for then fished, except no net is set.
Rod-and-reel (recreational)	Number of line-hours	Number of hours during which the lines were in the water times number of lines used.
Troll	Number of line-days	Total number of line hours/days in the given time period.
Surrounding nets (e.g. purse seines)	Number of sets and Searching time	Number of times the gear has been set or shot, and whether or not successful. This measure is appropriate when school is related to stock abundance or sets are made in a random manner. This represents time on the grounds, less time spent shooting net and retrieving the catch etc. This measure is complicated by the use of aircraft spotting as well as by the dissemination of information from vessel to vessel. Ideally, it should include the area searched as well. The measure is appropriate when a set is only made when a school has been located.
Jigs, (hand and mechanical)	Number of line-days	Total number of line days in the given time period.
Other small scale net gears	Number of operations	Number of fishing operations, whether or not a catch was made. These include push net, scoop net, drive-in net etc.
Other small scale stationary gears	Number of hours fished	Number of hours during which the gears were in the water for fishing, whether or not a catch was made. Those gears include guiding barriers, bag net, stow net, portable net, etc.
Harpoons / spears	Number of days fished	The number of days fishing (24-hour periods, reckoned from midnight to midnight) including days during which searching took place without fishing. If more than one spear-fisher operates from a vessel, the numbers of fishers (spears) need to be recorded as well.

SECOND	PRIORITY	
Fishing Gear	**Effort Measure**	**Definition**
Active gears, such as trawls	Number of sets made	Number of times the gear has been set or shot (either in mid-water or to the bottom), whether or not a catch was made
All gears	Number of days fished	The number of days (24-hour period, reckoned from midnight to midnight) on which any fishing took place. For those fisheries in which searching is a substantial part of the fishing operation, days in which searching but no fishing took place should be included in "days fished".

3.2 Biological Information

Biological information is the composition of the catch, including discards. As information about landings is usually easier to obtain than information about the catch, biological information is often based on landings.

3.2.1 Species Composition of Commercial Groups

The starting point for sorting catch into species is usually the commercial group. A commercial group may consist of one or more species. Species will be separated only if the buyers of the landings and their customers appreciate species as different commercial products.

For the scientific definition of stocks, species composition is a minimum requirement, and in practice is often all that might be achieved. A fish stock is a sub-set of a species, so before stocks (or management units) can be identified, the species must be identified.

For low value products, the number of species may be very large. A commercial group “Mixed low value small fish” may contain small specimens of the high value species as well. In any case, the enumerators must take samples from some trips (not necessarily all trips) to record the species composition of the commercial groups.

There is no way manpower and funds will allow for all species to be recorded. The sampling programme must prepare a list of the most important species. Other species found in the species composition samples would then appear as “Other”, although recording the number of species (or “recognisable taxonomic units”) in a sample may prove useful in future assessments. The number of species will depend on the ability of technicians to identify species accurately.

3.2.2 Data Requirements for Fish Stock Assessment

Ideally, three principal types of data are needed, broken down by stock:

- Total catches in weight for each commercial group, fleet and period
- Size and species frequencies within fleet commercial groups, based on sampling.
- Total effort by fleet and by period (for example number of fishing days/month).

Usually, it is not a great problem to collect samples of length frequencies. The funds for buying the samples must be available (although the fish can be sold after measurement), or the fishers/processors may allow measurements without charge. The necessary scientific and technical manpower to collect and analyse the samples must also be available.

Although it may be not possible to get some important types of data, whatever data is available should be obtained for monitoring purposes. For example, if length frequencies cannot be obtained, other types of data, such as catch (in weight) per day, should still be adequate for many types of fisheries assessment.

3.3 Economic Information

Bio-economics is a combination of resource evaluation (i.e. fish stock assessment) and a cost and earnings analysis of the harvesting sector. Ideally, the management and development of fisheries should be based on data and analyses representing all major aspects of the fisheries sector. Thus, biological, economic and sociological information should be collected and processed so the combined output can be used for rational decision-making.

The bio-economic methodology is structured by biological, technical and economic sub-models. The economic sub-model incorporates prices, costs and a range of economic performance criteria. The technical sub-model establishes a physical relationship between fishing effort and fishing mortality, and the biological sub-model describes how the fish population changes. As the exertion of fishing effort incurs costs, and as different species and sizes of fish realise different prices in the market, maximum sustainable yield is not, in most instances, a desirable objective of fishery management from an economic point of view.

3.3.1 Fish Prices

Bio-economics operates with two principal types of prices: ex-vessel prices and wholesale prices. Ex-vessel prices are those received by the fisher/vessel-owner at the landing site. Wholesale prices are those received by the first hand buyer when selling fish to either the domestic or export market. Fish sold for export will earn foreign exchange, which may have additional economic benefit.

Prices are always given by commercial group, and the commercial group is therefore a very important element linking biology to economics. The value of the landings is often a more useful quantity than landings weight as it takes into account changes in price per kilogram between species groups.

Ex-vessels prices are currently collected and for the main commercial species, can be compared with international published prices which are widely available. These variables are currently well covered in the data collection programme.

3.3.2 Costs of Fish Harvesting

There are three different types of harvesting costs, namely

(i) Costs depending on number of fishing effort units
(ii) Costs depending on the number of fishing vessels
(ii) Costs depending on the value of the landings (i.e. ex-vessel value)

The first category of costs is often assumed to be proportional to fishing effort, and is also referred to as “variable costs”. This category of costs comprises elements such as fuel and oil, repairs and maintenance, ice, crew wages (independent of yield in value), etc. Information on these costs can be collected routinely on a "per trip" basis.

The costs that depend on the number of vessels refer to costs that arise even if a vessel does not go out fishing. They are also referred to as "fixed costs" and comprise mainly of maintenance and depreciation of the engine and vessel. For many fishers, they may take the form of loan repayments. Routine data on these types of costs are currently not collected.

Until recently, information was available on imports of duty free fishing gear and equipment. This was a useful indicator of investment in the fishery as well as a measure of a form of subsidy. These data would be particularly useful with a registry, as they could be used to estimate investment and maintenance costs.

The third category consists of those costs that depend on the ex-vessel value of the landings. In fishing, crews are often paid a share of the value of the landings. Although the details of the share system may vary from place to place, usually some variable (effort dependent) costs, such as fuel, are deducted from the ex-vessel value prior to sharing the proceeds between the crew and the owner of the fishing vessel.

The total harvest costs of a particular fleet is obtained as the sum over all three cost categories. Clearly, total harvest costs will not increase linearly with fishing effort because some costs depend on the value of the landings produced by that effort, which changes with the intensity of exploiting the fishery resource. The total costs of the entire harvesting sector are given as the sum of the costs of each fleet.

4. DATA COLLECTION METHODS

4.1 General Principles

It is important to separate scientific data collection from monitoring for enforcement purposes. Where enforcement and science are mixed, the scientific data will be compromised and fishers are less likely to co-operate. However, due to the lack of resources, it is often difficult to separate the two completely.

Data can be collected in more than one way to allow checks on data collection procedures. For example, trip interview data can be compared to logsheets or buyer's forms to find significant differences. However, if there are few errors, this activity may be better directed at collecting new data. Double collection may only be desirable at the start of the programme and thereafter as random infrequent checks on data quality.

4.1.1 The Fishing Trip

An interview at the end of a trip forms the basis for most data collection. In the simplest case, a fishing vessel leaves the port, steams to the fishing grounds, fishes for a while and then steams back to the port where it lands all the catch. Together these events are called a “fishing trip”. The duration of the fishing trip is the time between leaving port and returning to port. This is often referred to as “days away from port” as a 24 hours day is often used as unit for time. For single day or night trips, hours may be a more appropriate measure. The “time fished” (days fishing) is the trip duration minus the time spent steaming to and from the fishing grounds. The duration of the trip and time fished are important variables for many different types of analyses.

The important feature about the “fishing trip” is that it should be possible to allocate catch and fishing effort to a fishing trip unambiguously. In practice, this may not always be easy. For many fishing trips, the allocation of catch and effort is straightforward, but there are also many types of trips that are more complex. Some of the most common deviations include group fishing, where vessels collaborate during the fishing operation, sharing catch and effort, transshipment where vessels offload catch at sea, and occasions when vessels land at multiple landings places. These deviations were not encountered in the Bahamas, but may become apparent as the data collection programme expands.

4.1.2 Fishing Vessels

A ”fishing trip” is carried out by one or more ”fishing vessels”. Thus there is a ”one-to-many relationship” between the vessels and the fishing trips (”for one vessel there are many fishing trips”).

The data about the fishing trip is combined with the data about the fishing vessel when the landings data are processed. For example, a set of trips can be grouped according to which fleet the vessels belong to and the total effort estimated for each fleet separately.

The set of data collected from a fishing trip cannot be processed in isolation, but only in combination with a vessel information. If a vessel register is not available, some other set of data, which can partly replace the vessel register, must be made available. In this case, the 1990 census is only data available, although a register is currently being developed.

4.2 Collection Methods

4.2.1 Vessel Registration

The vessel register is important to fisheries statistics. The creation and maintenance of a vessel register has first priority among the different fisheries data. The vessel register should contain the characteristics of each vessel, such as a unique registration code, the dimensions of the hull and the engine etc. These data have a wide variety of uses including bioeconomic and stock assessment analysis and the control of fishing activities.

It is of utmost importance that the vessel registration codes are unique, so no two vessels have the same code. Each administrative centre must have a unique code forming part of the registration code.

Vessel registration appears to be a significant problem in the Bahamas. The simplest solution would appear to be to extend fishing vessel to vessels under 20 feet. That is, all vessels that intend to fish must register with the Fisheries Department. This will require changes to legislation and general support from politicians. A computerised register of all fishing vessels would help enormously with data collection and enforcement.

