At what level should trochus management take place: at the fisher or market level?

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Introduction

In work on coastal resources in the Pacific, Nash (1993), who was responsible for the chapter on trochus, listed seven ways of managing this nacre-producing shellfish, which is particularly vulnerable to any form of intensive exploitation. They involved setting up (a) catch size limits (minimum and maximum), (b) fishing area access limits, (c) catch quotas (total allowable catch), (d) fishing seasons, (e) fishing reserves, (f) reseeding of natural settings with farmed juveniles, and (g) catch and fishing effort log-books and statistics. Although these statistics are not management measures as such, they provide a way of assessing the stock's status before implementing management measures and of monitoring the effectiveness of such measures.

In addition to setting up village-level fishing reserves that are jointly managed by public authorities and village leaders (this issue will be discussed in a later article), the choice of management method or methods for trochus stock is made by public authorities, i.e. national or provincial fisheries departments, which must also oversee their implementation or enforcement at the local level, i.e. with fishers. This monitoring/assessment of management methods is under the control of the national fisheries system that covers the entire "trochus" sector — from the resource to its exporters and managers (Fig. 1). Management of the system requires collecting, at a moderate cost, relevant and accurate information to develop indicators that will enable crises to be avoided or will minimise their negative impacts (see previous article). The main question for fisheries departments managing such a system is: At what level should information on the sector be collected — upstream at the fisher level or downstream at the level of the national trochus market in relation to the exporters and processors of this shellfish? These two possibilities are explored below.

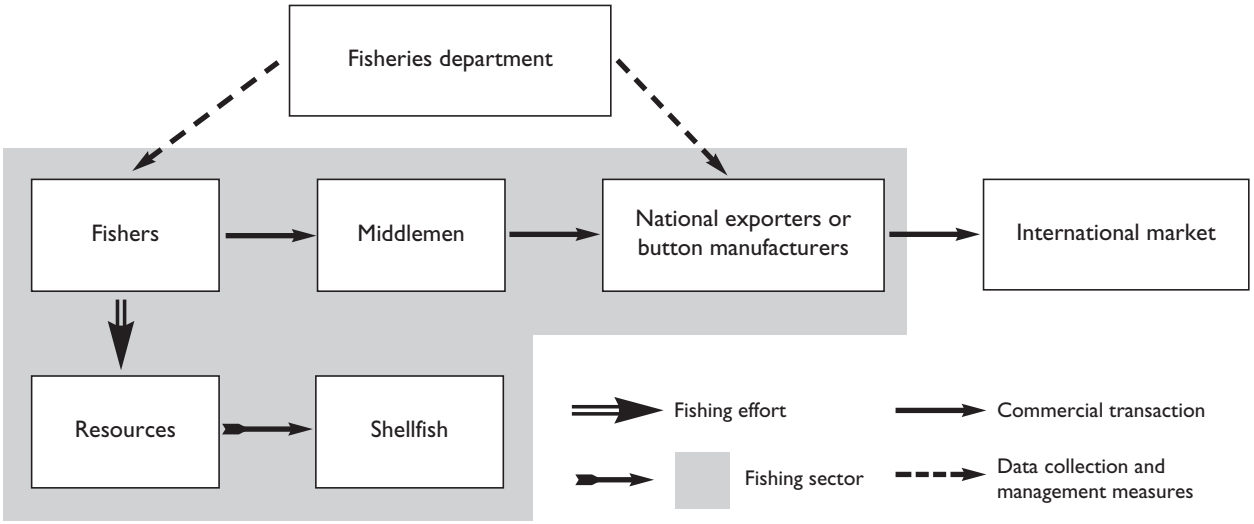

Figure 1. **Trochus fishery system and its management by public authorities**

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1. Data collection and management work with fishers

Conventional methods of fisheries management involve working with fishers to manage the resource. When there are signs that the stock is being overexploited, managers try to reduce fishing effort. Aside from reseeding in natural settings, all the management methods listed in the introduction come under this approach.

In general, overexploitation of fisheries stocks is characterised by an imbalance in the population structure; e.g. trochus that have not yet reached the stage of sexual maturity are overrepresented and adults, particularly older ones, are underrepresented. The whole problem of overexploitation arises from the fact that fishing effort is not determined by the status of the exploited resource but according to other production expectations since fishers treat their production as income. For that reason, the fisheries exploitation dynamics of trochus, and by extension the dynamics of overexploitation, are based on the "resource/production expectations" ratio.[2]

Trochus fishers operating in an area subject to overexploitation can choose one of three strategies:

- They can go to a new area where previously little fishing has been done but which is also further away. They can then hope to maintain the same level of production, although at a higher cost due to the increased travel time. Thus, they will have to fish for a longer period to maintain the same level of income, unless increases in productivity and associated income compensate for the higher costs.
- They can maintain their efforts in the zone subject to overexploitation and accept a drop in income due to the smaller catch.
- They can continue to exploit the current fishing area but give top priority to maintaining existing production volumes and income. The only way to do that is to increase their fishing effort to compensate for the drop in productivity resulting from the increasing scarcity of the resource.

