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Management of the Omani Abalone Haliotis mariae: An Integrated Policy

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Title: *Management of the Omani abalone Haliotis mariae: An Integrated Policy*

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Abstract

The Sultanate of Oman is a small coastal nation with a maritime history, regional trade and fisheries exploitation. Among those fishery industries is Oman's coastal abalone fishery, which command the highest prices per unit of weight among the other marine living resources. This study analyzes the fishery's biological aspects, structure, socioeconomic, policies, and management practices in an attempt to provide an understanding of the prime parameters, that in turn could be utilized for sound management purposes. It also provides a description of an integrated development and management policy for the abalone fishery. Finally, it is hoped that this research will provide valuable information for the Sultanate and guidelines for other researchers.

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Acknowledgment

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Glossary

Ministry	refers to the Ministry of Agriculture and Fisheries
Government	refers to the Government of the Sultanate of Oman
DGFR	refers to the Directorate General of Fisheries Resources, Ministry of Agriculture and Fisheries.
MSFC	refers to the Marine Science and Fisheries Center, the Ministry of Agriculture and Fisheries.
Fishermen and divers	refer to Omani fishermen and may include women.
Mt	Metric ton
R.O.	Rial Omani (Oman Currency Unit)
$	refers to the US Dollar

Currency exchange

An exchange rate of $ 2.60 to R.O. 1.00 has been used in this study.

Management of the Omani Abalone *Haliotis mariae*:

An Integrated Policy

I- Introduction

The Sultanate of Oman, see figure 1, is a small coastal country located in the arid mountains and desert plains of the eastern Arabian peninsula and has a long maritime history, tradition of fishing, and regional trade. While income from oil exports forms the motor of the economy, neither the Sultanate's reserves nor its annual production qualify the nation as a "high income oil country", by the Middle East standards. Oman's per capita GDP of approximately US $ 7,500 places it in the middle income group amongst other nations, even though much of its rural population lives in poverty. Covering an area of 300,000 Kilometers (Km) square of land and 350,000 Km square of ocean waters with 1700 kilometers of coastline, the Sultanate of Oman has abundant living marine resources[1].

The country has a population of 1,480,531[2] , of which 22,329[3] people are fishermen (about 1.5% of the population). By and large, the

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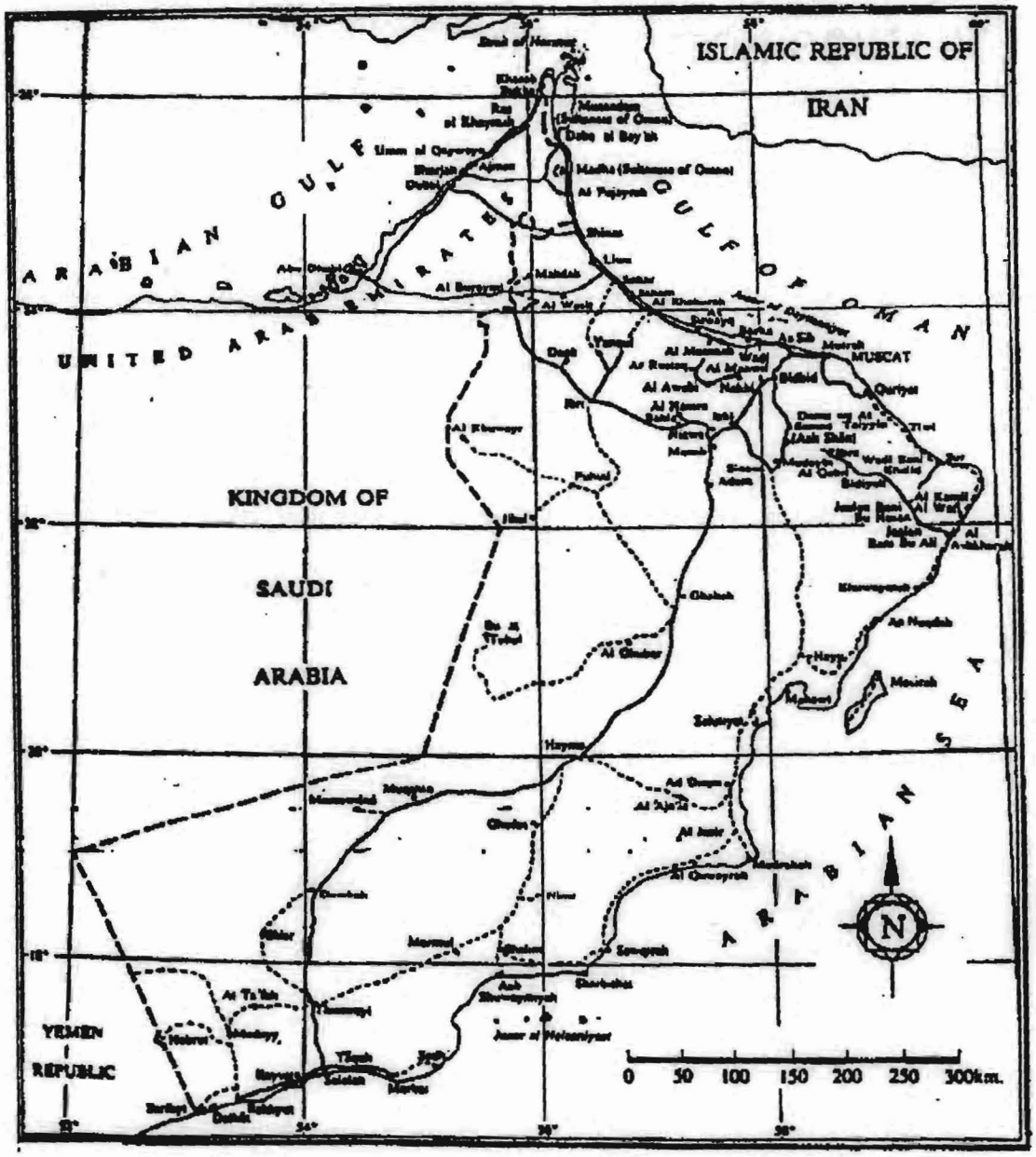
[1] Note: based on: Oman'94, which provides facts and figures about the country, is an annual publication of the Ministry of Information.

[2] Note: Oman have conducted its first population census in late 1993 and the Development Council published general population information: Development Council. Preliminary results of the general census of population, housing and establishments 1993.

[3] Note: For more information on Oman fisheries, i.e. landings, exports and imports, ..etc., see: Department of fisheries statistics. Annual statistical report for 1993. Ministry of Agriculture and Fisheries, Muscat, Sultanate of Oman.

Figure 1.

The Sultanate of Oman[1].



Source: National Survey Authority OR 1, edition 4 dated February 1993.

[1] Note: This map is not an authority on international boundaries.

agriculture and fisheries sector is the largest employment provider among all other economic sectors in the country. It employs about 52 percent of the national work force with a contribution to the national economy accounting for approximately 4.4 percent of the GDP in 1990 (World Bank, 1994)[1].

While composing a relatively small part of the national GDP, the importance of the fisheries sector cannot be ignored, especially in countries where marine resources are either a vital economic resource or a prime source of food. In Oman the average annual production of fish and shellfish that were caught for human consumption, livestock feed and exports during the last six years (1988-1993) was 121,497 metric tons valued at about 80 million US dollars (Annual Statistics Reports for 1988-1993, the Ministry).

Moreover, the nation's economy dependent on one export commodity, oil, which has very obvious and expected consequences. One example of these consequences is economic instability caused by the daily fluctuation in price. Wisely, the government in Oman recognizes the need for economic diversification. To this end, the nation is investing in development of sectors other than oil, including fisheries, so as to expand income generation and employment opportunities.

[1] Note: Upon Oman's government request to the World Bank to study the country's economy and recommend changes the World Bank produced the following report: The World Bank. Sultanate of Oman sustainable growth and economic diversification. Report No. 12199-OM. May 31, 1994.

Coinciding with this endeavor and recognizing that one of Oman's living marine resources is its coastal abalone fishery, which provides important seasonal employment opportunities and considerable income to remote coastal communities, this study provides a comprehensive review and analysis of the Oman abalone fishery. It represents the first comprehensive and multi-discipline study ever done on specific fish species of the Omani marine living resources. It also pioneers the documentation of the history of the Omani abalone fishery, which has provided an important source of income and employment to remote coastal communities for many decades.

The comprehensive overview includes a detailed description of the structure of the fishery, its socioeconomic importance, and the constraints blocking development and expansion of the fishery. It also considers alternative approaches to managing the fishery utilizing a greater community role in its daily management.

First this study reviews and analyzes the available biological information on the endemic Omani abalone species Haliotis mariae in an attempt to provide an understanding of the fishery as well as relevant biological foundations for a strong management strategies. Second, current management activities and practices including legal measures as well as the status of the fishery are analyzed as are projected long term future consequences on the fishery and the abalone fishing communities.

Finally, the study concludes with a description of an integrated management and development program.

A major constraint, which confronted this study is the unavailability of information. Needed studies have not been conducted and most documents concerning the Omani "Sufailah", i.e. the Arabic name for abalone, fishery are in unusable form. For example a number of biological studies and reports have been generated over the last two decades, in which all, but two unpublished documents are based on analyses of discarded abalone shells. Such studies, in my opinion, should not utilized for management purposes. The other two reports are based on studying actual living abalone in their natural habitats and controlled environments. For example, Johnson (1990) and Sanders (1982) based their reports on studying discarded abalone shells, but Stirn et al. (1994) and Ogawa (1994) studied abalone in their natural habitat and controlled environments.

To overcome information constraints the author has traveled to the Sultanate of Oman and conducted discussions with a wide spectrum of abalone interests in the country. These interested parties include individuals from academia, government agencies both local and national, fishermen and divers, merchants and fisheries private sector. The visit to Oman lasted for three months and the interviews were conducted in two phases. The author examined all abalone documents and documents to related subjects. After acquiring a reasonable knowledge of the fishery and

related parameters, the author conducted the first phase of abalone discussions. In this phase interviews were held with members of academia, government agencies including the ministry, and major fisheries companies.