4.2.2 Fisheries Census

The vessel codes in each fleet can easily be extracted from a vessel register at any time. If the vessel register is updated with a short time lag, the number of vessels by fleet can be calculated precisely. If a complete vessel register is not available, an alternative way of counting the number of vessels in each fleet is required.

A census or frame survey is an inventory list of fishing units at a specific time, sometimes combined with an indication of their activity levels (e.g. the number of active fishing days per month). A census is usually a complete enumeration as far as the number of units is concerned, whereas the activity data are often sampled.

The frame survey should be updated every fishing season or within some other time unit which forms the basis for raising samples to total landings. A full frame survey can be repeated less often, every five years or so. This suggests an update on the 1995 census is required unless a registration system is implemented.

4.2.3 The Trip Interview at the Landing Place

To collect information about the fishing-trip the crew of the vessel and/or the buyer are interviewed at the time of landing. The data in question are catch and effort and fishing trip details. Data on vessel details may also be collected if a dependable vessel register is not available.

The different types of data to be collected are indicated in Table 5, which gives a complete set of "trip-data". The complete set of "trip-data" is, however, not common. Most often only a sub-set of the data will be collected.

The fishers or the buyers will nearly always sort the catch into commercial species and size groups. The species and size groups are determined by the market prices and the appearance (size, quality etc.) of the species in the commercial groups.

Within a commercial species group, the species composition may then be sampled. Sometimes a commercial group (in particular in the case of valuable product for export) will comprise only one species, or even only a size group of one species. Expensive species like groupers may be gathered into small, medium and large grouper categories, and sometimes by species. This sorting may be carried out in the processing plant. However, the most common case is that the commercial group comprises two or more species. If the species composition is required, it is necessary to buy or otherwise obtain a sample, and then separate it into species.

The ultimate level of detail collected is the length frequency samples and/or other biological data. These samples will be the same as the samples taken for species composition, or sub-samples of the species composition samples.

Sometimes the fishers will be able to give information on the amounts discarded and they may also be able to tell the composition (species and size groups) of the discards.

While collecting landings data, the enumerator should also collect information on the gear, the effort and the fishing grounds. Two types of data related to effort can be collected:

1. **Effort**: for example, number of fishing hours or traps pulled
2. **Activity level**: Past fishing effort, for example the number of days spent fishing over the previous month.

The most basic effort data you can collect is the number of days away from port. If possible, the number of fishing days will also be recorded. Often this will be the only effort data available.

Table 5 The principal data types that should be recorded during a trip interview.

Sample information	Date of sampling Enumerator
Vessel information:	Vessel registration number Gear details
Effort and activity:	Days away from port, days fishing, additional detailed effort data
Spatial information:	Fishing grounds Landing place
Information on total landings:	Weight by commercial group Price per kg by commercial group
Discard information:	Percent discarded
Within commercial group samples:	Sample species composition from selected commercial groups Weight (number) by species
Within species, length frequencies samples:	Sample for length frequencies (and other biological measurements) for selected species Number of specimens by length class
Purchaser:	Processing plant purchasing Landings not purchased by processing plants

Effort data is currently not recorded adequately. The number of days fishing is a poor index of population size or fishing mortality for passive gears such as traps or condos. In addition, where several species are targeted on a trip, the effort directed at each species needs to be recorded separately. For long trips, this will not be easy to achieve through trip interviews and some other method, such as logbooks, needs to be considered.

The current trip interview lacks information related to the gear (such as soak time) and does not separate effort with the target species where more than one species is targeted on a trip. This makes it impossible to use the current measure of effort for many analyses.

Trip interviews should target smaller vessels, and data collected should be in a form that can attempt to estimate the landings which do not pass through processing plants. This would be a more directed landings estimation programme than currently conducted.

4.2.4 Vessel Log Books

Logbooks contain the essential fishing trip information, such as start and end date, fishing grounds, gear used, catch and landings etc. Each trip is recorded in the logbook on one or more pages. This sort of scheme is only applicable to larger vessels. For example, most large lobster vessels probably already keep their own logs, and may be amenable to such a scheme.

The compulsory logbook / sales slip system, is the ideal system from the data collector's point of view, as it allows for complete enumeration. However, logbooks and sales slips do not automatically imply a very high quality of data. Compulsory filling in of logbooks and sales slips needs to be combined with strict enforcement of fisheries regulations.

Logbook systems do not have to have 100% cover. However, if only a proportion of the fleet fill in these forms voluntarily, the data may be biased. The willingness of fishers and buyers to complete forms is self selecting and not random. To guard against potential bias, at least some data needs to be compulsory and fully enumerated or some forced sampling needs to be conducted. For example, those who do not co-operate could be required to have observers aboard their vessels, or subject to landings inspections. However, combined with trip interview data, even a co-operative logbook scheme is likely to be valuable.

With logsheets, a significant problem may be the quantity of data provided. Data entry to a database may become expensive. This may be reduced using a sampling programme rather than enter all data. It may also be cheaper to provide computers to the data supplier (robust laptop / palmtop) rather than employ large numbers of data encoder, although this may require more training for fishers.

4.2.5 Data From Processing Plants

Processing plants may hold data records for monitoring their own commercial activities. These records may also have other uses and be an inexpensive source of information for data collection programmes. In particular, processing plants may grade fish by size, which will be particularly important for shrimp. With co-operation from the processors, this is an inexpensive source of information. Where possible, additional information linking processed landings to individual vessels, and the sex and size composition within categories, should be collected. However, the processor interviewed did not keep records, but appeared willing to provide information if provided with forms.

Landings data from processing plants appear to be high quality, but do not cover all landings. The processing plant purchase report includes the date, product quantity, price and vessel from which the landings were bought. With HACCP requirements, processors may maintain trip landings separately in the processing facilities. It may be possible further biological sampling in processing plants to individual trips, making this type of sampling very efficient.

Processors also report exports in boxes of lobster tails graded by size. These data are currently not used, but do contain useful size composition information on the lobster stock. If they can be linked to purchases from vessels, they would form a very useful addition to biological sampling reducing the amount of sampling that needs be undertaken.

4.2.6 Data From Other Sources

Other types of data from the fisheries sector, which are not specific to fisheries only, are kept in databases outside the area of responsibility of the Fisheries Department. The types of potential data are very wide, and these information are peripheral to the immediate aims. Nevertheless, it is very valuable to review all data that might be available in monitoring the fishery performance at very little extra cost to the department. The following is an indication of the types of data which may prove useful.

a) **Demographic** data: human parameters of the fishing communities, e.g. statistics and details of fisher families. These data are often available from other departments, and include data such as the National Census.

b) **Infra structure** data: roads, housing, transport, ports, processing plants etc. If a Geographical Information System project exists, it is often very easy to incorporate landing sites and mooring facilities to produce maps containing this information.
c) **Institutional and Community** data: laws, regulations, inspection and enforcement of fisheries, education, taxation and subsidies, loan providers. Institutional data outside Government sources may be difficult to obtain. It should form part of the development of the fishing co-operatives to maintain relevant data bases on their own activities.
d) **Import / export** data: quantities and qualities of imported/exported marine products. The customs department should monitor exports and imports.
e) **Household** data: this is the sociological information on the fisher families, such as number of family members, their age, education, occupation, income, houses and installations in houses, ethnic background, religion etc. This should be available from national census data, but the Fisheries Department may need to ensure relevant questions are included (such as whether the family has individuals who are full or part time fishers).
f) **Meteorological and geographical** data: these data may be used for definitions of fishing grounds and seasons and to estimate environmental effects that drive the stock dynamics or limit fisheries.

Current fish consumption, by Bahamian residents and tourists, is unknown. A survey of fish consumption along with its substitutes (chicken, beef, goat etc) could be undertaken for a sample of households. The survey should ask how much of each food type is consumed on average in each week. This type of census should allow an estimate of total fish consumption broken down by type (grouper, conch, crawfish) and demographic and social category (e.g. by island, household size, income etc.).

The Ports Authority could be used to collect vessel register information. However, it may be considered unreasonable to expect them to collect any specialist fisheries information, and therefore the Fisheries Department ideally should be responsible for registering fisheries vessels, although they should liase with the Ports Authority. All vessels that intend to do any fishing should be registered.

4.3 Data Collection Forms

Some thought should be given to the design of data entry forms. They should be as simple as possible, but cover a wide variety of vessel and landing types. They should also be flexible, and enumerators should be encouraged to record any extra information they think is important.

In general, the layout and structure of the paper forms should reflect the layout and structure of the database forms, which are used for data entry. This makes data entry much easier and clearer.

Forms often make up a hierarchy. For enumerators recording data at a landing site, for each vessel observed there should always be a trip interview form. Other forms, such as those for recording biological data, may also be filled in. These forms, however, must be linked so that the information can be combined for particular types of analysis.

All data forms should have certain attributes in common:

Sample Number: This links forms together and links to any samples collected at that time. So for example, a trip interview form should be linked to any biological sampling forms taken from the same vessel at that time. Sample numbers are unique, and often made up of the date, a code for the enumerator and a sample sequence number.

Date, location of sampling (landing place): This identifies the sampling and is critical for interpreting samples.

Comments: There may occur various unexpected observations, which do fit into the specific fields, and this information may be entered in the “comment-boxes”.

Lists: Whenever possible, the fields are filled in by selecting an item from a list. This is not only clearer, but will link with the database system. For a large number of possibilities, codes may be used to indicate the appropriate choice.

In the following sections, the variables already collected are marked with an asterisk (*).

4.3.1 Vessel Activity

The primary aim of the form recording the vessel activity at a site is to ascertain the number of vessels which are active that day (i.e. have gone out fishing) and the number that have not, but have remained in port. This is particularly important if an interview is not made on all trips. Data should include the number of vessels that:

- are based at this site
- out for a one day trip (i.e. must land that day)
- out for more than one day (i.e. may not land that day)
- were sampled (i.e. for which a trip interview form was completed).

