EXPLOITATION TECHNIQUES VERSUS CHARACTERISTICS OF EXPLOITED SPECIES: WHICH PARAMETERS DEFINE THE IMPACT OF TRADITIONAL GATHERING ON INTERTIDAL SHELLFISH

Carla P. Catterall and Ian R. Poiner

INTRODUCTION

Many marine molluscs are gathered by humans for food or ornament, and the archaeological record indicates that traditional shell-gathering played an important role in small scale coastal societies around the world. However, few scientific investigations of the subject have been made, perhaps because shell-gathering is usually done by women whereas anthropological studies often focus on hunting by men (Meehan, 1982).

Shell-middens provide a valuable historical record of the use of shellfish by coastal societies, and of the impact of human exploitation on the shellfish populations (Shawcross, 1967; Swadling, 1976). However, the usefulness of this record is limited by a lack of information on either the gathering strategies and techniques of the human societies concerned or the biology and population ecology of the exploited species.

The impact of traditional use patterns on animal populations generally is poorly documented and poorly understood. Some reports have recently stressed that traditional Pacific societies may practise voluntary restraint and sound long-term management to ensure a sustained supply of essential resources. This could occur if the society was characterized by both a conservation ethic and an accumulated understanding of local natural history (Johannes, 1978).

On the other hand, there is evidence that pre-Western societies in the Pacific in some cases over-exploited their prey to the point of extinction, as in the case of the flightless birds of New Zealand (Diamond and Veitch, 1981). Thus, much of the apparent balance between traditional societies and their resources may be a result of all vulnerable species having gone extinct soon after a particular human group colonised an area, with the remaining prey species persisting by virtue of some biological properties which make it difficult for people using the technology and methods of that particular culture to deplete them. For example, Poiner, Catterall and Swadling (MS) found that the habits and wide depth distribution of Strombus species made them resilient to traditional gathering in Pacific and Caribbean coral reefs, but the introduction of diving and boat technology together with marketing have recently led to overfishing of the Caribbean s. gigas (Brownell and Stevely, 1981).

Thus, the effect of traditional gathering must be assessed and analysed with reference to two sets of information:

a set of the most important (ethnographic) parameters which define the exploitation techniques; and

a set of the most important (biological) parameters of the exploited species or population.

In this paper we will define these parameters as far as possible, and use these to examine the effect of traditional gathering on some tropical Pacific shellfish. We will then suggest a number of specific points for which information should be gathered and formally documented with respect to both traditional, gathering methods and'research into shellfish biology.

PARAMETERS OF TRADITIONAL EXPLOITATION

When using the term 'traditional gathering' with reference to shellfish we mean gathering techniques such as those described by Meehan (1982) and Poiner et al.(MS), for north Australian and New Guinea peoples respectively. -This normally consists of small parties of people, picking shells from intertidal sand, mud or reef flats and the sub-littoral fringe. This type of traditional gathering can be formally charhcterised by the following set of elements (following Catterall and Poiner, 1987),

Shellfish are gathered by people walking in the intertidal zone. The limit is the upper sub-littoral, which can only be reached at spring tides.

Shellfish are individually extracted from the surface, or, from within the sediment, either by hand or with the aid of small hand-held digging tools. Dredges or sieves are not normally used.

Individual shellfish below a certain size are likely to be rejected, but above this threshold the sizes collected reflect the available distribution rather than strong size selectiveness. This is probably to maximise gathering efficiency rather than a deliberate conservation effort, since many studies of foraging in simple nonhuman animals have shown a similar pattern (Pyke, 1984). Several studies (Hancock, 1970; Swadling, 1976; Meehan, 1982) have presented data which suggest that the minimum shellfish size collected by gatherers from intertidal flats is 20 to 30 mm (maximum dimension).

The catch is accumulated in bags, and is then transported to base by hand or boat.

Most shellfish are gathered for immediate consumption: Marketing opporturiities are limited, although some trading may occur.

PARAMETERS OF EXPLOITED POPULATION

To identify the biological attributes which are most important in determining the consequences of traditional gathering to shellfish, it is first helpful to consider the major features in the life history of a generalized gastropod and bivalve. We consider three aspects of the life-history: maturation, movement, and burying.

Maturation

Reproduction in most species is followed by the production of many eggs, from each of which hatches a swimming larva. A few species hatch a shelled juvenile directly from the egg. Immature stages grow until sexual maturity is reached. At this time growth ceases in some species; other keep growing throughout life.

Movement

The benthic shelled individuals may crawl relatively short distances (possibly, up to 1 km per lifetime for most species). Some species are totally immobile when benthic. However , pelagic larvae may potentially be carried much longer distances (hundreds of kilometres) by ocean currents. This permits recruitment from subtidal areas or distant populations. The extent of this depends on the duration of the larval stage and its behaviour, as well as on oceanographic factors.