In the second phase, the author conducted a one week visit to southeastern Dhofar, the city of Salalah, and towns of Sadh and Marbat during the period of 24-30, July 1994. During this visit a number of discussions as well as interviews were conducted with people of Marbat and Sadh, fishermen and merchants of Sadh, and government officials in the Governorate of Dhofar, including officials of the Department of Fisheries Resources in Salalah, the Wali (local governor) of Sadh as well as the representative of Sadh in the Majlus Al-Shura (a consultative council). The author then returned to Muscat and discussed abalone matters with fisheries officials within the ministry, and finally, with individuals from the private fisheries sector, including but not limited to general managers of the leading fisheries companies.

II- Materials and methods

This study is in part developed on the basis of the fact that, in relation to living marine resources, social and economic environments and practices affect the natural ecosystem of the marine resources which are being utilized. There are webs of linkages within sectors and between one sector and another. Management and development planning should investigate the significant linkages and connections between for example yellowfin tuna fishery expansion in the Sultanate of Oman and availability of transportation facilities, i.e. ports, airports , roads, etc. Another example could be the linkages between that fishery development and markets as well as marketing routes and facilities available to participants. It should be understood that decisions on certain policies and management strategies in one sector spills over with mostly negative implications on other connected sectors. Thus, it is necessary to establish a complete view of policy implications before making a decision on the next course of actions.

On the other hand, management and development of marine resources must be based on scientific foundations, so the risk of failure and the level of uncertainty are minimized. This scientific foundation in relation to living marine resources contributes to our understanding of their biology, ecosystem interactions, and effects of anthropomorphic and natural factors on the marine environment. It should be understood that there will always

be a need for more information and decisions in most instances will have to be made in situations of high uncertainties.

For the abalone fishery our understanding of its biological aspects and as they connect to the socioeconomic environment as well as the ideological environment of the people involved in its exploitation and management should form the foundation of an integrated[1] sustainable[2] abalone development and management regime.

Therefore, this study is based in part on review and analyses of the existing studies and information. Such information includes reports produced for or by the government of Oman as well as publicly available

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[1] Note: integrated management is an acute concept, that attempts to establish a complete picture environment for the decision making process. It, however, rests on integration of policy implications through, among other things, strong coordination mechanism. The following sources provide excellent discussions on integrated management.

Cicin-Sain, B., 1993. " Introduction to the special issue on integrated coastal management: concepts, issues and methods." Ocean & Coastal Management 21 (1993) 11-43.

Levy, J., 1988. " Towards and integrated marine policy in developing countries." Marine Policy Vol. ? P. 326-342. October 1988.

Olsen, S. B., 1993. "Will integrated coastal management programs be sustainable; the constituency problem." Ocean and Coastal management 21 (1993) 201-225.

Thia-Eng, C., 1993. " Essential elements of integrated coastal zone management." Ocean & Coastal Management 21 (1993) 81-108.

Underdal, A. 1980. " Integrated marine policy What? Why? How?." Marine Policy Vol. 4 No. 3. P. 159-169.

Vallega, A. 1993. "A conceptual approach to integrated coastal management." Ocean and Coastal Management 21 (1993) 149-162.

Vallejo, S. M. 1993. "The integration of coastal zone management into national development planning." Ocean and Coastal Management 21, 1-3 (1993) 163-182.

Watt, D. C. 1990. " An integrated marine policy: a meaningful concept?." Marine Policy Vol. 14 No. 4. P. 299-304.

Willman, R. and David I., 1993. " Integrated coastal fisheries management." Ocean & Coastal Management 21 (1993) 285-302.

Weide, J. 1993. " A systems view of integrated coastal management." Ocean and Coastal Management 21 (1993) 129-148.

[2] Note: The concept of sustainable development, which is to provide policy guidance for environment and economic development, appears in Chapter 17 of Agenda 21 of United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. An excellent discussion is provided in:

Cicin-Sain, B., 1993. "Sustainable development and integrated coastal management." Ocean & Coastal Management 21 (1993) 11-43.

documents on the subject of the Omani abalone whether in the libraries in the Sultanate or the United States. The author had access to the above mentioned government documents by virtue of being a member of the Ministry of Agriculture and Fisheries' staff. The author's background in fisheries science as well as his experience in fisheries management in Oman along with currently gained knowledge provided a solid basis for the conduct of this study.

In conclusion, this study is based on an examination of existing data supplemented by on site interviews. There are still a number of areas concerning abalone where more research is needed. It is concluded that a higher level of priority should be given to the development and management of this most valuable living marine resource, which commands the highest economic value per unit of weight among all other Omani living marine resources.

III- Biological review and analyses

1- Biology

Abalone are large herbivorous gastropods mollusks, i.e. marine snails. There are approximately one hundred species of abalone (Fallu, 1991; and Hahn, 1989) distributed world wide in temperate and tropical waters ranging from the low tide line to depths exceeding 50 meters (Hahn, 1989). Abalone live on or under rocks, and boulders and among seaweed, which are their major source of food. Taxonomically, all of the 100 species of abalone belong to the genus *Haliotis* . The generic name Haliotis, which means "sea ear", was given by Linnaeus in 1758 (Bevelander, 1988). Table 1, shows the taxonomy of the Omani abalone *Haliotis mariae*.

Molluska is the phylum, which includes abalone along with chitons, snails, clams, squids, octopuses, and others. These are non-segmented invertebrates with a mantle cavity that normally contains the gills, a definite head with radula, and a muscular foot. Gastropoda is the class, which besides abalone includes snails and slugs. These are invertebrates that have one shell, or no shell at all, but move by means of a broad muscular foot. Abalone are members of the Subclass Prosobranchia, which also includes limpets, periwinkles, cowries, whelks, and others. Members of this subclass are characterized by undergoing torsion during the veliger larval stage so that the mantle cavity and the gills come to lie at the front of the body, and the nervous system is twisted. Haliotidae is the

Table 1. Taxonomy of the Omani abalone[1].

Kingdom	Animalia
Phylum	Molluska
Class	Gastropoda
Subclass	Prosobranchia
Order	Archeogastropoda
Suborder	Zygobranchia
Superfamily	Pleurotomariacea
Family	Haliotidae
Genus	Haliotis
Species	mariae[2]

[1] Customized from: Fallu, R., 1991. Abalone farming. Fishing News Books, Osney Mead, Oxford, England.

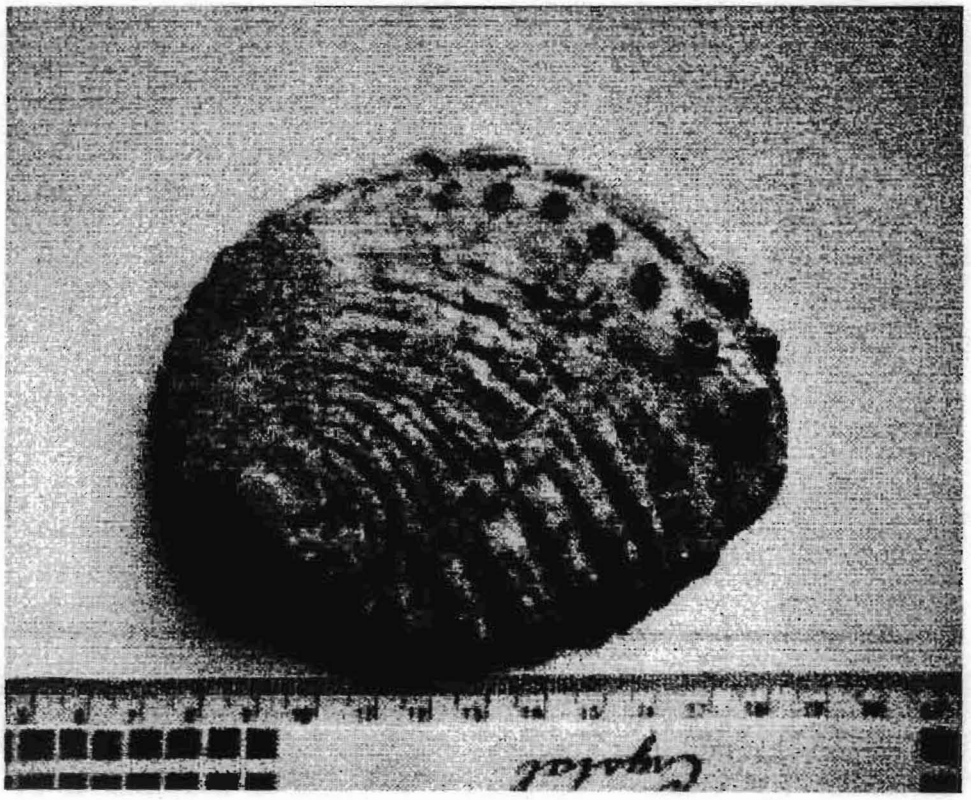
[2] Wood (1828) is the author who published the name and figure, according to the Index Animalium.

taxonomic family of abalone, where its members have flatted shell with greatly reduced spire. The shell has a row of holes through which respiration, and excretion take place, and some carry gametes.

Abalone are, as mentioned above, marine snails with one shell (photograph 1), which covers most of the soft tissues. Looking from above, abalone generally has an oval shape with the long axis anterior-posterior, but some species are more elongated than others. Among world abalone species is H. mariae, which is moderately elongated with clear spiral formation on the shell. Although spiral shells are common among snails, the abalone has a spiral flattened shell to almost the shape of a cup. It is, however, shallow only about a fifth as high as it is long. The head of the abalone is anterior and the apex of the shell spiral is posterior at the right hand side. Figure 2, shows the internal organs of abalone.