4.3.2 Trip

Most of these data are currently collected. For the trip interview form, the basic information should be (see also Table 6):

Vessel registration number: Once registration is complete for the fleet, the vessel registration number should be sufficient to get all the vessel details, although the possibility of validating and updating information may be provided.

***Gear**: The form should allow entry of several different gears with their characteristics (e.g. mesh size for nets).

***Fishing grounds**: Name of fishing grounds as reported by the fishers which might be linked to known areas marked on a map defined in terms of statistical rectangles.

***Landings**: The total quantity of fish being landed in weight by commercial group. Additional information may be required if the catches are processed at sea.

Discards: The total quantity of fish discarded. This is an estimate by the fisher and is likely to be inaccurate for larger quantities of discards. It could be provided as a percentage of the catch.

***Effort**: Effort information requested may depend on the gear used. However, all vessels should be asked for the number of days (or hours) fishing as this forms a shared measure between fleets and gears and is useful for estimating variable costs. Dates and times of departure and arrival at port and fishing grounds are recommended. Not only do they provide this information, but also allow analyses to consider time of day, moon phase and other factors that may affect catches.

However, more information is needed to estimate effort for some other gears, as discussed above.

Table 6 Example basic data form structure for vessel interviews (from MEP 1999). Example fictitious data is in italics. Note that in this format no calculated information is required (such as sea days or landed value as this calculated by the database. In all cases, the units of measure are written. In many cases, such detail on effort will be unavailable, in which case days fishing should be used by default. The data form should always include a section so that the data enumerator has the option of recording anything worthy of note, like a new gear which was tried and hasn't yet been recorded.

Departure Date: *23 Jan 98*	Arrival Date: *12 Feb 98*			Landing site: *Nassau*	
Captain name: *Joe Gascoigne*	Vessel name: *Holly's Folly*			Licence number: *NA*	
Days fishing: *15*	Fishing ground: *S. Andros*				
Number of crew: *10*	Number of crew actively fishing at any one time (if diving): *5*			Number of dinghies: *5*	
Number of species caught:					
Species	**Weight Landed**	**Effort**	**Gear**	**Price (B$)**	**By-catch**
Frozen crawfish tails	*1150lbs*	*5 days*	*Spear*	*5.50*	
Frozen crawfish tails	*1400lbs*	*100 condos 5 days*	*Hook*	*5.50*	
Conch fresh	*1560lbs*	*5 days*	*Dive*	*2.00*	
Nassau Grouper	*3 Kts*	*10 days*	*Spear*	*2.50*	*Yes*
Other Reef fish	*5 Kts*	*10 days*	*Spear*	*1.50*	*Yes*
Notes: *10 new condos deployed on this trip.*					

4.3.3 Species and Length Composition of a Commercial Group

The sample of the commercial group should reflect the composition. There are a number of ways of doing this, depending upon the logistics. A common technique is to randomly select boxes of fish within the commercial groups and identify the species and weigh or count them. For example, this may be easiest to do in processing plant after tails have been graded. The grading works as a stratification, so the size, sex and maturity composition within the grades only is required. As long as the total landing in number of boxes of each grade is known, the catch size composition can be worked out very accurately.

At the dockside, logistics are more complicated. While random sampling is desirable, the important issue is to avoid non-random selection that will lead to biases in species or size composition information (for example, selecting larger specimens only). Where the catch is small, all the landings should be included (i.e. complete enumeration).

It is usually assumed that these data are collected at the dockside. There is no strong reason for this, although it is valuable to be able to link the catch composition to a particular trip. These data are based on the processed product and are related to the tail size. However, it may be able to relate these data to particular vessels and trips due to HACCP which requires that product is monitored from catching through to the consumer to ensure quality. The same paper trail may be usable for linking biological data to landings data. Although there is currently no routine biological data collection, projects with the University of Miami have collection sex and size frequencies of conch and spiny lobster from within processing plants.

The following data variables should be recorded for each trip if possible (note that some may not be possible to record all in the processing plant).

Number of species: The total number of species identified within the commercial group.

Sample weight: The total weight of the all specimens identified of each species.

Then of the sample, for each fish measured the following should be recorded:

Species name: The “Species name” should be a code selected from a look-up table, which reflects a full taxonomic (scientific) classification of the species.

Sex and maturity: For some species, this is very difficult without considerable laboratory work. Other species are simple to measure. Where the cost of measurement is high, only a small sample should be taken and returned to the laboratory for inspection. This sample must be random.

Length and Weight: Standard length measurements are usually straightforward to obtain. These should be standardised by species (e.g. fork length for finfish) and use consistent units. Some additional non-routine sampling may be useful to build morphometric models to convert between measures (e.g. length weight relationship).

4.3.4 Variable Costs & Earnings Per Trip

These data are closely related to the other trip interview data, but they are largely used for a different purpose. They could be collected in addition to other trip data. Currently no cost data is collected routinely.

A time budget: The time of leaving port and arriving at the fishing grounds, and the time leaving the fishing grounds and arrival at port, and other times steaming between fishing grounds. These data are often collected as part of the effort data.

Expected trip duration: This can be compared to the actual trip duration and deviations may indicate unfavourable conditions for fishing.

Ice used: The quantity of ice used during the trip.

Target species group: The expected main catch composition, species (size group of a species) or species group.

Price by commercial group: The price received for the landings broken down. Fish that is not sold should also be recorded. For example, some low value fish may be retained by the crew for their own families.

Buyer: The name of the buyer (merchant, processing plant, exporter etc.)

Damage/loss (estimate): For example, estimated value of lost or damaged gear, damage of engine etc.

Some variable costs depend on the effort (time fishing). Other trip related variable costs depend on the weight or value of the landings.

Ice: Cost of ice used during the fishing trip (e.g. amount used and price per litre).

Fuel and Lubrication: Cost of fuel (oil or gasoline) and lubrication used during the fishing trip (e.g. amount used and price per litre).

Water: Cost of water used during the fishing trip (e.g. amount used and price per litre).

Food: Cost of food consumed by the crew during the fishing trip.

Bait: Cost of bait used during the fishing trip (e.g. amount used and price per kilo).

In many cases, the crew will receive a share of the value of the landings. The method of allocation and amount allocated to each share should be recorded.

Total value of landings minus cost deductions

Divisible earnings: The amount to be shared by crew and vessel.

Shares: The percentage or amounts of the divisible earnings allocated to each stakeholder. In general, the share is split between the vessel owner, the skipper and the crew.

4.3.5 Logsheets

Logsheets should probably include fields for the date, weather and location as well as catch. Where logsheets cover a mothership operation, individual dinghies will visit separate groups of condominiums or shoals (see Table 7). These need to be recorded. It is likely that different shoals and condos have different catchabilities, which will confuse their use in assessments. However, in general they should be treated like traps. The numbers of shoals or condos and date of last visit should be recorded. The following

A precedent for data collection from sports fishers should be established. As for the semi-industrial fleets, sports fishing vessels could be required to keep log-sheets. By their very nature, however, they catch fewer fish but tend to target larger fish and particular species. The quantity of data they produce may be large and it is difficult to see how the Fisheries Department could manage this additional work with current resources. Monitoring sports fishing, while important, is less important than monitoring commercial fisheries.

Table 7 Example logsheet data form structure for mothership vessels (from MEP 1999). Example fictitious data is in italics. Note the similarities between log sheet and the trip interview data sheet. The two should, as far as possible, record the same types of data. The logsheet form should be finalised in consultation with fishers. Note the use of codes (which should be clearly defined) to ease filling in the form.

Departure Date: *23 Jan 98* Departure Port: *Nassau*	Arrival Date: *12 Feb 98* Arrival Port: *Nassau*	
Captain name: *Joe Gascoigne*	Vessel name: *Holly's Folly*	Licence number: *NA*
Days fishing: *15*	Fishing ground: S. Andros	
Number of crew: *10*	Number of crew actively fishing at any one time (if diving): *5*	Number of dinghies: *5*

Date	Time		Lat/Long	Species	Catch Weight	Men fishing	Con-dos	Gear	By-cat-ch
	Out	Back							
24 Jan 98			*STEAMING TO GROUNDS*						
25 Jan 98	*0700*	*1600*	*23°45' 74°50'*	*CT*	*350lbs*	*10 men*	*22*	*HK/FD*	
25 Jan 98	*0700*	*1600*	*"*	*RF*	*20lbs*	*10 men*	*22*	*SP*	*Y*
25 Jan 98	*1600*	*1700*	*"*	*NG*	*40lbs*	*2 men*		*FD*	
26 Jan 98	*0600*	*1200*	*23°45' 74°30'*	*CO*	*160lbs*	*8 men*		*FD*	
27 Jan 98			*DEPLOYING 10 CONDOS*						
28 Jan 98	*0700*	*1700*	*23°40' 74°30'*	*CT*	*400lbs*	*10 men*	*24*	*HK/CO*	
Notes:									

4.3.6 Vessel Registration

The vessel register should be considered a part of the fisheries statistics, and should cover all fishing boats. Currently only vessels over 20 feet in length are registered. There is a general field on the registration form requiring a description of the vessel. More specific fields recording vessel hull, dimensions, engine power, freezer capacity and so on would be better as it standardises the information recorded.

The Port Authority should register all vessels over 10 feet in length, but there appears to have been some confusion over whose responsibility these smaller vessels are. Therefore it is likely most small fishing vessels are currently unregistered. The general vessel registration includes hull construction, year built and engine power which are not included on the fisheries registration form, but would be useful.

The following presents a list of variables that should be considered. Variables marked with an asterisk (*) are currently collected on the Fisheries Department registration form.