Burying

Vertical movement shifts individuals between burial and exposure on the surface. Some species are permanently in one or other state. In others, the propensity to bury may vary with size or age (Catterall and Poiner, 1987).

POTENTIAL EFFECTS OF EXPLOITATION

These life-history factors interact in the following way with the human-gather ing strategy to determine whether a given individual shellfish is collected.

First, the size of the individual is important, since the probability of being gathered will usually be negligible up to about 20 mm, but few individuals over 30 mm would be rejected. Thus if the size at maturity is less than about 20 mm, a gathered population will always contain individuals capable of reproducing. If the size at maturity is greater than about 30 mm, then there is a risk that all or most reproductively active individuals will be removed from the local population, potentially reducing recruitment.

Second, buried individuals are less likely to be gathered then individuals on the surface, irrespective of size, since they are difficult to detect visually and only worthwhile extracting with digging tools in areas of extremely high density (for example, Meehan, 1982).

Third, subtidal individuals are less accessible than intertidal individuals. The mean low water level of spring tides is typically exposed for only a few days in some fortnights of the year. Below this level, individuals are inaccessible unless diving or dredging techniques are used. If there are subtidal populations near to qathered intertidal areas, and if the benthic stages of the life-history are moderately mobile, then local replenishment of gathered areas may occur by migration. Otherwise, the local gathered population is at risk of extinction.

Fourth, there may be more distant populations which are not exploited for some reason (for instance, inaccessibility to those walking or in small boats). Depending or-i the duration of the pelagic larval stage, larvae may recruit from these populations to the gathered intertidal populations various distances away.

Thus, the combination of the properties of size, at maturity, intertidal burying, existence of subtidal populations, mobility of benthic stages, and duration of pelagic larval stage should strongly influence a local population's persistence in the face of gathering.

A species with large size at maturity, no burying, restricted to the intertidal zone, and with pelagic larva of short duration' or lack-ing would be likely to go extinct in areas close to human,, settlements. Fortunately, (or perhaps logically) most species do not possess this, combination of attributes. Conversely, species which, reach maturity at.a large size, bury, are distributed down into the subtidal, and which have mobile benthic stages and long-duration pelagic larvae should have a high resilience to gathering.

IMPACTS ON SELECTED TROPICAL SPECIES

In Table 1, the biological and ecological attributes discussed above are presented for six tropical Australian molluscs (three bivalves and three gastropods): Anadara sp. or blood cockle, Tapes sp. or cockle, Saccostrea (Crassostrea) sp. or oyster, Trochus sp. (niloticus) or top shell, Strombus sp. and Melo sp. (amphora) or baler shell. The information in Table 1 was obtained from a variety of sources, including Brownell (1977), Yapp (1977), Nash (1984), references and data in Catterall and Poiner (1987), and unpublished data. In some cases the necessary information was difficult to obtain, and informed extrapolations were made from information on congeneric species. Even for apparently important species such as the commercially cultured rock oyster Saccostrea commercialis details of the life-history have not been published.

All shellfish considered in Table 1 mature at more than 30 mm, so all are potentially at risk on the basis of this property. For each of the remaining four properties, some of the species are at risk,. The shellfish fall into two groups: one in which the risk of local population depletion due to traditonal gathering is relatively low (few asterisks in the Table: Andara, Tapes, Strombus, Melo), and one in which the risk is high (many asterisks: Saccostrea, Trochus).

Table 1. Biological attributes important to the effects of traditional gathering, and their values for six tropical Australian shellfish species. An asterisk indicates that a particular attribute puts local populations at risk of depletion if heavily collected by traditional methods.

ATTRIBUTES	MOLLUSC SPECIES					
	Anadara	Tapes	Saccostrea	Trochus	Strombus	Melo
SIZE (mm) AT MATURITY	* 50-60	* 20-30	* 50-60 (females)	* >>30	* 40-60	* >>30
INTERTIDAL BURYING	often	often	* rare	* rare	often	often
SUBTIDAL POPULATIONS	yes	yes	* little	* little	yes	yes
BENTHIC MOBILITY	* poor	* poor	* poor	moderate	moderate	high
PELAGIC LARVAE	probably * weeks	3-4 weeks	3-4 weeks	* 3-4 days	3-4 weeks	* none
PREDICTED GATHERING IMPACT	low	low	high	high	low	low

Good data with which to test these predictions do not exist. However both Meehan (1982) and Poraituk and Ulijasvek (1981), while commenting on traditional use of a wide range of shellfish including Anadara, Tapes, Melo, mention that oysters Saccostrea in particular have apparently been collected out close to settlements, and are gathered as soon as they become available. Additionally Nash (1984) reviewed evidence that Trochus populations have been heavily overfished in almost all parts of the Pacific where they have been commercially exploited (although this is not strictly traditional gathering, the methods used were not generally technologically advanced). Therefore the predictions of Table 1 are generally supported by the available evidence.