The outerside of the shell is usually rough with other mollusks, sponges, or algae growing on it. The inerside of the shell, after removing the flesh, is seen to be smooth generally pearly and iridescent. This color makes the shell of the New Zealand abalone, H. iris, very attractive and much sought after (Fallu, 1991). The shell has a row of holes, mostly 6 in H. mariae, extending anteriorly from the left hand side to over the head. The posterior holes are usually blocked and anterior ones are the biggest. Abalone use these holes in the respiration and excretion process.

Shell length, the greatest linear dimension, is more convenient to

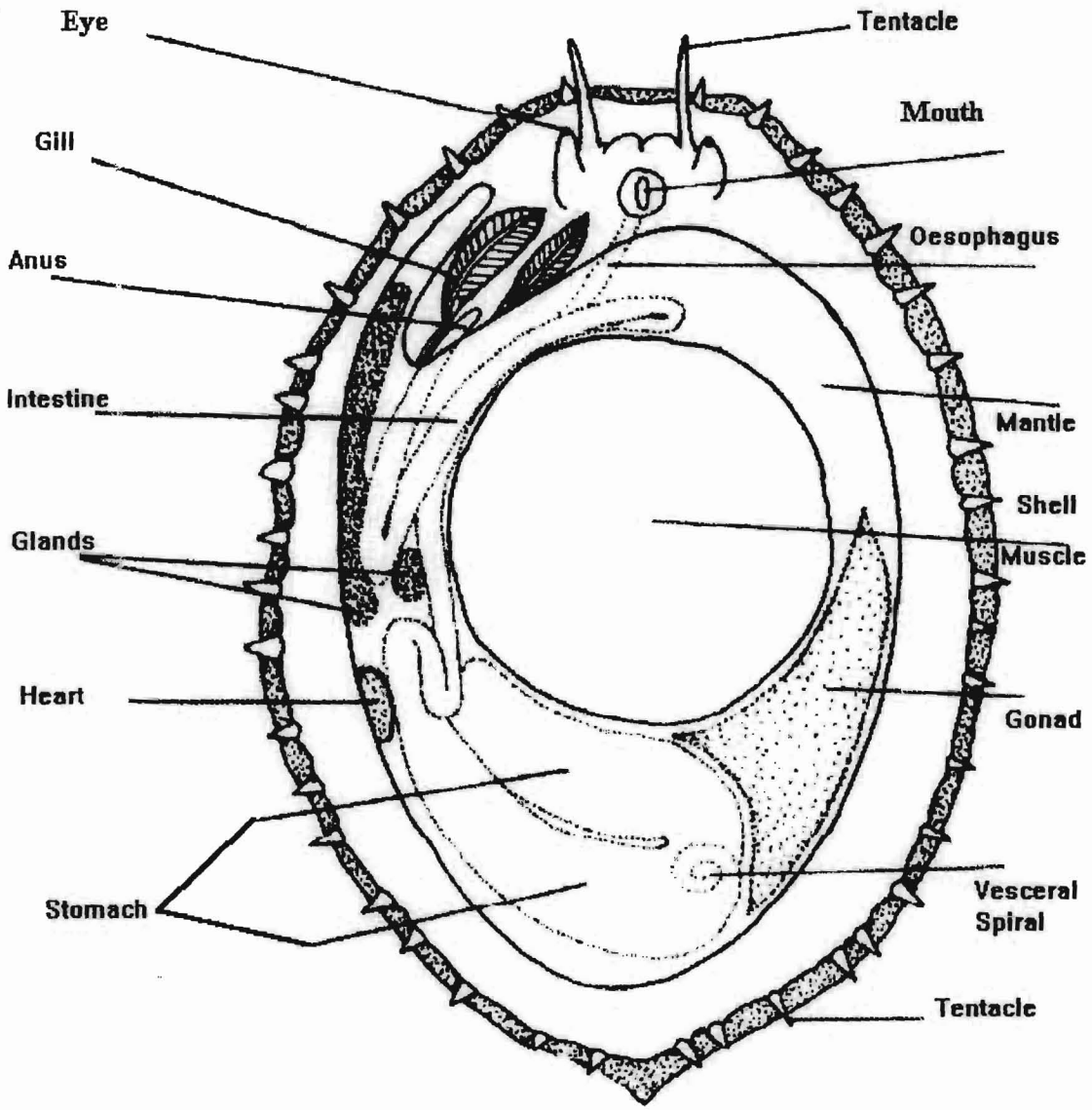


Photograph 1. An abalone, Haliotis mariae, shell from Sadh Sultanate of Oman[1].

[1] Photographed by the author on August 15, 1994.

Figure 2.

Internal organs of abalone.



Source: Customized from: Fallu, R., 1991. Abalone farming. Fishing News Books, Osney Mead, Oxford, England.

measure and is one of the most commonly used measures of size (growth) of abalone. Shell length is usually related to body weight (fresh flesh) and it is thus, more practical to use shell length as an indicator of growth rather than to pull the animal out of the rocks to weigh it. Shell length to weight varies from species to species (Fallu, 1991), such as the shell of the red abalone (H. rufescens) as well as the shell of the Omani abalone (H. mariae) cover almost all of the foot, but the shell of the ear abalone (H. asinia) is much smaller and covers only small portion of the foot.

Abalone in the natural environment hold onto rocks and boulders with their feet in snail-like way. Abalone has series of tentacles by which it detects predators and food. When abalone is turned upside down the foot is the largest visible organ. The edible flesh (organs) of abalone are, usually the foot, the mantle, and the gonads. At the front of the foot is the head, which has no teeth, but a tongue-like organ covered with teeth - the radula which is used to rasp macroalgae, is snail-like with tentacles. Under the row of holes of the shell, there are paired gills located in the mantle cavity where sea water is drawn anteriorly and passed over the gills, oxygen is absorbed and waste materials are excreted. Then, the used water is expelled out through the holes of the shell.

The digestive organ is hidden behind the foot, which could represent an inverted mushroom with the sucker on the outside and the stalk of the foot is attached to the middle of the shell. Abalone are heterosexual, the

sexes are separate, with the reproductive gonad adjacent to the shell holes. The only identification measure of the sex in abalone is by dissecting the animal and observing the color of the gonad directly. While females have blue, green, or brown gonads, males have gonads that are cream or ivory in color. The size and color of the gonads in abalone are good indication of sex and sexual maturity. In terms of its respiratory system, abalone's blood contains the copper based blood pigment haemocyanin, which is colorless when oxygen is deficient (Fallu, 1991).

2- Distribution and abundance of abalone

A- Worldwide

As it is indicated previously, worldwide there are about one hundred or so species of abalone, most of which are too small or in very low abundance to be of significant commercial value to harvesters. The most important commercial abalone are presented hereafter with reference to their location.

North America

The red abalone, H. rufescens, is the largest in the world with maximum length of 280 mm (Tegner, 1989) and weighing over 1.7 kg (McAllister, 1976). Red abalone, which is historically the most important

commercial species in California, is also found in Mexico and Chile (Fallu, 1991; Hahn, 1989).

The green abalone, H. fulgens, is found from Santa Barbara to Baja California and on the Channel Islands. This species of abalone has an iridescent shell, that is considered to be the most beautiful in the world (Hahn, 1989).

H. Orrugata is known by the common names: corrugated or yellow, pink abalone; it is distributed from intertidal to 60 m depth along the coasts of south California (Cox, 1960; Tegner, 1989).

H. sorenseni, which is commonly called white, or Chinese abalone, reaches a maximum length of 250 mm (Cox, 1960). Because of its tender white meat, this species is the most highly valued abalone species in North America (McAllister, 1976; leighton, 1972). White abalone occur from southern California to Mexico in 12 m to more than 35 m depth (Cox, 1960; Howorth, 1978).

H. assimilis, threaded abalone, may reach a maximum size of 175 mm (Hahn, 1989). However, Tanger (1989) estimated the maximum size of the threaded abalone off California at 152 mm. Threaded abalone are found in greatest densities from 23 to 35 m depth from central California to Mexico (Cox, 1960).

H. Cracherodii, is known commonly as black abalone, which (Cox, 1960) could reach 200 mm in size, is found intertidally up to depths of 6 m

in waters 7 to 24° C off the coasts of California (Howorth, 1978). Black abalone is not significant commercial species, due to its dark meat and inferior flavor (Cox, 1960).

The flat abalone, H. walallensis, reaches a maximum shell length of 178 mm (Hahn, 1989; Tegner, 1989). Flat abalone are distributed from British Colombia to the Mexican waters. They are found from intertidal to 17 m in northern California, 7 to 20 m in central California, and at depths more than 27 m in southern California (Howorth, 1978).

Haliotis kamtschatkana, pinto abalone, reaches a maximum shell length of 152 mm (Howorth, 1978; Tegner, 1989). It is found from the Aleutian Islands to south California in intertidal waters to depths of 17 m. In its southern range of distribution, the shell is long, narrow, highly arched, has a rough irregular surface and prominent spire. However, in its southern range, the shell is oval, not as highly arched with smooth surface, and the spire is not as high (Cox, 1960). The pinto abalone has a lower meat weight in proportion to shell length than other species of North America (Livingstone, 1952).

Japan

The ezo awabi, H. discus hannai, which grows to a maximum shell length of 200 mm, has a thin elliptical shell and is found from Siberia to China (Ino, 1980). This species of abalone is the only species in Japan tolerant to cold water temperatures of below 5° C (Uki and Kikuchi, 1984).

Although Haliotis discus hannai habitat is restricted to intertidal waters to 5 m depth (Imai, 1977), is the most commercially valuable abalone and the majority of cultured abalone seed in Japan (Inoue, 1976).

H. discus, which is commonly called kuro awabi, (Ino, 1980) grows to a maximum length of 200 mm and has a slightly hard meat. It is found along central and southern Japan with optimum abundance at 2 m waters(Imai, 1977).