***Owners name and address**: Full name and address of the primary owner.

***Home port**: Port of registration.

Association: Membership of fishers co-operative, if applicable.

Credit scheme: Financing body (moneylender) of the vessel.

***Vessel registration number**: The unique vessel registration code. No two vessels should have the same vessel registration code.

Radio call sign: Radio call sign used to uniquely identify a vessel.

***Name of vessel**: The name of vessel painted on the vessel.

Type of registration: Fishing vessel (full time/part time/foreign/recreational etc.)

Main fishing grounds and species: The intended main fishing grounds and target species.

***Main Gear**: Types of gear fitted or available.

Construction material: Wood, steel, glass fibre, cement etc.

Year vessel built: The year the vessel was delivered from the shipyard.

First year of fishing: The year the vessel started to fish and land the catch.

Propulsion data: Method of propulsion, information on all engines, such as engine make, age, and horsepower

***Crew number**: The average number of crew on an average fishing trip.

Registered length for regulation purposes (m), Maximum length (m), Overall length (m), Breadth (m), Depth (m), Gross tonnage, **Net tonnage, Hold capacity**

Remarks by the Registration Authority: Any additional information relevant for the vessel registration.

Additional linking information may be required if the vessel changes hands. In this case, the vessel must be re-registered.

Preceding vessel registration number: The former vessel registration code/number and name of vessel as given in the registration box.

Date of change of ownership and new registration: The dates when the vessel changed hands.

The vessel at some point will be scrapped. It is very important that the register maintains a list of active vessels and that this list is kept up to date. In addition, the effective life of a vessel is valuable for calculating depreciation.

Date and reason for termination: The reason may be scrapping of vessel due to old age, decommission, capsize, sale of vessel for non-fishing purpose, etc.

Economic data may be collected at registration. However, much of these data may be sensitive and may require a separate sampling programme to obtain an unbiased estimate.

Insurance: larger vessels might be insured against loss or damage

Loan structure and repayments: Loans for the purchase of vessel, engine and gear may be structure in different ways, but include capital repayment and interest.

Vessel, engine and gear purchase cost: Vessel and/or gear may be purchased outright.

Fixed refit and maintenance costs: The vessel, engine and gear may regular servicing or replacing even if not used.

4.4 Codes

Despite the development of computers, codes are still useful for recording information. There are a number of reasons for this. Codes act as shorthand replacing complex descriptions, and can speed up data entry once enumerators become familiar with them. They are also often more stable than names and descriptions. For example, scientific names for species may be subject to changes by taxonomists. Codes avoid linguistic problems and aid international data exchange. They also lend themselves to the use of look-up tables in databases, which prevents many data-entry errors.

National codes may be required for the biological species, commercial group, landing site and so on. A number code already exists for the landings sites. Where possible, codes should be clear in their meaning. For example, the vessel registration code could start with two letters indicating the island where the vessel is based (e.g. NP for New Providence).

Commercial groups may be very different to taxonomic groups and coding commercial groups may therefore prove useful. In classifying groups, three aspects may need to be considered, the type (species), size and treatment or quality. The code may include quality grade (e.g. freshness) and processing (e.g. fresh, iced, salted, dried and "for export").

A code system used for international exchange of data needs to meet standards different from those of a national code system. This may need to be considered if a regional database system is established. International codes for species and gear types exist, and may avoid the need to develop local codes. Often, however, due to the complexities of fisheries and ecosystems, such codes are never quite appropriate and a national code system is deemed more appropriate.

The CFRAMP database system, TIP/LRS, already contains coding consistent with the systems used in the USA. Where relevant, it is recommended these are used unless they cannot fit local data.

4.5 Recommendations

For larger vessels, a logsheet programme should be implemented, where vessels are required to complete and return logsheets at the end of each trip, usually for trips longer than one day. The logsheets should contain daily records of the vessels activity and catch. However, this requires co-operation from the vessel captains.

On trip interviews, effort data needs to be recorded differently. Effort needs to be recorded separately by target species and gear used. Also, for some gears, specific types of effort need to be recorded. For passive gears, such as traps and condos, the date when the gear was last hauled or fished would be ideal as the soak time could be recorded. Otherwise the number of gears checked or hauled should be recorded. Note for spiny lobster, this would include the number of shoals checked.

Biological sampling in the processing plants is probably the easiest and most efficient way to monitor biological variables of the main commercial species. If biological samples lobsters could be taken and linked on a database to logsheets reported from vessels and export reports of graded tails, data obtained from a trip would be complete. This would allow very high quality analysis and monitoring.

5. SAMPLING

5.1 Overview

It is important that a standard random sampling scheme is adopted. Without random sampling, there is no objective way to interpret the information collected. This can lead to very poor estimates of the state of the fishery and hence poor decision making. It is important that all staff in the data collection system understand the principles of sampling and the way it is done.

Sampling schemes for the trip interview should revolve around landing sites. For example, a particular island may possess 20 sites where fish are landed, but only 2 enumerators. An enumerator can only visit one site on any one day, so enumerators should be allocated randomly to the sites. They then record either all landings or a sample of landings at that site on that day.

As well as trip interview sampling, it is possible to sample for logsheets. In this case, a random selection of vessels are requested to maintain a record of their daily activities on a trip. The random sample should be taken from the vessel register (vessels over 20 feet) or a subset of these vessels. Sampling is not usual for logsheet based data collection, which generally assume complete enumeration, but offers a number of advantages. Less resources are required to implement the system, it is less onerous for fishers and the system may still work where completion of logsheets is voluntary.

The following sampling regime concentrates on estimating catch and effort. It should cope with all other data variables, which might be required. For example, the three stage design for trip interview below includes biological data collection. However, in some cases additional sampling may be required, although it should follow the same framework.

5.2 Stratification

5.2.1 Island Stratum

The appropriate administrative and logistic stratum will be to divide the sampling among islands. This will not improve estimates, but will be necessary to administer the data collection programmes. The allocation of sampling effort should primarily be related to the quantity of landings and effort in each island. The nearest variable related to this in the census is the number of vessels (Table 8). Without taking into account sampling costs, the optimal allocation is simply proportional to the number of active vessels in each island. If we assume that a fixed number of sites can be sampled in each island, the number of vessels landing at each site can be used to give a cost of sampling each vessel. Further improvements in the optimal allocation of sampling can be obtained with better sampling cost data (e.g. costs of visits to the islands) and with an indication of the variability of catch and effort among islands.

Table 8 Recommended strata and enumerator allocation based on number of non-sports boats recorded in the 1995 census (see Thompson 1992, p107). The basic sampling allocation is proportional to the number of vessels operating from each island, which should be related to the number of landings. However, the cost of sampling a vessels, related to the number of vessels per site, can also be taken into account, which results in a slight revision to the optimal allocation. Note that vessels are not divided into size categories.

Island	Vessels	Basic	Cost
Abaco	468	18.03%	15.93%
Andros (North)	210	8.09%	6.92%
Andros (South)	182	7.01%	6.34%
Bimini	43	1.66%	1.87%
Cat Island	49	1.89%	0.99%
Eleuthera	324	12.49%	15.61%
Exuma	82	3.16%	1.97%
Grand Bahama	332	12.79%	12.65%
Long Island	207	7.98%	7.36%
New Providence	492	18.96%	24.19%
Acklins and Crooked Islands	80	3.08%	1.70%
Berry Islands	23	0.89%	0.94%
Inagua	31	1.19%	0.71%
Mayaguana	27	1.04%	1.46%
Ragged Island	35	1.35%	1.18%
San Salvador	10	0.39%	0.19%

5.2.2 Vessel Stratum

Larger vessels will tend to go out for trips longer than one day and land to processing plants. This suggests these vessels should be treated differently to the smaller vessels. If possible, they should be required to complete logsheets to provide daily monitoring data. As vessels over 20 feet are registered, these form a natural large vessel group.

The stratum will probably break the fleet into three parts:

- Large vessels which agree to complete logsheets. These vessels may require some incentive to take part in the programme.
- Large vessel which do not agree to complete logsheets. If these are not known before sampling begins, they will form a stratum after sampling is complete. However, even if they do not agree to complete logsheets, some information on them must be obtained for comparison with vessels that do. This means they may form a particular group sampled using trip interviews.
- All other vessels. These would be mostly small, artisanal vessels that would not be able to maintain a log. These vessels would be the subject of trip interview sampling.

Further vessel classification may result from analysis of the 1995 census (which was not possible for this report) and from data collected.

5.3 Trip Interview

The main aims of the trip interview will be to estimate the catch (particularly landings not going through the processing plants) and to estimate the fishing effort for all vessels. Note that it is likely to be more convenient, with industry co-operation, to do as much sampling in the processing plant and through a logsheet programme than through trip interviews and sampling at the dock side. Thus the trip interview programme should particularly target smaller vessels not landing to the processing plants.

5.3.1 Three Stage Design

If sampling is carried on at different levels, they are referred to as stages. For example, landing sites may be sampled and then vessels landing at each site may also be sampled.

Stage 1: Landing Site

In many cases, this will be a visit of an enumerator to one landings site each day. If there are as many landing sites as enumerators, this stage will be fully covered and its contribution to the variance of estimates will be zero. Otherwise, on each day, a random site is chosen and allocated to each enumerator. In addition, enumerators may cover more than one landing site in a day. This would decrease the effective number of landing sites.

Stage 2: Vessel landings

If an enumerator stays all day and vessels land singly, then an enumerator may be able to cover all vessels, recording their catch and effort. However, if vessels land in groups or the enumerator is only able to stay for part of the day, a number of landings may be missed. A significant problem is that it may not be feasible to obtain a clear random sample, and any estimates assuming the sample is random may be biased. If more than one site is to be covered, the day could be split into segments, and each segment allocated at random to the sites. Some care must be taken in the design of this to prevent bias.