The latter two strategies will inevitably lead to a greater imbalance in the population structure of the stock.

In this context, two types of indicators are likely to be helpful in managing the information system. The first deals with characterising the risk of overexploitation, while the second emphasises the system's vulnerability to this risk. A third indicator is aimed at assessing efforts made to reduce this risk or to reduce overexploitation that already exists.

1.1 Characterising the risk of overexploitation

Indicator of existing overexploitation

The number of juveniles caught compared to the total number of catches surveyed is the most relevant indicator in this regard. This type of indicator is generally derived from data collected at landing sites. The wide geographic spread of such sites is a characteristic of the Pacific Islands with trochus being landed on beaches near fishing villages. This situation, which can be described as the "scattering" of landing sites, imposes serious constraints on data collection (Cillaurren and David 2000). Maximum efficiency would require field deployment of a "flying squad" of surveyors for several months a year — a very costly exercise (Table 1).

Table 1. **Indicator of risk of actual overexploitation**

Indicator no. 1: *Number of juveniles caught compared to total number of catches surveyed at landing*	
Relevance	Very good
Precision	Very good as verification is visual and carried out by fisheries department agents
Cost of acquisition	Very high as a team of several surveyors must be mobilised full time

Socio-economic indicators of potential overexploitation

These indicators provide information on fishing pressure, which is estimated in terms of exploitable surface area units. There are two different indicators:

a) Number of trochus fishers in villages near the exploited reef compared to the total exploitable surface area of the reef;
b) Annual number of fishing trips compared to the total exploitable surface area of the reef.

Information on the number of trochus fishers can be obtained at no cost through national maritime affairs or fisheries departments when the fishers are registered (which is rare). When this information is not available, field surveys are required,

2. This involves using a socio-economic approach to fisheries exploitation to supplement the biological approach that is of course more common (Laurec and Le Guen 1981).

but the cost/relevancy ratio is prohibitive (Table 2). The number of fishers is, in fact, a poor indicator of fishing effort due to large differences between fishers in the frequency of fishing trips.

Establishing the boundaries of the exploitable space is also a problem due to uncertainties about both bathymetric readings and marine facies. In general, the bathymetry of the shallow areas (5–25 m) that correspond to the trochus habitat is poorly known. Sounding points are rare and interpolations made from them are imprecise. Airborne laser altimetry should significantly improve this situation in future years, but this technology is still being developed and is costly, as was shown by the conclusive experiment carried out on Reunion Island with the CASI system (Despinoy et al. 2003). Without precise bathymetric readings, it is difficult to differentiate between various marine bottom features at depths of more than 15 m, whether the signals originate from airborne or satellite technology. In fact, aerial photos and satellite images are the two resources normally used to map reef formations (Bour et al. 1986; Bour 1988; de Vel and Bour 1990; Bour et al. 1992). The launching of very high resolution (i.e. about one metre) satellites such as Ikonos or QuickBird now makes it possible to consider reef cartography at scales of 1:25,000 or even 1:10,000. However, the cost of using such images to map large surface areas of reefs can quickly become prohibitive.

The annual number of fishing trips compared to the reef's total exploitable surface area is a much more relevant indicator since the number of fishing trips is a better indicator of fishing effort than the number of fishers, but this indicator is costly. In fact, several series of surveys are necessary to take into account intra-annual variability in the number of fishing trips. However, an experiment

Table 2. **Potential overexploitation risk indicators**

Indicator no. 2: *Artisanal fisher population of the villages near the exploited reef compared to the total reef surface area that can be exploited by commercial fisheries*			
	Numerator	Denominator data	Overall indicator
Relevance	Low: (a) it is assumed that fishing effort is the same for all fishers (b) it is assumed that fishing effort is evenly spread over the entire exploitable surface area	Low: (a) the exploited surface area is depicted by the exploitable surface area (b) it is assumed that abundance is evenly spread throughout this zone	Low
Precision	Good to average: Depends on the number of informal artisanal fishers (by definition not registered) compared to the total number of artisanal fishers	Low for bathymetric data, which are poorly known for the 5–25 m depth zones (few sounding points so poor quality interpolation) Good to low for marine facies identified by satellite detection; the precision decreases with depth	Average
Cost of acquisition	None, when the indicator is derived from government data High if new data have to be acquired	None if existing data are used Average to high (depending on the surface area to be mapped) if new data have to be acquired (cost of purchasing and processing very high resolution satellite images)	None (rarely) to high (usually)
Indicator no. 3: *Yearly number of fishing trips compared to the total surface area that can be exploited by commercial fisheries*			
	Numerator	Denominator data	Overall indicator
	Good	Low: (a) the exploited surface area is depicted by the exploitable surface area (b) it is assumed that abundance and fishing effort are evenly spread throughout this zone	Low
	Good	Same comments as for indicator no. 2	Low
	High, requires several series of surveys throughout the year	Same comments as for indicator no. 2	High