Tokobushi, H. diversicolor supertexta, is a small species of abalone reaching about 50 mm shell length and is of negligible contribution to the fishery in Japan (Imai, 1977).

Madaka,H. gigantea, is the largest Japanese species reaching a length of 250 mm and has a tender meat (Ino, 1980). It is a deep water species with the highest abundance between 10 and 50 m depth along islands in the Sea of Japan southwest of Hokkaido (Imai, 1977).

Megai, H. Sieboldii, (Ino, 1980) grows to about 170 mm and has a soft tender meat (Imai, 1977). It is distributed at central and southern Japan at depths mainly between 2 and 28 m (Inoue, 1976).

H. Asinina, mimigai, has very small, thin, and narrow shell, which covers only a small portion of the foot. It is found along the tropical and subtropical regions of Japan at 7 m depth (Ino, 1980).

Korea

Along the Korean coast, there is a 12° C isothermal line at a depth of 25 m deviding the coast into two thermal regions. To the north of this line H. discus hannai is found, but H. discus, H. gigantea, and H. sieboldii are found to the south of the isothermal line (Ino, 1980).

New Zealand

The black paua, H. iris, which grows to 170 mm, has very iridescent shell. This intertidal abalone (<9 m depth) has wide distribution along the coasts of New Zealand. Despite its highly valued shell the meat is dark, has inferior flavor, and of poor quality (Dutton, 1981).

H. australis, silver paua, is small abalone with a maximum shell length of 125 mm and has a wide distribution along the rocky coasts of New Zealand. This species is very active and observed moving around during the day (Dutton, 1981).

H. virginea, virgin paua, which is further subdivided into four subspecies, is very small abalone reaching a maximum shell length of only 70 mm (Dutton, 1981). This abalone species lives beneath rocks in the intertidal waters and has the widest distribution of all abalone species in New Zealand (Murry, 1983).

South Africa

H. midae although small is the only commercial abalone in South Africa. This abalone is found near Cape Town and grows to a 90 mm shell length in 6 years (Newman, 1969).

Australia

The black lip abalone, H. ruber, is the most important species in Australia reaching a shell length of 200 mm. It is found along the southern coast and Tasmania in waters < 10 m deep (Harrison, 1969).

The green lip abalone, H. laevigata, which grows to 140 mm total size, has white meat and occurs at depths < 40 m (Harrison, 1969).

H. rosei, which is the smallest commercial species in Australia, grows to 80 mm in length and found in waters < 5 m (Shepherd, 1992).

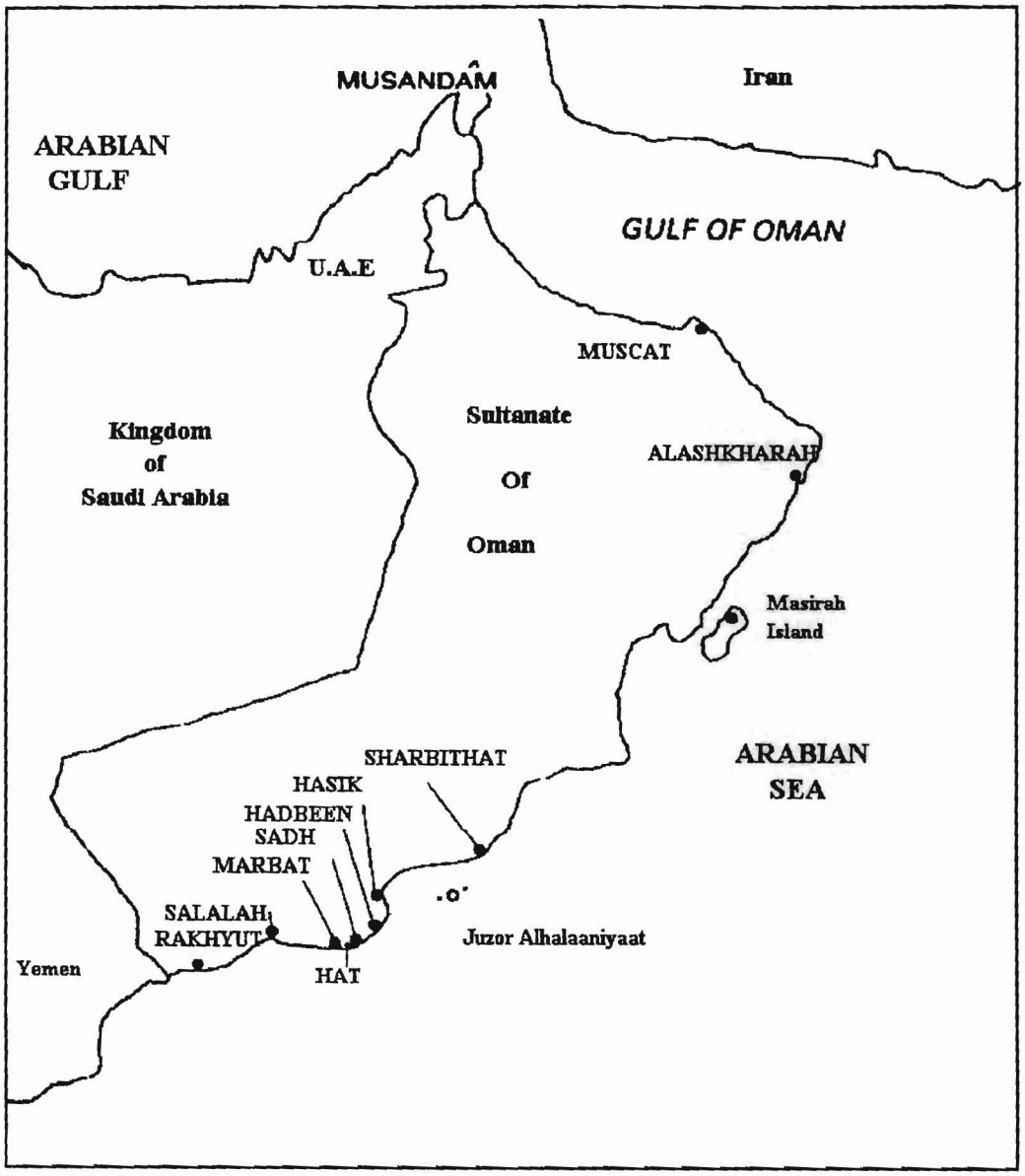
B- In Omani waters

The haliotid gastropod Haliotis mariae is considered to be an endemic species restricted to the Omani coastal rocky waters of the Arabian Sea (Figure 3.). Abalone exists along the southeastern coast of Oman with significant landings at towns of Sadh, Hadbeen, Hasik, Marbat, and Sharbithat. Apparently, Haliotis mariae is centrally located at the intertidal waters along the coasts of the town of Sadh and its immediate vicinity.

The full range of distribution of abalone along the coasts of Oman has never been surveyed. There is a great possibility of finding commercial abalone stocks along coasts, where it had been fished in the past but is not presently fished. These areas include coasts of Masirah Island, Juzor alhalaaniyaat (Johnson, 1990), Rakhyut, and as far north as Alashkharah. The author visited the southeastern coast of Oman in the late summer of 1994 and spent three months investigating as well as interviewing

Figure 3.

Abalone landing ports in the Sultanate of Oman.



individuals interested in the abalone fishery on issues related to abalone fishery development and management in Sadh, the center of the abalone fishery. It is the author's belief on the basis of anecdotal data that abalone have existed and has been fished from Rakhyut near the southern boarder of the Sultanate to Alashkharah in the north. Although the abalone may have been existed in batches of small stocks, this coastline is vast extends about one thousand kilometers.

Although abalone stocks have been found between Marbat and Sharbithat as well as on Juzor alhalaaniyaat and the east coast of Masirah Island, they were most abundant near Sadh with large numbers at depths exceeding 6 m (Johnson, 1990). Sanders (1982) surveyed the coast along Sadh and its vicinity through eighteen ten-minute dives covering intertidal waters to 18 m depths. He suggested that density and size of abalone are directly related to depth and abalone was present in waters as deep as 18 m in cracks and crevices of rocks above a sandy bottom. Abalone juveniles were found in clusters at 4 to 6 m intervals on the undersides of boulders and rocks. Ogawa (1994) found abalone at Sadh in waters thirty m deep, which by and large is the maximum depth at which abalone is discovered. This could be the first credible evidence supporting the old hypothesis suggesting the existence of deeper population of abalone acting as a buffer for the heavily fished coastal stocks.

During the eighteen standard dive survey Sanders (1982) collected 409 individuals of abalone with mean catch of 22.7 pieces per dive. Then, he assumed that divers covered 1196 m^2 per diving hour and on this basis measured the total area surveyed to be 1998 m^2 with mean abalone density of 0.205/m^2. He also further assumed that the handling time was 5.1 seconds per abalone and the width of the abalone producing reef was 100 m. Later, he measured the length of this coastline by using a navigational chart and assumed the abalone abundance in the un-surveyed area is about the same as in the surveyed area. He finally, estimated the total abundance of abalone in the currently fished areas is approximately 1,804,000 pieces of abalone. Previously, however, Development Applications Corporation (1981) surveyed approximately the same coastline with sixteen separate dives and estimated the abundance of abalone to be 1,200,000 individuals. Besides those two surveys there has not been any attempt to assess the actual size and the relative abundance of this valuable fishery resource.

The Omani abalone Haliotis mariae, constitutes a very valuable marine resource, which probably has existed for many decades, nevertheless, remains not understood. This endemic abalone species is comparable with other large commercial abalone on a worldwide basis. It possibly has some unique biological features distinguishing it from other abalone. However, the omani abalone has evolved in its nutrient-rich environment completely

isolated from other abalone species and has developed its own adaptation techniques.