Stage 3: Biological Sampling

Biological sampling includes identifying species, and measuring size, sex and maturity of a random sample from the catch. This is a time consuming operation and therefore would require an additional team, including a biologist, besides the main enumerator. Of the sample for which trip interviews have been conducted, a smaller set of random trips are selected and measurements are taken from the catch. The catch itself may be sampled if it is large. Such sampling is best conducted by stratifying by commercial group. Again, obtaining random samples may be difficult due to logistics, but every attempt should be made to take individual fish at random.

Note that sampling is not necessary at each stage on every occasion. In many circumstances, total enumeration may be possible and is often desirable. If there is no extra cost in total enumeration, there is no point in sampling. For example, if the enumerator visits a site where only a few vessels land, the enumerator should monitor all landings.

If more than one site can be visited in a day, as in New Providence, it will be important to record vessel activity. This is, in essence, the number of vessels which land at a site on that day. The number of vessels subject to a trip interview will be a proportion of this.

5.3.2 Within Strata Sampling

The usual approach to estimating total catches (and other variables) from sampled data is to raise the sample using variables that have been accurately censused. For example, with a vessel register we may multiply the average landings per vessel by the number of vessels at sites not sampled to obtain their expected landings. This requires accurate census or registration data not available in the Bahamas. The option suggested here is to base sampling on landing sites.

Although strata will account for some variance in the data, there will be considerable variation within strata between sites, which must be covered by random sampling. There are two options:

Simple random sampling without replacement. This is simple to organise and implement. The estimates of the mean and variance are simple to calculate. On any day, all sites have an equal chance of selected, and available enumerators are allocated each to one site on each day.

Unequal probability sampling without replacement. In the same way we can allocate greater sampling effort to the most important sites by making them more likely to be selected in the random sampling process. On any day, sites have a chance of being selected which is proportional to their importance, and available enumerators are allocated at random each to one site on each day. Although the method is a much more efficient design to simple random sampling (Table 9), estimates are complicated to calculate and impossible for large strata. Software has been provided for the strata defined (see "BahamasSamplingEstimation.xls").

Table 9 Simulated sampling of eight sites in a district of the Dominican Republic illustrating the superiority of the unequal probability design. Both the estimated standard deviation (SD) and the Root Mean Square Error (Root MSE) are lower for the unequal probability design for exactly the same sampling effort. This method would result in greater confidence in analysis of the data and hence probably allow higher levels of harvesting under the precautionary approach.

Summary Table

	Total	**Variance**	**SD**	**MSE**	**Root MSE[1]**
Unequal Probability	5896	8352	91	11605	108
Random	5908	155373	394	165641	407

[1]Root MSE is the square root of the sum of squared differences between the estimated and true value of the variable being measured. It provides an absolute measure of the performance of the sampling method with a lower value

Given the much better performance of the unequal probability design, it is the preferred option. However, the method is more complicated, particularly the estimation, and although software has been provided, some training would be necessary in its use. Despite this complexity, it is still recommended that the unequal probability design is used as it makes better use of the sampling effort. In these data collection programmes, most of the work (and cost) goes into collecting the data, while the estimation, with suitable software, takes little time and effort. On the other hand, more important than efficiency is the sustainability of the data collection programme. If a more complex design would jeopardise this, then the simple random sampling approach should be adopted.

Table 10 Summary of the strengths and weaknesses of the two within-strata sampling approaches.

	Strength	Weakness
Unequal Probability	Much more efficient for a fixed sampling effort	Calculations are more complex
	Makes intuitive sense to spend more time at most important sites.	Probabilities need to be proportional to variable of interest.
	Sampling and estimation can be automated using the computer	
Simple Random Sampling	Simple to implement and estimate values of interest	Relatively inefficient, so it is effectively more costly

5.3.3 Sampling Logistics

Often logistics and random sampling designs are in conflict. For example, although ideally fish should be selected at random within each commercial class so that the sample will represent the size and species composition of landings, in practice this is not possible. What may be possible is to select boxes or kits in a random sequence or use some other system to avoid bias. For example, count a random number (between 0 and 9) of boxes being removed from the fish hold before selecting a box to measure its contents, thereby measuring approximately 10% of the catch. However, even this might not be possible, depending on how vessels are offloaded of their catch. The only way to develop a practical approach is through negotiation between enumerators and statisticians. Through discussions, both should appreciate the others point of view and a compromise should be reached. Note that sampling in processing plants is likely to be much easier and is the preferred option for commercial species such as lobster.

It is usual for sampling programmes to undergo revision as always problems will be encountered and need to be resolved after the programme has started. Typically, these are related to the practicalities of data collection.

5.4 Logsheets

Usually where fishers are required to complete data sheets, complete enumeration is assumed. However, this may not always be necessary or possible. For example, the volume of data may be too great for the available resources or not all vessel captains co-operate. With a complete register, a sample of vessels could be selected and requested to maintain a log for a trip, month or year as appropriate. The data can be treated as a statistical sample for estimation purposes.

How the logsheets should be allocated to fishers would require consultation. It may be easier to use complete enumeration. If a vessel skipper agrees to complete logsheets, they may prefer to do it for every trip. Alternatively, they should have the option of doing it on only a proportion of trips. Note however, in almost all large-vessel fisheries maintaining logbooks is required and accepted, and the Bahamas is an unusual case. This should be brought to the fishers' attention.

If sampling is based upon voluntary provision of data, it will be necessary to deal with refusal to provide data. This can be dealt with using post-stratification, where the sample is stratified, once the data has been collected, into compliant and non-compliant vessels. The non-compliant stratum must be re-sampled in some way to obtain information, which may be compared with the compliant vessels. For example, if a number of vessels refuse to complete logsheets, a few could be chosen at random to take aboard observers to monitor their operations. This would allow a measurement of any bias there may be in the refusal to co-operate. It is important to note that some observations must be obtained on non-compliant vessels.

5.5 Recommendations

If a significant sampling programme, including biological data, is to be developed, more staff will probably have to be employed. Using sampling, numbers of staff can be kept to a minimum. Currently not all islands are covered, and it is likely more sampling effort would be required in the family islands. A decision on the amount of sampling necessary should come from a review of the data collection objectives.

It is recommended that the stratification including costs and gear variance is used in the first instance (Table 8). Once two years data has been obtained, the situation should be reviewed and optimal allocation recalculated based on real observed variance and costs. Sampling can then be redistributed to optimise data collection subject to logistical constraints.

The unequal probability design should be used to sample landing sites. This will allow robust estimates of total landings and average CPUE without a vessel register or up-to-date frame survey. It will be possible to incorporate auxiliary information from the vessel register and elsewhere in the future.

At least initially, logsheets should be allocated randomly as a sample and apply only to voluntary vessels. Trip interview methods should be applied to non-compliant vessels and "other" vessels as separate strata.

If possible, most biological sampling should take place in processing plants. This should incur much lower costs than attempting to sample at the dockside. For vessels not selling their catch to the plants, sampling at the dockside may be necessary. However, it should be noted that a considerable amount of size frequency sampling is necessary to obtain useful information in fisheries where a large number of species are caught. Currently this is beyond the human resources available to the Department, which perhaps should concentrate on lobster, conch and Nassau grouper for these sort of data.

6. ESTIMATION

6.1 Overview

This technical section is provided for completeness. Estimation techniques are dealt with in detail in Thompson (1992).

Data can be provided in sufficient form for stock assessment. Often this means an estimate and its variance rather than raw data. However, in some cases a stock assessment model can be fitted to raw data, so raw data should be available for an assessment if required.

Performance indicators recommended for the small-scale fisheries in the Bahamas are simply estimates of key variables such as CPUE, catch and profit. These are simple to calculate, but the statistical estimation may be more complicated. Some important estimators are provided.

For more complex stock assessments, which should be undertaken for spiny lobster among others, estimates of catch composition and effort may form the main inputs into the analysis. Where possible, estimate variance should also be available, as it will form an important part in model fitting, supplying confidence intervals and any subsequent risk assessment.

In general, estimates for the different sampling stages can be scaled upwards directly. This allows us to consider each stage separately in terms of the estimate and its variance.

6.2 Estimating Total Landings

6.2.1 Simple Random Sampling

To estimate totals, at least one variable must cover the whole population. For example, a vessel register maintains the total number of vessels. The total catch of a sample of vessels can be raised to the entire fleet based on the number of vessels in the fleet. Furthermore, the register can be used to stratify the sample, and vessel attributes can be used as covariates, both of which will improve the estimate.

This requires two stage sampling by site and by vessel landing. Assuming random sampling without replacement, the estimate of the total catch at a particular site.

$$C_i = \frac{M_i}{m_i} \sum_{j=1}^{m_i} C_{ij}$$

$$C = \frac{N}{n} \sum_{i=1}^{n} C_i$$

$$\mathrm{var}(C) = \frac{N(N-n)}{n(N-1)} \sum_{i=1}^{n} (C_i - C/N)^2 + \frac{N}{n} \sum_{i=1}^{n} \frac{M_i(M_i - m_i)}{m_i(m_i - 1)} \sum_{j=1}^{m_i} (C_{ij} - C_i/m_i)^2$$

In the simplest case, all landings at a particular site are recorded, making the total catch estimate exact and eliminating the second term of the variance estimate.

The small sample size makes stratification within an area difficult. If there are 4 enumerators and 20 sites, stratification would have to interfere with the allocation over a number of days to be applicable. For example, combining over a month would mean that we could allocate 120 visits. Sites could be split into three strata based on the numbers of vessels landing at each site, and visits allocated accordingly. As long as visits are randomly distributed amongst days and sites within strata, estimates should be unbiased. Although more efficient than simple random sampling, the approach has problems. Visits cannot be randomly assigned over days and sites as the number of visits per day is constrained by the number of enumerators, so allocation cannot be truly random. Any constraints or time series patterns in the data may lead to bias. For example, fewer enumerators may be available at weekends and there may a distinct weekly pattern in landings.