in monitoring deep-bottom fishing in Vanuatu showed that this cost can be lowered significantly if the fishers actively cooperate in collecting information (Cillaurren and David *op. cit*.).

1.2 Indicator of fishery system's vulnerability to the risk of overexploitation

The fishery system's vulnerability to overexploitation does, of course, depend on the status of the resource and the fishing effort. It also depends on the ability of public authorities to act at the community level to set up fisheries management systems to reduce this vulnerability or the effects of overfishing when it is already a fact. This ability is easy to assess and provides a good indicator of the fisheries system's vulnerability.

In general, trochus exploitation and sales of fishery production are organised within fisheries systems on four different spatial levels, i.e. village, provincal, national and international. Public policy decisions are made and resource management is organised at the national level except in cases where this organisation is decentralised to the provincial level. In contrast, management measures are implemented at the village level, which is also the level of production and fresh consumption, as final consumption of the shellfish after processing takes place at the international level.

This duality in scale between the spatial frameworks for organisation of management and those for production and the implementation of management makes it difficulty to put management measures designed at the national level into effect at the village level. In general, the greater the difference between the two levels, the harder it will be to establish relationships between those levels in order to manage the fishery and oversee the fishery system and thus, the greater the vulnerability of that system to overfishing. Vulnerability is therefore highest when management measures are designed at the national level but implemented at the village level (Table 3). For that reason, the difference in scale provides a good indicator of vulnerability (Table 4).

1.3 Indicator of reduction of risk of overexploitation

Reduction of the risk of overexploitation can be measured directly by evaluating the effects on the stock or on fishers of measures taken previously, or indirectly by measuring the effort required to reduce overexploitation. The difference in catch per unit effort between "t_0", the period corresponding to maximum overexploitation, and "t_1", the period following implementation of management measures, is the most relevant indicator in terms of direct measurement (Table 5).

Table 3. **Difference in scale between organisation and implementation levels of resource management**

	Implementation level:	Country	Province	Village
Management organisation level:	Country	No conflict		
	Province	Level 1 conflict	No conflict	
	Village	Level 2 conflict	Level 1 conflict	No conflict

Table 4. **Indicator of vulnerability to overexploitation**

Indicator no. 4: *Difference in scale between organisation and implementation levels of resource management*	
Relevance	Good
Precision	Good
Cost of acquisition	None

Table 5. **Indicator of vulnerability to the risk of overexploitation**

Indicator no. 5: *Difference between CPUE corresponding to implementation of management measures and CPUE corresponding to maximum overexploitation*	
Relevance	Good
Precision	Good
Cost of acquisition	Very high

However, there are two problems in deriving this indicator: (a) overexploitation of trochus stocks must have already been noted, and (b) catch and effort data must be monitored — a costly and labour-intensive operation.

2. Data collection and management of the trochus market at the national level

2.1 *Indicator to characterise the risk of overexploitation*

As shown in Table 1, characterising the risk of overexploitation using data collected from fishers is very costly. However, it is possible to significantly reduce the costs of acquiring the information used to derive this indicator by looking at the fishery from a socio-economic and regulatory angle. Fishery control can then be carried out at the national sector end (Fig. 1), whether this involves the shell exporter or the plant that processes the shells. This method is also much simpler since rather than trying to describe a demographic structure, the emphasis is on simply looking for specimens below the legal size (Table 6), which indicates current overexploitation and is a warning of even more severe future overexploitation. Inspections carried out with customs agents make it possible to rapidly determine if fisheries products that are smaller than the legal size are included in exports. This type of system is easy to set up when there is political will to control overexploitation of fishery resources. It is also quite inexpensive as one or two duly-sworn agents can do the work part-time. When there are no trochus button factories and all of the production is exported, inspection of exporters' trochus stocks can be left to customs agents.