Clearly, there has been little effort to study this abalone species especially in fishery management fields such as, life history, resource mapping, distribution, abundance, and mariculture as well as abalone pearl and shell culture and utilization. Thus, there is an urgent need to lunch such studies immediately. The Marine Science and Fisheries Center has the necessary capabilities to conduct such activities , if well structured, coordinated and motivated.

3- The abalone coast

The coast adjacent to Salalah city consists of rocky shores, long wide sandy beaches, coastal cliffs, some of which are visually gorgeous and of considerable landscape value (IUCN/ROPME/UNEP, 1985).

The rocky coastline of Southeastern Oman is primarily composed of metamorphic rocks, and consolidated sedimentary limestones. These rocks, by their very nature are relatively erodable by wave action, especially during the monsoon season. Along the abalone coast and as one goes northward the coastal topography increasingly becomes more rigid and the rock formation changing to hard (igneous) rocks, and sandy beaches become confined only to small embayments and inlets. These hard

platforms produce many cracks and crevices in the rock structure giving rise to flora and fauna that are eco-adapted to the ambient environment.

Furthermore, the motor of the unique ecosystem off the southern coast of Oman, as it appears to me, is the seasonal wind driven upwelling. The prevailing monsoon gyre during the summer months brings cold nutrient rich water from the deep Arabian Sea given rise to a unique ecosystem among other Omani coasts. Usually, tropical marine ecosystems are driven by sea grass beds, mangroves forests, and coral reefs, but the unique ecosystem off the southern coast of Oman is also motorized by planktonic and benthic algal resources, which provide additional forms of energy to that environment and subsequently boosting its productivity.

As I observed rocks and mountains along the abalone coast, they appeared growing. That is, trails of wave erosion are clear and follow a systematic pattern from top of platforms down to the surf zone. The growing mountains is an evidence of tectonic activities, where apparently the land plate is overriding the Arabian Sea plate producing a rigid mountainous coast.

4- Habitat and Environment

A cornerstone to the understanding of the biological characteristics of the abalone is the understanding of its habitat as well as the seasonal changes in environmental conditions prevailing off the southeast coast of

the Sultanate. Therefore, this section provides the necessary description of these conditions.

The major factors affecting the oceanographic environment of the Arabian Sea off the coast of Oman could be attributed to the southwest and northeast monsoons. During the period from approximately May to September, the southwest monsoon system causes the surface waters to be replaced by colder, and nutrient rich deep waters. But during the period from November to March, the wind pattern changes producing the seasonal northeast monsoon, which is associated with a much less wind driven water circulation.

This seasonal wind driven upwelling regime imposes low temperatures on otherwise tropical environment, specially during August when water temperatures reach lowest levels of between 18° to 21° C. Taylor (1985) noted that the presence of large abalone, Haliotis mariae, which are normally associated with cooler waters, suggests that the current upwelling system has existed since the Lower Miocene period, for 15 million years. The water temperature increases to 26-28° C in November, but decreases in February to 22-24° C in association with seasonal decease of the seaweed production. Thereafter the sea temperatures increase rapidly to high levels of 25-27° C in May-June (Sanders, 1982; Johnson 1990).

The habitat of abalone in the fishing ground has many cracks which run along the rocky substrata where numerous rocks of 3-4 m in diameter and

40-50 cm boulders observed, by Ogawa (1994) to form large accumulations on the bottom of the faults. A thick community of the macroalgae Sargassopsis zanardinii on the surface of rocks and boulders with the phenomenon of Isoyake[1] and drifting Sargassopsis zanardinii with many feeding traces in the cracks and on the bottom of the faults are common (Ogawa, 1994).

The wind driven seasonal temperate ecosystem, which is attributed to the abundance of nutrients accompanied with cool temperatures, prompts algal blooms of Ulva sp. And the growth of shallow seaweed forests of Sargassopsis sp., Ecklonia radiata, and Sargassum sp. (Barratt et al., 1986). At the village of Hat, which is located south of Sadh, dense algal forests grow to a depth of 6 m, but beyond this depth concentrations of coralline algae and corals dominate the bottom to approximately 10 m, where the rocky bottom give rise to soft substrata composing mainly of sand (Shepherd et al., 1992).

5- Life Cycle

One of the vital prerequisites of sound management is an understanding of the natural life history of abalone. Generally, the life cycle of most animals have evolved to match their environment, where environmental changes stimulate adaptation mechanisms. Environmental changes, which

[1] Isoyake as described by Ogawa (1994) is the presence of eaten up plumelets of macroalgae before they grow up to fronds. This is due to the presence of herbivorous marine animals, such as abalone and sea urchins.

possibly act as stimuli may include variations in temperature, day / night lengths, and availability of suitable food (Fallu, 1991). In this context, different species of abalone have evolved in adapting to different parts of the globe they live in, so the magnitude of stimuli to which abalone respond may vary, but most abalone species respond to similar environmental factors. Sex in abalone is separated and abalone adults discharge sexual material in the water column during spawning. Fertilized gametes develop into a Trochophore, which in turn grows into a Veliger, which are both drift and join the zooplankton community. Finally, the Veliger larva develop into creeping Staee, at which settlement may occur (Fallu, 1991). Figure 4 shows a suggested life cycle of abalone.

6- Sexual Maturity

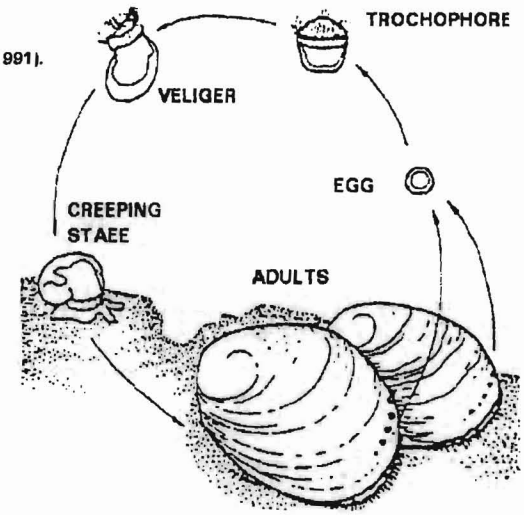
In early November 1991, i.e. the beginning of the legal fishing season, Shepherd et al. (1993) collected and identified samples of gonad from the commercial divers at Hat, for sex and the stage of sexual maturity. Those gonads were found to be either rounded or polygonal indicating mature abalone and imminent spawning. Fecundity (E), which is the number of eggs produced by one abalone female in millions, is estimated to have a linear relationship with total weight (W) in grams. Shepherd et al. (1993) estimated the following relationship: $E = 0.018\ W - 1.01$

Apparently, the existence of linear relationship between fecundity and

Figure 4.

Shows a suggested life cycle for the abalone, Haliotis mariae.

Sperms and eggs are released into the water to form fertilized eggs which hatch and developes through several pelagic stages, such as the trochophore and veliger pelagic larval stages (Shepherd & Johnson, 1991). However, Stirn et al. (1994) observed that the morphology and temporal phases of larval organogenesis are somewhat different from other species. One example of this eco-adaptation is the spawning of monolayer-eggs or substratum-attached egg masses by female abalone, Haliotis mariae.



total weight is customary among abalone species (Hahn, 1989). Size at first sexual maturity was determined, by Shepherd et al. (1993) by contrasting percent of sexually mature abalone against their size and sexual maturity estimated between 60 mm and 100 mm at Hat and Hadbeen. However, the fifty percent sexually mature population estimated at 65 mm for Hat, but 75 mm for Hadbeen and possibly 55 mm for Sharbithat abalone stocks. Since, sexual maturity is age-dependent rather than size-dependent (Shepherd et al., 1993), the sites that have fifty percent of the population sexually maturity achieved at larger sizes suggest higher growth rates. This clearly suggests differences in growth with different localities, which is consistent with the author's findings from discussions with divers and fishermen.

Stirn et al. (1994) found abalone spawning at age less than one year with an egg production range of 4-8 X 10^5, but Sanders (1982) suggested 2^+ year as the age at first sexual maturity. Shepherd et al. (1993) found that the sex ratio of the Omani abalone could change from higher percentage of females among young populations to equal, i.e. 1:1, for 100-110 mm size populations. Johnson (1990) also estimated equal sex ratio abalone populations along the southeastern coast of Oman.

7- Mortality and Recruitment

Recruitment or first size entering into the fishery was estimated to fully occur at second year age class for Hat populations, but possibly third year cohorts at Hadbeen and Sharbithat. A length-weight equation was estimated 44 abalone at Hat, that relationship shows a non-linear pattern between weight (grams) and length (mm) of H. mariae. The equation is $W= 0.00167\ L^{2.98}$ (Shepherd et al., 1993). Following methods of counting the number of annual growth checks on abalone shells (Sanders, 1982) that are left along beaches, Shepherd et al. (1993) estimated a life expectancy of 11 years for H. mariae.

The maximum yield is estimated to occur at 3^+ to 4^+ year age class and at the present level of exploitation and age at first capture egg production is at 2-29 % only, Where as a worldwide accepted minimum is at 40 %, which will maintain sustainable recruitment levels. This, however, translates to raise the legal minimum size to 105-115 mm or 4 year age, which is not feasible economic and political idea.

Several scenarios for the natural mortality of the Omani abalone were suggested, one of which is 0.53 per year with the basis or rationality is length-frequency analysis of piles of discarded abalone shells (photograph 2) from the commercial fishery. Another estimate is 0.47 with anecdotal data from divers being its basis (Sanders, 1982). Higher levels for fishing mortality is suggested as between 0.6 and 1.0, by Sanders (1982). Shepherd et al. (1993) estimated the natural mortality of the Omani abalone

Photograph 2. A pile of discarded abalone shells, by commercial divers and used for abalone biological studies[1].

[1] Photographed by the author on July 27, 1994.

to range between 0.3 and 0.5, but fishing mortality of 0.6 to 1.2.