6.2.2 Unequal Probability Design

The same multistage estimate for the variance applies. However, the estimate for the primary stage, landing sites, is altered to account for the unequal probabilities. In general, the Horvitz-Thompson estimator is appropriate for all unequal probability designs (Thompson 1992):

$$C = \sum_{i=1}^{v} \frac{y_i}{\pi_i}$$

where C is the total (e.g. catch) to be estimated from a sample of v observations, y_i, each with a probability of π_i of being included in the sample. Notice that where the probability of a site being included in a sample is proportional to size of the catch, the calculation is similar to using raising factors. However, in contrast to raising factors, the design is more robust as departures from this assumption do not automatically lead to biased results and the method is self-correcting with adequate sample sizes.

The most robust variance estimator for this stage is positively biased, but always positive (the unbiased estimator can be negative) and easy to calculate:

$$\text{var}(C) = \left(\frac{N-v}{N}\right)\frac{s_t^2}{v}$$

where N is the number of items in the population, and s_t^2 as sum of squares statistic calculated as:

$$s_t^2 = \frac{1}{\sum v_j - 1}\sum_{j=1}^{V}\sum_{i=1}^{v_j}\left(\frac{v_j y_i}{\pi_i} - C_j\right)^2$$

where v_j is the number of samples taken within a particular unit. Note that this assumes the variance remains constant over samples. This is useful for the sampling proposed here, as the number of samples taken on any particular day is small. Repeat samples may be combined over each month, and the variance estimated from the month combined which should lead to an accurate estimate. In simulations, this variance estimate was found to be higher than the MSE, and a poorer estimate than that derived from the inclusion probability covariance matrix (the unbiased estimate). However, the latter is much easier to calculate and hence recommended for initial use. Further work could be used to compare these approaches to test their behaviour, using for example, bootstrapping.

The method is straightforward once inclusion probabilities are available. If the probabilities of selection vary for every possible item, the probability for each sample permutation will be different. For a large population of items, the direct estimation becomes impossible (the number of calculations is dependent on the factorial of the number of items in the population). Software was developed to calculate these probabilities using two techniques to reduce the problem:

- A dynamic programming technique reduces the problem from one of permutations to one of combinations, so the number of calculations is reduced from $N!$ to $N!/(r!*(N-r)!)$ where N is the population of items and r is the sample size. It ignores the order in which sample items are drawn which is not relevant for calculating inclusion probabilities.
- Groups of items with the same probabilities are treated together. They will share the same probabilities, although individual items will still need to be taken into account in

terms of their removal as they appear in samples. In general, when dealing with groups, only the number of group items in the sample needs to be accounted for, significantly reducing the number of calculations.

The limit on the number of items is around 20. Above this, the calculation becomes very slow unless a significant number of items share the same probabilities, and results may be inaccurate. Under these circumstances, an alternative design may be better (Thompson 1992).

The software is supplied in the dynamic link library "UnequalSampling2.DLL". This file must be in the current path of current directory for the unequal probability calculation software to work in the appropriate EXCEL spreadsheets.

6.3 Landings Composition

The landings composition is based on the total landings by commercial group and uses the same estimate. However, the species composition within the commercial group should be based on random sampling of individuals. This makes the estimated composition dependent on multinomial distribution (see Thompson 1992). The expected landings of a particular species is the proportion of individuals in the sample which belong to that species multiplied by the total catch. The same estimation technique applies to catch in size groups. Note that the larger the number of categories, the larger the sample size should be to get adequate numbers of fish within each category. For this reason, raw lengths should be recorded so that different size categories can be tested.

6.4 CPUE

Unlike total catch, CPUE is an average value. The average CPUE for one day, estimated across sites, is best estimated as the ratio between the estimate of the total catch and total effort. Total effort can be estimated in the same way as the total catch in an unequal probability design.

Auxiliary data, such as gear type and vessel characteristics, could be used to improve estimates of CPUE in particular. Although the 1995 census information is available, it is very old and therefore it is not recommended that it is used unless the information can be updated.

6.5 Other Indices

Other indices can be estimated using the same methods. All indices are totals or averages, so they use the same principles of estimation. The database should contain reports that calculate the estimates and their variance automatically.

Indices based on stock assessment are estimated differently. However, the variance of estimates of total catch and effort are often useful in these assessments, and can be used in a variety of ways. It is always important to produce some estimation of the variance or confidence interval in estimated quantities.

7. DATABASES AND DATA MANAGEMENT

7.1 Overview

The Fisheries Department has a database, but it is very inflexible and poorly structured. A priority is to develop a database suitable to the data collection programme, and the uses of the data.

7.2 Database Design

A database should be used to store the raw data. All processing of data should be executed by the database system. If processed data are entered, as incurring the greater cost of pre-processing, the validation of data becomes difficult and some types of analyses may become impossible.

It is important to develop the database simultaneously with the development of the data collection programme, as the database acts as a check on the consistency of the data collection programme. The database will show if the programme actually produces the expected output. The database will also help in the search for the best stratification.

A “database” consists of “Tables”, “Forms” and “Reports”. These three main components are linked by aid of “Relations” and “Queries”. Below follows a very brief introduction to these basic concepts. For a more comprehensive introduction, the reader is referred to the textbooks on databases.

The “tables” are the containers of the data, the “forms” are the tools used to interact with the database and the “Reports” are the output produced by the database.

7.2.1 Forms

The “forms” are the tools for all communication with the fisheries database. The “soft-forms” are the screen pictures through which you communicate with the database.

It is important that the forms are designed so that the data entry is “friendly” to the encoder. The paper interview forms should not be too different from the “soft form”. The encoders with their accumulated experience should contribute to the design of the database forms.

In the design of forms, as much as possible should be included in each screen, without making the form too complex. Furthermore, look-up tables should be used and checks should be made on field entry, to ensure data is as error free as possible. For example, the encoder should not enter the name of the province from the keyboard, but should select it from a look-up table.

The “copy record” allows the encoder to change the data that differs between records, rather than type the record in again each time. Many of the data entered are the same for subsets of records. For example, the name of the landing place remains the same, for all interviews from that landing place.

Encoders should enter all relevant information with respect to a trip at the same time. This is how relationships between data records are formed.

7.2.2 Reports

There are three types of reports needed from a database.

- Administrative reports monitoring data collection activities, for example giving amount of data collected from each site in each month.
- Assessment reports, containing processed data for analysis in a stock or bioeconomic assessment.
- Annual reports producing standard statistics used to monitoring the performance of the sector.
- Sector profiles, giving an overall description of the fisheries sector, which may need to be infrequently updated. The annual reports and sector profile should complement each other.

A database system should include a number of pre-prepared reports covering administrative and annual reporting requirements. Annual reports will require a certain amount of interpretation on behalf of managers, but largely be standardised output. Assessment reports are likely to need specialised queries and, with a exceptions, may need to be extracted by the scientist doing the assessment.

It is useful if the annual reports do not change too much between years, in order to maintain the compatibility between years to allow easy comparison. Once officially reviewed and accepted, annual reports should be archived for easy access and distributed to interested clients.

A fisheries sector profile may be considered an extended census, where it has been attempted to describe all elements of the fisheries sector of an administrative division or the entire country, depending on the size of country.

7.2.3 Software

The database software should be able to deal with large amounts of data. Even smaller fisheries build up large numbers of records over time, and accessing these records can be slow with less expensive software.

Users who want to apply the data for non-standard (e.g. research) purposes is not satisfied with the pre-prepared reports. They will need the data structured a specific way, to allow for some specific processing. The best way to approach this is to train users in Structured Query Language (SQL), which is implemented as standard in many database software packages. However, they implement SQL to different degrees, and it should be ensured that the "SELECT" queries in particular are well catered for before purchasing a package.

The Fisheries Department has two options. Firstly, it can develop its own database. This is costly and requires more resources and expertise than currently available in the department. Alternatively, the CFRAMP TIP/LRS might be used, if it can be adapted to Bahamas needs. The current TIP database is fairly rigid and does not allow for extension. However, it should be a lot easier for the Fisheries Department to maintain a system based on this software, as the software is shared regionally.

7.2.4 Data Validation, Errors and Backup

Raw data entered on the computer needs to be checked and validated in as many different ways as possible.

Some data should be validated automatically at the time they are entered in the database. For example, the order of magnitude can be checked and rejected if a value has been given in kilograms where it should have been tons. In addition, dates can be validated. For example, lower and upper limits for acceptable dates can be specified, so that the database will give a warning when a date is outside the limits. These are examples of the easy-to-detect errors.

Data selected from look-up-tables will contain only values from the look-up-table, so the only possibility for error is that the wrong value is selected.

There are usually a number of consistency checks, which a database can perform automatically. For example, the date for leaving and returning to harbour for different trips of the same vessel can be compared.

Statistical verification may be used to identify unlikely values. If a commercial group appears in a sample, but not in the other similar samples, it may be an error and can be checked against the original record. However, if the observation can not be ruled out through investigation, it must be accepted even if it appears unlikely. Most analyses are robust enough to allow for a small number of such errors without giving incorrect results.

In other cases, two independent sources of information can be obtained. For example, a logbook may report the landings and these can be compared to the buyers reports of their purchases from the vessel. Data from the commercial fishery may be compared with data from experimental fishery, which for example, may reveal erroneous species identification.

Supervision and on-the-job-training of enumerators is a kind of double sampling, as the supervisor will check any data collected by the enumerator, and they will (hopefully) sort out any discrepancy between them. Supervision and discussion between programme-staff is probably the most efficient tool for data validation.