2.2 *Indicator of fishery system's vulnerability to the risk of overexploitation*

In general, the trochus export or processing facilities that will be inspected are located in the capital and are thus in the same geographic area as the national fisheries department that oversees trochus stock management. Application of the indicator described in Table 4 shows that this alignment between the geographic level of trochus resource management and enforcement of management rules minimises the vulnerability of the fisheries system to overexploitation as long as the inspections are properly carried out. In fact, seizing products that are under the minimum authorised size puts all the sanctions on exporters or on the manufacturers who process buttons and does not penalise village producers, whose responsibility is much less. They simply respond to demand from buyers, who are the real driving force behind this fishery since fishers are just their agents. The trochus market does, in fact, have the characteristic of being controlled by demand. Punishing the end buyer situated at the far end of the sector has two advantages: (1) control is much simpler than trying to take action at the level of fishers because there are a limited number of operators and they are located near the departments in charge of carrying out inspections, and (2) this measure has real value as a teaching tool for offenders. Seizing a buyer's trochus stock because it contains a large number of shells under the regulatory size will cause significant financial losses to the buyer – repeating these losses too often could jeopardise the buyer's business. For that reason, it is highly probable that next time the buyer will refuse any shells that are too small. A refusal, whatever the number of middlemen between fishers and the penalised end buyer, should lead fishers to concentrate solely on trochus of adequate size at the risk of not being able to sell their catches to the middlemen who come to buy them.

2.3 *Indicators of reduction in risk of overexploitation*

Two indicators can be identified in this area:

- The mean annual number of inspections carried out in facilities that export or process trochus;
- Total annual fines for trade in illegal fishery products or the value of the seizures of such products (Table 7).

Table 6. **Overexploitation risk indicator**

Indicator no. 6: *Percentage of juveniles in stocks of national shell exporters or processors*	
Relevance	Good if all exporters and processors are inspected
Precision	Good, as verification is visual and carried out by fisheries departments or customs agents
Cost of acquisition	Low, as only one or two agents have to work a few weeks each year depending on the number of establishments to be visited None if these inspections are carried out by customs agents

The first indicator shows the efforts made and the second makes it possible to estimate their effectiveness. In fact, all positive inspections must be followed by dissuasive sanctions so that the offender does not repeat the offence. In general, offenders are likely to resent the sanctions imposed and public authorities must arbitrate between their anger and the risk of overexploitation. When the latter is seen by the general public and judges as a grave threat to the sustainability of coastal economic and social systems, the choice is clear: the exporters or manufacturers must be convicted. If not, this weakness can be seen to reflect a lack of concern on the part of the authorities about overexploitation of reef resources. It also suggests that the general public and the judicial system lack information about the threat because the public authorities have made insufficient efforts in this regard.

In the end, making laws and implementing management measures do not achieve anything if there are no means (regulatory and especially non-regulatory) of enforcing them. This is particularly the case for fisheries. This highlights a paradox that will have to be dealt with in future; i.e. the law, whose standard-setting aspect is by definition exclusive, increasingly involves a participatory aspect as a prerequisite to low-cost enforcement (both financially and socially)[3].

Conclusion

The question is "At what level of the sector should trochus be managed — with fishers or at the market end?" This brief overview of possible indicators (i.e. (a) to characterise the risk of overexploitation, (b) to estimate the fishery system's vulnerability to this risk, and (c) to assess the effectiveness of the management measures implemented to reduce this risk or to reduce overexploitation) shows that it is clearly less costly and much more effective to intervene at the end of the sector once minimum catch sizes have been set. The lower costs and maximum effectiveness of this approach can be explained largely by the absence of a difference in scale between the fisheries departments that set up and enforce the regulations and the trochus exporters or processors who are supposed to follow the regulations. Eliminating differences in geographic scale between the decision-making level and the level at which management rules are implemented must be one of the guiding principles of fishery system management. However, this principle does not mean that work by fisheries departments is limited to just the end of the sector. They can also work upstream with fishers as long as they delegate a large part of their prerogatives to them and allow them to manage their own resources as part of a co-management approach. This aspect will be discussed further in another article.

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Table 7. **Indicators of reduction in risk of overexploitation for commercial fisheries systems**

Indicator no. 7: *Mean annual number of inspections carried out in facilities that export or process trochus*	
Relevance	Good if the inspections are followed by severe sanctions for offenders
Precision	Very good, as verification is visual and carried out by fisheries department agents
Cost of acquisition	None, as data are available from fisheries or customs departments
Indicator no. 8: *Annual total of fines for trade in illegal fisheries products or value of seizures of such products*	
Relevance	Good – a very few positive controls followed by severe sanctions guarantee a reduction in overexploitation
Precision	Very good
Cost of acquisition	None, as data are available from fisheries or customs departments

3. In regard to protected marine areas, the appearance of participatory management reflects as much an economic reality (controlling poachers through eco-police on boats is very costly, which is why it is better to reduce poaching in neighbouring communities by involving them in management) as it does a change in conservation philosophy.

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