However, Siddeek and Johnson (1993) estimated total mortality of Sadh male abalone at 1.7 per year and 1.57 per year for females during 1987 to 1989 fishing seasons. A considerably high total mortality estimate is suggested for Sadh abalone of 2.37 per year and, but a lower estimate of 1.66 for Hadbeen, based on analysis of length-frequency of discarded shells, by commercial divers in late 1991. This suggest higher fishing pressure on abalone populations along Sadh coasts, which is reasonable as it is the center of the abalone fishery in the Sultanate. Shepherd et al. (1993) estimated low egg production of 2-8 % at Hat and age of entry to the fishery of 1^{+} year cohort, as a direct result of intense fishing effort on the sexually immature abalone. Assuming high reliability to these finding, then the fishery at Hat is at imminent risk of recruitment over-fishing.

8- Growth and nutrition

Despite all abalone species are classified within the genus Haliotis and have a worldwide growth parameter (k) of between 0.2 to 0.5 which is about 1.3 to 2.5 mm per month (Days and Fleming, 1992), the Omani abalone has k values of (Sanders, 1982) 0.75 per year which is about 4.3 mm per month. Stirn et al. (1994) measured growth of cultured abalone at a typical rate of 3.3-4.3 per month with a maximum of 4.8 per month, which is very high growth rate for abalone in a worldwide basis.

Shepherd et al. (1993) estimated a mean growth rate of 43.1 mm per year and measured growth of seven tagged abalone, released, and recaptured after 308 days at liberty in their natural environment with an average growth rate of 25 mm per year.

The Omani abalone H. mariae inhabiting one of the largest upwelling ecosystems in the world (Savidge et al., 1988) shows exceptionally high growth rate within its natural nutrient-rich temperate waters occurring in a tropical environment. In this environment young abalone are only found on crustose coralline algae under boulders (Shepherd et al., 1993), but with increasing size abalone juveniles move into crevices and cracks where they remain for many years. Abalone feeds on a wide range of diet consisting mainly of macroalgae which include besides red algae a verity of brown seaweed. Examples of these are the dominant endemic kelp Sargassiopsis zanardinii, the deep water kelp Ecklonia radiata, along with many species of the genera Sargassum, Cystoseira, Spathoglossum, Endarachne, and Suhria (Stirn, et al. 1994).

9- Spawning season

Several estimates of the spawning season of the Haliotis mariae are available in the relevant biological documents. While Sanders (1982) suggests that the major reproductive season is October to November,

Shepherd et al. (1993) January to March. However, Siddeek and Johnson (1993) suggest two spawning seasons with a major peak from November to January, which is in turn consistent with the findings of Stirn et al. (1994) of two spawning seasons, one during the fall and the other on spring. Ogawa (1994) also suggests a major spawning season of three months including November. This clearly indicates uncertain findings, which could not be used for management purposes. It is also possibly indicates inconsistent scientific procedures, which may lead to findings that are questionable for management purposes. Nevertheless, the ministry should launch its own studies through the MSFC, so the scientific procedures could be monitored and management needs are fulfilled.

10- Competitors and predators

The highly cryptic behavior of young abalone may relate to their susceptibility to predation. Spiny lobster, octopuses, crabs, fishes, and predatory gastropods may feed on juveniles of abalone (Salon and Breen, 1988). However, predators of adult Haliotis species include fishes, sea stars, crabs, and octopuses (Cox, 1962; Tegner and Butler, 1989).

Ogawa (1994) found sea urchins, which compete with abalone for food and living space, present at density six times greater than that of abalone at Sadh coast. Also, abalone predators, such as lobsters, fishes, and octopuses were plenty. Other obvious potential competitors for food and space with abalone include chitons, and limpets. Scheibling (1994) demonstrates experimentally the significant effect of abalone versus chitons and limpets in limiting macroalgal abundance on different platforms depends on the densities of chitons and limpets.

IV- History and past management of the abalone fishery[1]

The Omani abalone or sufailah fishery probably have existed for many decades. Discussions with the people of Sadh, including divers, merchants, fishermen, and government officials have revealed some of its undocumented history. In order to establish an understanding of a coastal fishery, which could then be used in developing sound management and development regime, the historic existence as well as the socioeconomic setting should be understood.

The fishery for abalone, Haliotis mariae, in the Sultanate of Oman is reported to take place along the southeastern coastline of the Arabian Sea. Probably, it has been in existence for several decades, where people of Sadh - the center of the fishery- are able to recall exploiting abalone prior to World War II. Abalones at that period were mainly harvested for their pearls. This study may represent a pioneer study documenting, investigating, and analyzing the longevity of the abalone fishery, the socioeconomic importance, and the implications on the existence and prosperity of those partially enclaved fishing societies scattered along the southeastern coast.

The Sufailah fishery has, possibly, provided villagers and townsmen along the southeastern Dhofar with the primary source of income, while the other fisheries are a subsidiary source of income as well as the prime

[1] Note: This section is largely based on interviews with fishermen, divers, and people of the abalone coast given the author's perspective. Because no relevant literature exists.

source of daily diets and proteins. In rural coastal areas subsistence fishing activities prevail as a consequence of lack of adequate markets or marketing channels.

In the past prior to the World War II and up to late 1950s, abalones were exploited for their peals, which were sold to Omani merchants in route to India and East Africa. However, later dried abalones were exchanged for dates from the north, where again merchant vessels carried it along with dried sharks, shrimp and other dried and salted fishes mainly to India and Africa. The Oman merchant trade collapsed following the development and growth of international shipping vessels, as well as the development of cultured pearls and has resulted in the death of the Arabian Gulf trade and exploitation of pearls. These effects have been magnified by the massive exploitation of oil and better income generating activities as well as higher living standards. However, in relation to abalone fishery a clear direct result is the reduced value of abalone pearls. Another less direct implication of modernization on the fishery is an increase in markets for the product and higher prices for its meat that in turn may produce excessive fishing pressure on the sustainability of the stocks.

During the period prior to 1970, abalone was transported to Yemen, where one merchant used to export it to fish markets of the Far East. At that period divers were paid R.O. 1 for 200 pieces, then for 100 pieces of dried abalone. Furthermore, following the political changes of 1970 in

Oman as well as the investment in massive development projects by then the new government, the establishment of Dubai, United Arab Emirates as an international trade center not only in the Arabian Gulf, but serving most of the Middle East, and heavy investment of capital in abalone trade for the Asian markets, by Alzain Al-Zibidi - the son of the Yemeni abalone merchant - who moved to Dubai, are major factors which shaped the abalone fishery as we know it today. During the 1970s, abalone divers as well as gatherers including women and children have been paid R.O. 1 for between 5 to 10 pieces, by Salem Al-Mahri who is the agent of Al-Zibidi in eastern Dhofar.

1- The Fishery

The fishery is primarily conducted in shallow waters along the subtidal rocky coasts of Marbat, Sadh, Hasik, Hadbeen, and Sharbithat. Harvest of abalone is completely carried out by local skin divers using only face masks and occasionally flippers and snorkels. They operate in sibtidal shallow areas when the sea conditions permit, using a knife or pry to remove the abalone from its rocky habitat. The maximum working depth although believed to be less than 10 m (Johnson et al., 1992; Sanders 1982), interviews with divers as well as buyers and locals of Sadh suggest a maximum diving limit in the order of 15 meters. The foot and all other edible flesh of the abalone are separated, boiled in sea water for about one

and half hours, and sun dried at the harvesting areas prior to being exported by merchants.

Today, the abalone market is exclusively dominated by six buyers from Sadh. Surprisingly, none of the fish processing companies is present in this valuable and expensive fish business. The areas of southeastern Dhofar are lightly populated, so during the fishing season buyers usually establish camps along the arid rocky shores to be used as bases for abalone exploitation and processing. Buyers also pay all meals and miscellaneous expenses for all divers including those who are resting for few days at the camp. These expenses are not included in the price paid to divers for abalone flesh.

Al-Zobidi following his father's legacy has supported divers by lending them non-interest loans as well as non-interest mortgages to building their houses and establishing essentials of modern day needs. These loans were based on future expectations, i.e. estimates of abalone future catches in accordance of each individual diver. Al-Zobidi continued exporting dried abalone to the orient fish markets through Dubai, United Arab Emirates for many years, but the 1991 season was his last year of inherited abalone business and tradition.

During the 1981-82 season, divers were paid R.O. 1 for four abalone, but by 1986 divers received R.O. 2 for three pieces of abalone wet flesh for processing. The price continued to increase, so by 1988 each abalone was

sold for R.O. 1 irrespective of size. In 1990, abalone merchants change from a piece basis to R.O. 22 per kilogram (weight basis). Abalone price continued to increase and in the 1992 season it reached its maximum, that is R.O. 50 per kg, which is equivalent to US $ 130 per kg.

However, 1992 is also the year, which witnessed the withdrawal of the abalone giant merchant, i.e. Al-Zobidi, leaving behind a family heritage and long tradition, as well as the emergence of a number of local buyers who have entered the huge fish market of the orient without experience. The result was that, prices have fallen as individual buyers have sold abalone for far less than it could command. This could be attributed to many reasons, one of which is that divers are used to receiving cash payments for the abalone they deliver but they also get paid in advance for abalone that is still grazing the rocky substrata. In contrast, now they must wait for months before receiving full payment for what they already have delivered. Another reason could be the fact that those buyers are emerging from small villages and are not educated in how to negotiate contracts in an international fish market.

Consequently, the buyers during the 1993 season have changed their policy to R.O. 35 per kg instant cash payment, but R.O. 40 per kg with grace period up to the export of the commodity. Apparently, the same policy has continued for the last season, but divers and buyer are

demanding government intervention to facilitate and organize processing and marketing of the abalone.