The processed data should be evaluated by comparison with general knowledge and common sense. All computed total catches should be evaluated for their reasonability.

Finally, the only true protection against computer failures or data management errors or natural disasters is to backup data onto robust media (e.g. CD-ROM). Regular backup is probably the most important data management task.

7.2.5 Table Structure

This will not necessarily reflect the data forms or the way the data are collected. Relational databases have their own rules of data structure. Although the basic data is recorded in tables, it is in the relationship between tables that much of the information lies. It is important that the database is well constructed, and that data entry procedures are strictly adhered to. This ensures that the integrity of the data and these relationships are maintained.

This integrity is often the reason for hierarchical nature of data entry and the enforced use of look-up tables. In addition, some information is entered by the computer, and the encoder cannot change it. Hence, the construction and maintenance of the database is not an easy task, and will require expertise and consultation.

The current databases and dBase III software need updating. The data management system does not allow adequate access to the data and is too rigid in structure. In particular, tables are broken into monthly files and spread over a number of databases on separate computers. This does not make efficient use of the relationships between data and undermines the relational database structure.

The database should be transferred to a new database system set up in modern software. The new database should be restructured to deal with the following flaws in the current system:

- The main tables containing information on summary catch and effort by trip, licences, prosecutions and duty free permits should be placed in one system. This would allow the Department of Fisheries to make better use of available information by exploiting the relationship between these data. For example, licence information would be available for adjusting vessel fishing power in catch effort data to improve stock assessments. Other data tables should be added as needed. There is never a need to have more than one database.
- All raw data should be entered into the system and not be processed prior to data entry. Monthly landings records from the processing plants should be entered as is, and not used to update the trip interviews by hand as is currently done. This procedure can be automated. Furthermore, the comparison between the processor monthly reports and the estimates from the trip interviews will give a statistical estimate of error and bias in the interview data which can be used to improve analyses made on these data.
- Data validation needs to be undertaken as data is entered. While some checking takes place, it still allows significant amounts of inaccurate data onto the database, such as duplicate records and incorrect values. All these problems could be prevented.
- Standard database queries need to be developed to provide up-to-date data in the necessary formats as required. The current database is largely inaccessible to fisheries staff. Many of the performance indicators (e.g. employment, GFP for the harvesting sector, CPUE) can be generated automatically. This will improve data access and make much greater use of the available information in day to day management decisions.
- Wherever possible data should be acquired in computerised format. Where fishing vessels and processors have computers, the Fisheries Department should be prepared to provide software for data entry. For trip interviews, inexpensive palm-top computers can be used to enter data as it is gathered saving time and allowing more sampling. In both cases, data should be downloaded directly into the database.
- All available historical data should be entered into the data management system. The key to predicting the future of the fishery is its past behaviour. With a longer time series of historical data, more accurate analyses will produce better management decisions.

The following table structure has been suggested (MEP 1999). However, it may be more useful for a the Fisheries Department to use the CFRAMP TIP/LRS database for its core system, and build tables around it. This would allow greater external technical support and probably improve the sustainability of the system.

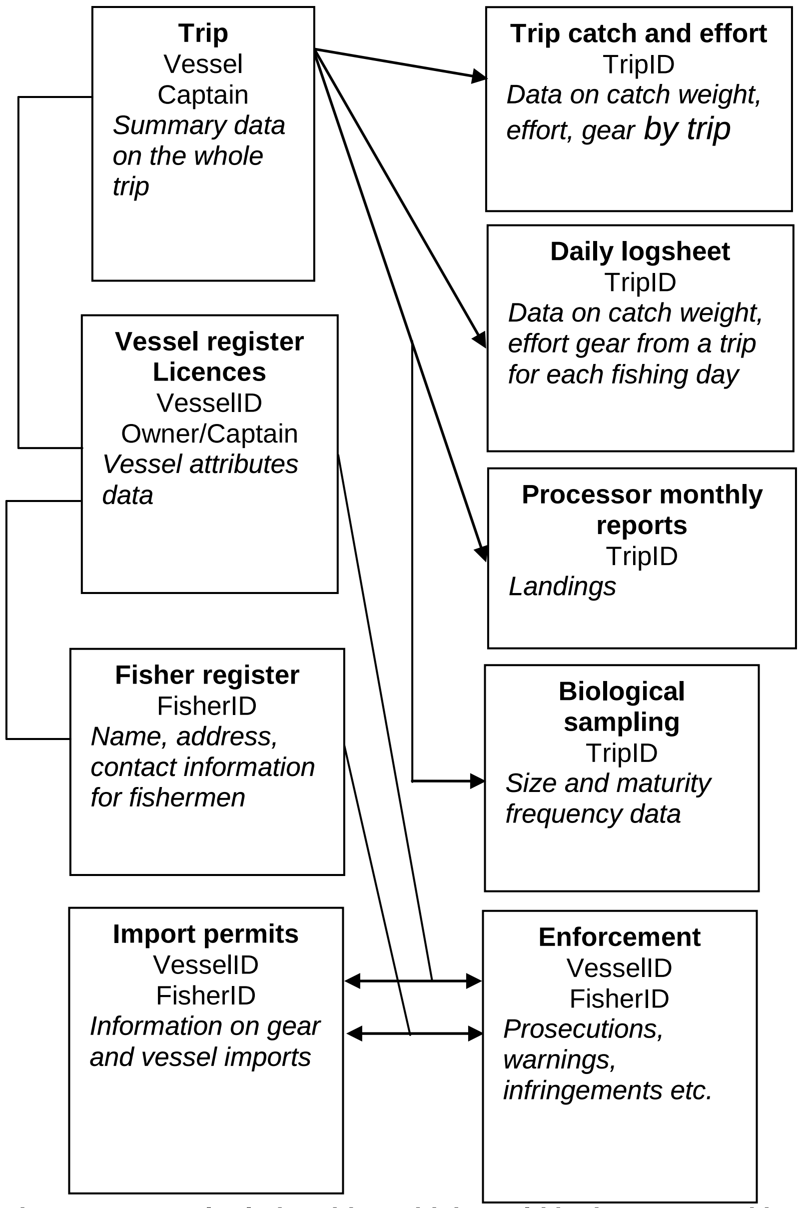

Figure 3 General relationships which could be incorporated into the fisheries database (MEP 1999). General look-up tables (gear types, species etc.) are not indicated to simplify the layout. Arrows indicate one-to-many relationships. All additional tables should incorporate as many relationships as possible rather than record separate information.

7.3 Recommendations

The Fisheries Department should consider using the TIP/LRS system sponsored by CFRAMP. To design and maintain a good database is costly and often beyond the technical capability of the available staff. A regional database, maintained by a number of countries, should reduce costs and allow access to technical support. However, the database must either be flexible or suit the needs of the Bahamas fisheries adequately to serve their purpose.

8. IMPLEMENTATION OF THE SAMPLING PROGRAMME

8.1 Budget

This section lists some possible items for considerations when preparing a budget of a data collection programme. It is not possible to prepare a generic budget for a data collection programme, due to the variability of local conditions.

The budget should be carefully prepared particularly for recurrent costs which will determine whether a programme will be sustainable or not. Recurrent costs will include salaries, maintenance, running costs and transport (e.g. local flights between islands), communication costs, regular training and workshop costs.

8.2 Training

Training is one of the most crucial components in the preparation and successful implementation of a data collection programme and must always be given high priority.

Training during the planning and implementation phases is different from the routine training of an on-going data collection programme. Regular training is an indispensable part of a sampling programme. New staff members on each level obviously have a need for training, but all personnel on all levels need regular training to maintain work quality.

The first training programme should train trainers so that the programme is supported internally and therefore sustainable. Ultimately participants should include fishers, data collectors, supervisors, researchers, computer operators, directly responsible data producers and users, and decision-makers. Training workshops should be regular. This will allow the programme to improve, adapt and maintain a freshness despite its routine nature.

Training courses and workshops are a good means for addressing methodological and operational problems encountered in the implementation of data collection programmes. They provide the opportunity for bringing together staff with different responsibilities and activities, such as data collectors and supervisors, data operators, statisticians and researchers.

The training courses and workshops should address all aspects of the sampling programme, and it is important that staff on all levels understand and support the overall idea behind the programme. Enumerators, for example, are often in a situation where they are questioned by fishers about the data collection programme and they should preferably agree with the programme and be able to explain and justify it.

As well as specific skills training, the key questions should be explained and discussed with all types of staff, although the topics should be dealt with in a way matching the different staff groups. Key questions are:

1. Why collect data? (objectives of data collection programme)
2. Who are the clients? (who should we collect data for)
3. Which data to collect? (say, from commercial fishery or from experimental fishery?)
4. How to collect data? (What are the sources of data?)
5. How to store and process data? (Including databases, bio-economics and fish stock assessment).

6. How to report on fisheries? Which groups of clients should get which type of reports?
7. What are the costs of data collection, and where does the funding comes from?

Training high level decision-makers should not be neglected. While they will have little time available, introduction to the concepts particularly of reference points, performance indices and the objectives of data collection. The decision-makers, such as government ministers, need to understand how data is processed into information that they can use. The choice of performance indices and reference points is clearly a policy choice.

Information is the prerequisite for rational management and development, but that information costs money, as explained in various international agreements, such as the ”Code of Conduct for Responsible Fishing”. Decision-makers' appreciation of the value of these data will help considerably in dealing with problems (usually funding) that arise.

It is important that all staff have a good understanding of other staff's work. For example, encoders and enumerators should be familiar with the other's activities and have experience in each other's work.