Changes in gathering practices will alter the predicted effects of harvesting. A future task is to identify which changes to gathering practices place previously resilient populations at risk. Changes in technology which give access to buried and subtidal individuals may do this, as will technology which permits access to distant, previously inaccessible populations. Marketing will lead to increases in predation pressure, increasing the risk of overfishing.

'The shift from resilience to overfishing of Strombus gigas in the Caribbean following marketing and better technology was mentioned previously. Recent information from the Philippines (Montano, pers. comm.), suggests the Strombus luhuanus stocks there are becoming depleted following increased use for shell jewellery. Overfi-shing appears to have.driven to extinction several well-established introduced populations of Tapes philippinarum in Hawaii (Yap, 1977).

NEW INFORMATION PRIORITIES

We have already referred to the lack of good data concerning the, important parameters of traditional shell gathering (Meehan, 1982), as well as the important biological and life-history attributes of tropical and subtropical shellfish (even commercially important ones).

Below, we suggest some priorities for the collection of data relating to both sets of attributes. Unless such data are gathered it will be impossible either to predict the effects of various styles of gathering on tropical shellfish, or to assess whether traditional gathering practices could potentially deplete natural populations of shellfish. It will also be impossible to resolve the question of whether the apparent'lack of over-exploitation by traditional groups is due to a cultural conservation ethos or to the interaction of shellfish life history with gathering technology and economics.

Ethnographic Information

Collecting unit
- usual sizes of gathering groups
- sex and age composition
- number of people fed from gathering expedition

Collecting technique'
- collecting method (walk, sit, swim, etc.)
- use of diving or swimming aids
- use of tools for, extraction
- preference for surface versus buried shellfish
- specialisation of gathering trips (mainly for one species at a time? several' species?
- how is the catch carried? how far? what are limitations on distance?

Size selectiveness
- are certain sizes preferred or avoided?

Collecting areas and times
- when do gathering trips occur and what influences this?
- how are collecting localities chosen?
- how regularly is a particular locality visited?
- what is the maximum water depth during gathering?
- relationships of gathering trips with tidal cycle?
- relationships of collecting locations with distance
- method of travel

Economics
does trading occur? how often, and over what distance?

Natural history knowledge (for each species gathered)
spatial and tidal distribution
burying
sex difference, time of reproduction and recruitment
growth rate at maturity
movement capacities
miscellaneous (eg whether venomous)

Biological Information

Life history
growth rate of benthic stages
age and size at maturity
sex differences
longevity and factors affecting it
duration of pelagic larval stage

Movement
mobility of benthic stages
habits of pelagic larvae
oceanographic: current movements

Burying or other refuges
proportion buried and its relationship with size, age-, season---
proportion in other refuges such as inaccessible crevices

Distribution
depth ranqe
habitat specificity
spatial dispersion

Reproduction
duration of breeding deason
regularity of recruitment
density dependence of recruitment

REFERENCES

Brownell, W.N., 1977. Reproduction, laboratory culture and growth of Strombus gigas, S. costatus and S. pugilis in Los Roques, Venezuela. -Bulletin of Marine Science, 27, 668-680.

Brownell, W.N. and Stevely, J.M., 1981. The biology, fisheries and management of the queen conch, Strombus gigas. Marine Fisheries Review, 43, i-i2.

Catterall, C.P. and Poiner, I.R., 1987. The potential impact of human gathering on shellfish populations, with reference to some north-eastern Australian intertidal flats. Oikos, in press.

Diamond, J.M. and Veitch, C.R., 1981. Extinctions and introductions in the New Zealand avifauna: cause and effect? Science, '211, 499-501.

Johannes, R.E., 1978. Traditional marine conservation methods, in Oceania and their demise. Annual Review of Ecology and Systematics, 9, 349-364.

Meehan, B., 1982. Shell Bed to Shell Midden. Australian Institute of Aboriginal Studies. Globe Press: Melbourne.

Nash, W., 1985. Commercial culture of the marine gastropod' Trochus niloticus in Torres Strait: its feasibility and prospects. Proceedings of the Torres Strait Meeting, Port Moresby,,1985. Commonwealth Department of Primary Industry: Canberra.

Poraituk, S. and Ulijaszek, S., 1981. Molluscs in the subsistence diet of some-Purari Delta people. Purari River Hydro-electric Scheme Environmental Studies. Vol. 20. Office of Environment and Conservation and Department of Minerals and Energy, Papua New Guinea.-

Shawcross, W., 1967. An investigation of prehistoric diet and economy on a coast site at Galatea Bay, New Zealand. Proceedings of the Prehistoric Society, 33, 107-131.

Scheltema, R.S., 1971. The dispersal of larvae of shoalwater benthic species over long distances by ocean currents. in Crisp, D. (Ed.), Fourth European Marine Biological Symposium. Cambridge University Press: Cambridge, 7-28.

Swadling, P., 1976. Central Province shellfish resources and their utilisation in the prehistoric past of Papua New Guinea. Veliger, 19, 293-302.