2- Past and current management practices

Oman issued its first fishing legislation in 1981 through the Royal Decree No. 83/81 concerning the protection and sustainability of the fisheries resources. That law, among other things, prohibited all fishing activities including diving without licenses as well as exclusively limiting commercial fishing to Omani citizens with a history and tradition in fishing. Other Omanis as well as outsiders could apply for recreational fishing permits, which state the allowable fishing activities, the geographic limit, and other conditions. This first piece of legislation also prohibited the use of destructive fishing methods, like monofilament gill nets, in the Omani Exclusive Economic Zone, but did not touch on any single fishery. Nevertheless, community rules although may defer from one place to another prevailed in all fishing towns and societies along the country coasts for centuries.

Wisely, the fisheries law as well as the ministry acknowledge and respect fisheries-community rules and traditional practices, but there has not been any attempt to institutionalize any of the existing community-rules. This first control over fishermen's activities emerged as a result of the clear need to protect fish resources from depletion and maintain a suitable fishing effort level. The Omani regime of governance was able to

sense the need for limiting the magnitude of fishing efforts, especially on nearshore fisheries as well high value living marine resources. Therefore, the ministry established the first fishing law and educated fishers on the needs and the objectives behind it and encouraged them to get on board by obtaining permits and adhering to the regulations[1].

Abalone used to be harvested when the sea conditions were suitable to allow diving, that is usually during the post and pre monsoon months, which are from September to March depending on the geographical location. However, as the county's infrastructure increasingly was developed and the villages and town got more connected to each other as well with major cities in Oman and the world, prices of abalone and other living marine resources increased. The high returns on investments of efforts and capital have encouraged many people to participate not only in the abalone fishery but many other high value fisheries. Thus, a need for new action in the behalf of the government was unavoidable. In 1987, the ministry following the usual reactive approach in fisheries management to deal with problems as and when they develop established a close season from 1 April to 1 October annually to protect the abalone stocks and to preserve a sizable parental population.

This regulation was clearly not enough to stabilize the fishing efforts and to maintain sustainable harvest of abalone. The landings continued to

[1] Note: Based on interviews with government officials and personal experience.

decline accompanied with increasing fishing efforts. Thus, the pressures and the needs were reestablished so by 1991 sound managerial action was desperately needed. In that same year the ministry issued a new regulation, basically limiting the fishing season to November and December and introduced a minimum size limit of 90 mm shell length. These management measures are based on educated guesses, but not scientific facts. Unfortunately, the biological aspects of the abalone resource that should provide the foundations of sound management and sustainable development are neither understood nor adequately investigated. The following section considers where the current regulations are driving the abalone fishery.

V- The Status Quo: an analysis

1- Management

In the Sultanate of Oman management, conservation, exploitation-related issues, and protection of living marine resources are under the direct responsibility of the Ministry of Agriculture and Fisheries. The ministry establishes fishing laws and forms the necessary fishing policies. Implementation of fishery policies, enforcement of fishery laws and regulations, and policy monitoring are some of the daily routines of the Directorate General of Fisheries Resources (DGFR), which is referred to as the competent authority under the fisheries law. The DGFR also has responsibilities for the collection of data generated by the fisheries sectors, analysis of the industries, conducting research, educating the publics, licensing of fishermen and fishing vessels, and other related matters.

With regard to the abalone fishery a number of management measures are currently enforced. First of all, a closed annual season from January 1 through October 31 limiting the fishing season only to two months is imposed. A minimum shell length of 90 mm is also decreed and collecting abalone in shallow waters less than 8 meter deep is prohibited. With these vague and difficult to enforce regulations there is the concern about the conservation of the stock and sustainability of the fishery in part of the ministry, the divers, and the merchants.

2- Legal considerations

The Marine Fishing and Living-Aquatic-Resources Protection Law with the Executive Regulations as amended in 1994 and in relation to the abalone fishery Article 15 states[1]:

> " (1) Fishing and capture of abalone during the reproductive period, which starts on the first day of January and continues until the last day of October of each year, is strictly forbidden.
>
> (2) Fishing and collection of abalone with shell length less than 90 mm as well as fishing and collection of abalone in shallow waters with a depth less than eight meters is forbidden.
>
> (3) Possession, preparation for market, and dealing in abalone during the reproductive period mentioned in item 1 of this article is forbidden. Dealing includes transport, sale, purchase, export, and all related transactions.

[1] This is an unofficial translation of original in Arabic.

(4) At the end of each fishing season, individuals, companies, and establishments that possess any quantity of abalone shall register this quantity with the department of fisheries resources in the relevant region. Licenses issued by the competent authority shall authorize allowable quantities."

Section one imposes a closed season during the reproductive period of abalone. However, there is little scientific evidence indicating the exact period of the reproductive season of abalone. In fact as noted earlier, a number of studies suggested completely different scenarios for the spawning period, even during November which is the first month of the two months fishing season currently in effect.

Section two forbids catching abalone with shell length less than 90 mm as well as collecting abalone from shallow waters less than 8 meters depth. The rationale for the minimum size limit is to allow abalone new recruits to reach sexual maturity and subsequently spawn at least once before entering the fishery. Apparently the measure is well supported by scientific findings, since many studies have suggested similar sexual maturity sizes.

Section two also forbids fishermen from catching and collecting abalone in shallow waters of depths less than 8 meters. The justifications

for this requirement are not clear and the scientific biological studies on the Omani abalone completely contradict with such management measure. Those studies appear to agree on that abalone is distributed in shallow rocky waters with maximum abundance in the intertidal areas up to 10 meter depths. Also, divers and buyers unanimously agree on that abalones are found as well as currently fished in shallow waters including the intertidal zone. Surprisingly, enforcement personnel agree that the abalone fishery is conducted from intertidal rocky shores to depths reached by skin divers.

Therefore, the needs, objectives, and justifications behind it are not clear. Nevertheless, it suggests that scientists and law makers do not adequately communicate, so who ever wrote that section (section 2 of Article 15) has failed to understand that abalone in deeper waters should also be protected from excessive fishing efforts.

3- The licensing system

The DGFR as well as its branches along the coastal provinces grant eligible Omanis fishing permits allowing them to engage in various fishing activities within the relevant regions. For fisheries administrative reasons the country is divided into six coastal provinces. Thus, any fisherman who has a fishing license is eligible to participate in all fisheries available in his region of residency subject to the provisions of the Marine Fishing and Living-Aquatic-Resources-Protection Law.

When considering the implications of such a policy, it is obvious that fishermen could concentrate in one fishery if they desired to do so. That is legally no one fisherman can be excluded from any fishery in his/her reach. Consequently, the ministry may witness the collapse of first the fishery of highest return on investment then the next high and so on. For example, all fishermen in Dhofar governorate could dive for abalone during its legal fishing season, then move to the lobster fishery, and the next valuable resource. This is of especial importance to coastal fisheries, such as the abalone fishery, where participation does not need investment in more than personal time (the time to dive). Another factor in the sound management of abalone is the near proximity from the coast as well as the easy accessibility and high prices of coastal marine resources.

The fate of these coastal fisheries is bleak, if current management practices are continued and will result in severe economic losses. The excessive fishing efforts on coastal resources certainly well reduce their abundance and likely to deplete the stocks. Then, fishermen will find it more profitable to move to the next fishery and the cycle will continue until all of the coastal marine resources are completely depleted.

4- Enforcement

Fisheries enforcement activities including surveillance operations are very costly, especially in coastal developing nations where Oman is no

exception. First of all, these activities are designed and administered in a non-cost-effective way. That is the full cost is paid by the government, with no taxes on fish landings and the penalties imposed on offenders are too small to cover either the enforcement cost or the court system costs (personal communication and experience).

However, the most important issue regarding fisheries enforcement in the Sultanate is lack of motivation. That is, a clear cut policy on implementation of the fisheries regulations is highly needed. There should not be any non-legitimate exemptions, the rules must be applied on all participants equally.

Enforcing the previously mentioned regulations for the abalone fishery will not be easy. First the practicability of the regulations is challenged and criticized by divers, buyers and more importantly enforcement by personnel. The legal minimum size requirement of 90 mm shell length is impossible to monitor given current fishing practices. Fishermen dive for abalone from fishing boats and they remove the edible flesh from the shell and discard the abalone shells in the sea. Thus, how and when the measure of 90 mm shell length can be monitored given available enforcement officers. Buyers receive abalone wet flesh for processing and actually in most instances they do not see the shells.

The abalone coast of southeastern Dhofar is lightly populated, i.e. small human settlements scatter along the arid coast. Although the country

has established most of its modern infrastructure during the past two decades, along most of the Arabian Sea coast of Oman roads are not paved, most of the public services are not adequately provided, and efficient communication routes are not in place. It is my understanding that the government plans to develop this region during the incoming five-year development plan. With these difficulties in mind, it is clear that enforcement of the closed season, from January 01 to October 31, will be difficult to achieve. First of all, access could be either through the sea or land by using 4W-drive vehicles, where enforcement personnel explained to me how difficult it is and how many vehicles they lose during these operations. Second, the sea option is not valid, because the fishery is in very shallow waters, ports are not available in the fishery area, boat operations are costly, and others.

Last but not least, the 8 meter or deeper legal fishing zone is not only has no scientific biological basis but is also unenforceable. Possibly, assigning one observer for each fisherman, which is totally unachievable and unjustifiable, may result in enforcing such management measure.

Currently, the closed season is lightly enforced, but the minimum size limit and the 8 meters depth zone of prohibited abalone fishing are both not enforced. The Department of Fisheries Resources in Salalah, which is responsible for the daily management of the abalone fishery blames, among other things, the impracticality of the regulation. In fact and as it is

mentioned earlier in this study, the fisheries regulations in general are vague, but are not achievable in the case of the abalone fishery. Nevertheless, the Department of Fisheries Resources in Salalah did not recommend a better regulations in light of their daily management of the abalone fishery and has not make any quantifiable efforts to modify and fix those regulations.