8.3 Consultation

The programme should prepare material to inform the industry and the local administration about the sampling programme. A pamphlet of a maximum of 20 pages with many illustrations, aiming at the public as a whole, should be prepared. The data collection programme may get assistance from professional information experts (e.g. journalists or artists) to formulate the text and the illustrations of the pamphlet to reach a wide audience, but with special emphasis on the target group, the fishing community. The programme should design a logo to make the programme easily recognisable and visible and may prepare other material, like a presentation, T-shirts and note books with the logo of the programme etc. Funds must be allocated to this type of activity, as a bad relationship with the industry may destroy an otherwise well-designed data collection programme.

The fisheries administrators are the primary users of the data collection programme. There must be a good relationship between the fisheries administration and the data collection programme. Therefore, regular meetings and consultations should be arranged with them.

The main purposes of consultations are:

1. To establish good relationships among stakeholders
2. To establish agreements on exchange of data
3. To get advice and information
4. To inform about the data collection programme (objectives and methodology)

In addition to stakeholder consultations, technical issues can benefit from regular expert workshops. Standing committees and working groups on fishery statistics (i.e. stock assessment, statistic standardisation groups) could be set up and play a key role in the co-ordination of data collection programmes, particularly in those cases where different agencies or institutions are involved in various applications sectors and components of an overall survey system. Statistical Committees should meet on a regular basis and their composition and level of authority should allow submission of their recommendations to higher government authorities for consideration and action.

8.4 Exchange of Experiences with Other Countries or International Organisations

Irrespective of differences in type and size of fishing industries, fishery data collection programmes are generally based on certain basic and commonly accepted approaches. The Bahamas can benefit from the experience and knowledge of other countries in the region. Exchange can be facilitated by regional workshops, expert consultations and study tours.

Regional meetings can help deal with:

1. Regional workshops on processing of combined data (including fish stock assessment and bio-economic analyses);
2. Standardisation of data format, for exchange of data
3. Establishment of regional databases
4. Co-ordination of data collection from shared resources and vessels not landing in the home country

8.5 The Iterative Process of Implementing a Data Collection Programme

Once a programme has started, it will need to be regularly revised. Although modifications of programme are needed more or less every year, the modifications should be made so that the compatibility with earlier years is maintained. If there are no major changes in the fisheries sector or the resources, the annual modifications should become gradually smaller. The sampling programme in particular should be reviewed early on in the implementation. As more information comes available, it will be possible to improve the sampling efficiency.

a) **Define objectives of data collection.** What type of general background information is required, which type of resource evaluation or bio-economic analyses is required?

b) **Identify data.** For example, what should be the content of the Fisheries Annual Report? What is needed for resource evaluation or bio-economic analyses?

c) **Identify data sources.** Who can supply information, where? Identify all parts collecting information or are keeping files about the fisheries sector.

d) **Design data collection programme and design database.** Construct a stratification on fleets, landing places, species and season. Select data collection stations, decide on frequency of sampling, allocate tasks to enumerators, design data forms for interview and for data entry, and make the budget.

e) **Execute training courses for enumerators, encoders and support staff.** Create a “team-attitude” – make all staff feel they are important for the programme.

f) **Collect data**. Design interviews and fill in forms, execute frame survey or vessel registration, execute on-the-job training, make contacts to fishers, distribute material of the sampling programme, pamphlet, T-shirts, etc.

g) **Create database**. Select commercial software and create an application for fisheries database in collaboration with enumerators and encoders. Create a database to meet the requirement specified in a, b and c.

h) **Enter data in database.** Enter data into the computer and carry out preliminary validation, train enumerators and check their performance.

i) **Execute pre-processing of data and validate data.** Estimate the first indices. Compare samples to identify extreme values and do other validation exercises.

j) **Evaluate data collection programme and database.** Prepare detailed administrative reports, compare plans with actual achievements. Compare actual costs with budget. Identify the problems and their solutions. Invite consultants for independent evaluation. Compare to other data collection programmes, for example, programmes in other countries.

k) **Arrange user meetings with administrators.** Administrators are here the senior staff in the fisheries directorate (central and provincial) who are associated with the data collection programme in the sense that they are the official publisher of the fisheries statistics and they are the supervisors of the data collection programme.

l) Compile relevant recommendations and return to d) if necessary

m) **Process data.** Complete processing, possibly with resource evaluation or bio-economic assessment.

n) **Prepare reports.** Administrative reports, catch/effort reports, resource evaluation report, bio-economic analysis, etc.

o) **Evaluate reports.** Do the reports contain the expected data? Do reports provide the analyses and advice expected? Is the current sampling frequency adequate? Are additional data required?

p) **Consult with managers, politicians and representatives from industry and fishers associations.** Are the primary users satisfied with the reports? Are there additional requests from the users. Do the managers actually apply the reports as a part of the basis for their management decisions? If necessary, return to a) to redesign programme.

Production of manuals should start as soon as possible as a means for communication within the programme staff. Manuals are not permanent and should be revised regularly. Documentation will also be important. Training materials should be obtain prior to starting the programme as implementing training courses and workshops should be one of the first activities.

9. PROPOSED PROGRAMME

9.1 Overview

The objective of the data collection needs to be identified. This can be done by developing precise policy centring on performance indices and reference points. Considerable amounts of research already exist on key commercial both in Bahamas and in the Caribbean region. This information can be used in a consultative workshop representing high level decision-makers, the fishing industry and fisheries managers. By clearly identifying how data will be used, greater co-operation may be obtained from fishers in data collection.

After identifying how the data will be used, the appropriate variables and methods can be defined. This will require alteration of current data forms and some training. It is important to review methods at this stage. For example, some processing plant managers indicated that it might be possible to record some additional trip information on their purchase forms, such as days at sea. This information may or may not be useful depending on whether there is a logbook programme or better trip interview coverage.

Consultation with stakeholders needs to be undertaken. Consultation through meetings is key to deciding upon data collection objectives and to implementing a logbook scheme.

An effective data management system needs to be implemented to make better use of data currently available. Ideally, the database should be an extension of the upgraded TIP/LRS system, which should be finished by the end of 2001. This should allow rapid development of the database and shared maintenance and training costs with other countries.

A sampling programme making optimal use of available resources needs to be developed. The programme needs to cover trip interviews and logsheets. The trip interview sampling needs to be spread among islands more widely. This can be done with a formal programme, including periodic visits to nearby islands. Training of enumerators must be undertaken to direct data collection away from complete enumeration and more towards estimation of desirable variables.

As much as possible should be made of sampling from the processing plants. The collection of data from this source has been demonstrated by research projects carried out by the University of Miami. Biological data collection is much less expensive than in other ways. The amount and type of information collected through this source needs to be explored. In particular, whether data on landings can be linked to particular trips for which trip interviews can be conducted.

Staff need training in using the database, basic statistics and estimation. All staff need to be aware of data collection objectives and how the information should be used. It may be possible to combine this with short courses for a number of enumerators and staff from other countries, reducing costs. The most important training will be for using the database, which, for the TIP/LRS database, would allow shared training with other countries.

9.2 Programme

	Activity		Days
1	**Prepare presentation and materials** suitable for Management Objectives Workshop and stakeholder consultation.	Fisheries Management Consultant Facilitator	6 days 6 days
2	**Data Collection Objectives Workshop**	Fisheries Management Consultant Facilitator Two local counterparts Decision-makers Other staff	4 days 4 days 4 days 2 days
3	**Stakeholder consultation** methods for data collection. 8 meetings of 1 travel day and 1 meeting day covering as much of the fishery as possible. The primary aims would be to: • Discuss Policy and Data Collection Objectives • Discuss a logbook scheme and other data collection initiatives	Facilitator Two local counterparts	16 days 16 days
4	**Report recommendations** based upon consultations and management workshop	Facilitator Two local counterparts	4 days 4 days
5	**Implement sampling programme** for improvement of the current system. System development should include: • Develop and test a logsheet programme • Trip interview programme • Processing plant sampling	Statistics Consultant Two local counterparts	20 days on going
6	**Implement database upgrade** (Assumes TIP/LRS is used as core database, but adaptations required) Reporting should meet management objectives. May have to include extensions for logsheet system.	Database Consultant	15 days
7	**Staff training**: in-job training would form part of implementing the sampling programme. Additional training might be required in data management, which is covered here.	Database Consultant	10 days

9.3 Budget

The following budget represents the worst case. Substantial costs may be saved by providing a local facilitator. If the TIP/LRS system is adopted, the database development and training could be carried out as part of the TIP/LRS upgrade.

	Days	Rate[1]	Cost (US$)
Fisheries Management Consultant	10	330	3300
Statistics Consultant	20	330	6600
Database Consultant	25	330	8250
Facilitator[2]	30	330	9900
International Travel	3 trips		6000
Subsistence[3]	114	100	11400
Local Travel[4]	16	300	4800
Computers and software[5]	One computer and software		1700
Communication	Telephone, Internet, modem		500
Educational Material	Leaflets, posters		1000
Total			53450

Notes

[1]The consultant rates are assumed to be the same. However, an external facilitator would probably be more expensive.

[2]A local/regional facilitator should be employed. The fisheries department may be able to provide staff in this role, which would eliminate facilitator honorarium, but not subsistence. If an external facilitator is used, the number of days allocated should probably be scaled down, with more reliance on local counterparts.

[3]Assumes USD100 a day as an average over all Islands, including the family Islands. This covers local travel to the islands as well as subsistence in Nassau, which is likely to be more expensive.

[4]Costs of local travel will vary. This assumes travel by aircraft. The local itinery can probably be organised to reduce this cost. However contingency is probably required to allow fisheries staff to visit islands to set up meetings as well the travel during the meetings period.

[5]The Fisheries Department already possesses a number of computers, although some are becoming outdated. An alternative to purchasing a computer might be to network the computers they already have to a server. This would give greater access to data, but they would require a client-server database.

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