5- Landings, efforts, and the stock

A- Landings

In 1981, the shallow water harvest of abalone was estimated to be 1,200,000 pieces as well as the size of the population. Assuming both estimates are correct, then the Omani abalone should have been fished to the point of extinction in 1981. Since the fishery is still going on, either one or both of the estimates are wrong. However, the 1982 catch is estimated at 200 tons (live weight), by Sanders (1982). In 1985, one camp at Hadbeen is estimated to land 16 tons of fresh abalone flesh. The fishery between Rakhyut and Hasik is estimated to export between 15 to 30 metric tons of dried abalone, which is equivalent to 115-230 MT live weight, to Dubai, U.A.E. in 1981.

Since 1988, abalone production estimates are based on the analyses of buyers records. In the past abalone is harvested when ever the sea conditions permitted diving activities. During the period from 1987 to

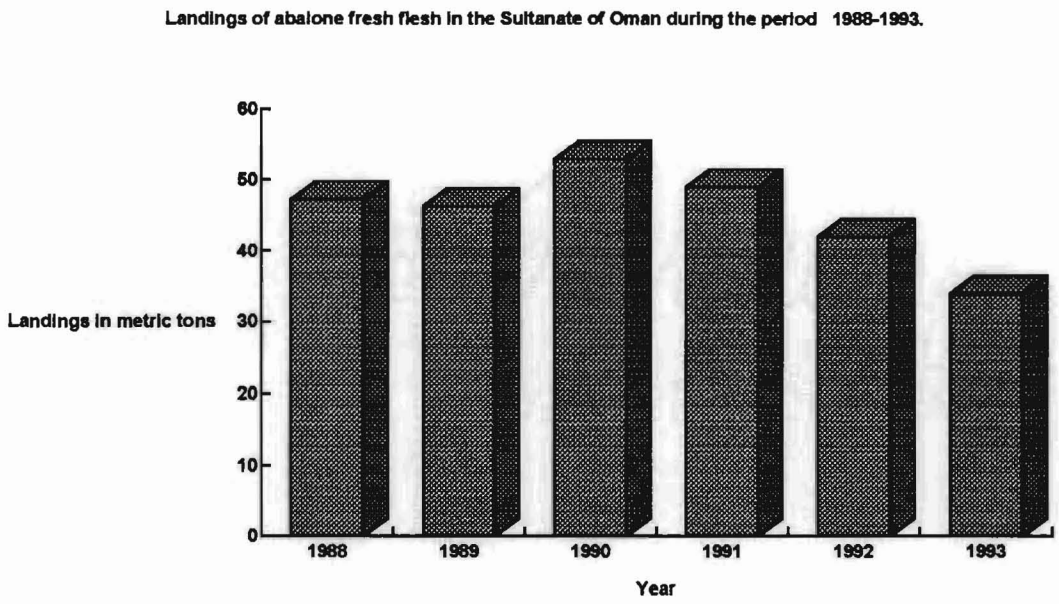
1990, fishing for abalone was limited to six months per year (October to March), by the fisheries law. Since 1991, the harvest season is reduced to two months, November and December, only. These differences in the duration of the fishing activities have unavoidable implications on the landings. Figure 5, shows the estimated landings of abalone fresh flesh for processing in the Sultanate of Oman during the period 1988-1993.

Generally, the overall trend in the abalone fishery is moving towards declining landings. The 1991 season, which is the year when the shortened season is introduced, fishermen landed 53 metric tons of fresh flesh for processing, but the 1992 production with four tons decline is estimated at 49 metric tons. Consequently, the falling trend continued so the 1993 production amounted to only 34 MT, which represent almost 36 percent decline compared to the 1991 harvest.

Landings of 300 piece per day and 19 kg per diver per day are reported (Johnson et al. 1992). In 1988, the average daily catch per diver is 2.2 kg, which is approximately similar for 1993. The total value of the abalone fresh flesh landings is estimated at US $ 4 million. This figure excludes the export value and all other stimulated indirect economic activities.

However, the 1992 hike of fresh abalone price to R.O. 50 per kg accompanied with other factors have resulted in severe losses to buyers and exporters. Thus, some of them have either quit the abalone business or reduced their number of camps. This has in turn resulted in reduction in

Figure 5.



Source: Compiled from: Fisheries Statistics Annual Reports. Department of Fisheries Statistics, the Ministry.

the number of total fishing efforts.

B- Efforts

As indicated above, the licensing system does not specify specific fisheries within fishing regions and the management practices do not require more than a fishing license to participate in this valuable fishery.

Given fisheries enforcement limitations and constraints, the abalone fishery is practically open to who ever can access it. In fact, employees of government agencies as well as many private establishments take their vacations during the abalone season to participate in the fishery. The high prices of abalone along with weak enforcement activities will guarantee constantly increasing fishing pressure. Also the fishery is a seasonal nearshore activities, which do not require permanent investments in capital and labor. This fact allow fishermen to enter and leave the fishery with negligible costs. It also may result in great fluctuations in the total number of fishermen. In 1991, the total number of divers is 525, but in 1993 the number has dropped to 256 divers.

Increasingly, the composition of fishermen is shifting towards part-time fishermen as opposed to full-time involvement in the fisheries sector. Part-time fishermen include those who are working in government agencies and private businesses, but posses fishing licenses. Nevertheless, many

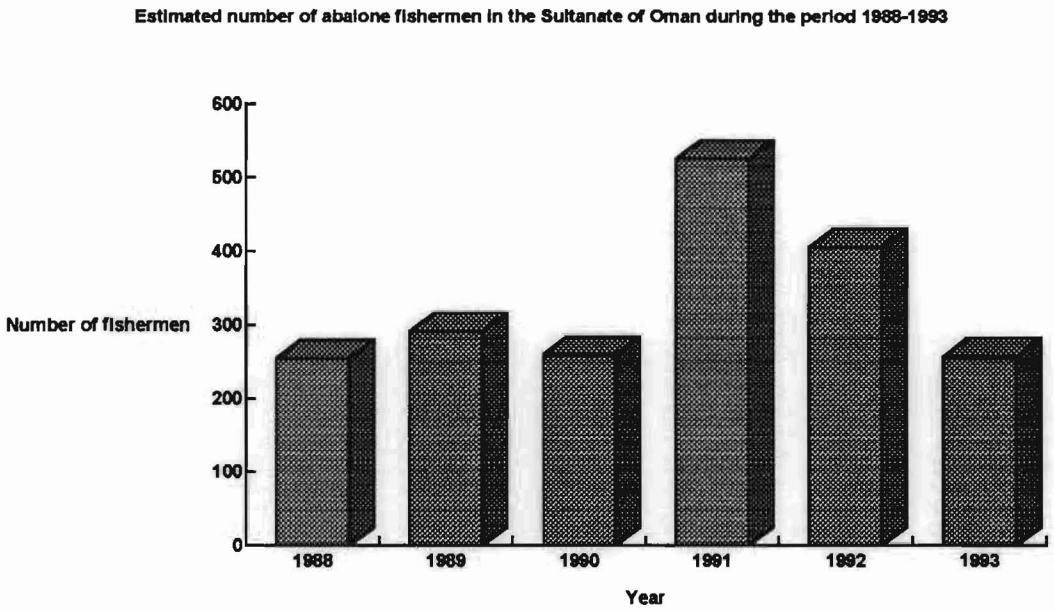
new participants in the abalone fishery are aliens to the sea and the fisheries business, as indicated by divers and buyers. Figure 6, shows the estimated number of fishermen participating in the abalone fishery in the Sultanate of Oman during the period 1988-1993.

C- The stock

Since 1981, there has been increasing concerns about overutilization, protection of sizable parental population, and sustainability of the fishery. Sanders (1982) assumed 85 mm shell length to be the mean size of first entry into the fishery and estimated 96 mm shell length to be the mean size of total harvest. Johnson et. Al. (1992) estimated 65 mm shell length to be the size at first entry into the fishery and 97 mm shell length to be the mean size of commercial harvest sampled during the period 1987-1990. He also estimated the percentage of harvested abalone less than 70 mm shell length increased from 2.1 % in 1984 to 3.2 % in 1995 to 7.2 % in 1988. Siddeek and Johnson (1993) estimated higher total mortality values for the 1991 season compared to 1987 to 1989 fishing seasons. They also suggested higher fishing pressure as the direct cause of the higher mortalities, that has led them to suggest increasing the minimum size limit to 110 mm shell length.

The above findings along with harvest statistics suggest only one thing, that is the abalone stock/landings are declining and the current management

Figure 6.



Source: Compiled from: Fisheries Statistics Annual Reports. Department of Fisheries Statistics, the Ministry.

measures are not able to sustain the fishery.

6- Monitoring and research

Monitoring of catches and fishing efforts along with the relevant statistical analyses are the responsibilities and daily activities of Department of Fisheries Statistics, the ministry. Although, in my opinion, this department has been very weak in providing meaningful reports, the Oman-United States cooperation in strengthening this department with the US educated Omanis successfully participating in its daily operations it should be going in the right direction.

In relation to the abalone fishery, the department provides abalone buyers with statistical log books for registering daily catch data and the department collects them after the fishing season. Then the department staff run all related statistical analyses on these data.

The Marine Science and Fisheries Center (MSFC), the ministry is established in 1986 with eleven sections covering all aspects of the marine sciences and charged with establishing and conducting research on the marine environment of the Sultanate. Since its establishment the MSFC has conducted numerous research activities, but unfortunately little has been done on the abalone fishery.

In summary, the abalone fishery have provided remote coastal communities with necessary incomes for many generations. This fishery

resource, which has the highest value per unit of weight among all other Omani living marine resources, was able to prosper without government regulations for many decades, but with the increase in communication as well as increase openness of the country to the outside world have contributed to, among other things, increase production, higher price, and over-utilization of the abalone resources.

However, sound management regulations must be based on concrete scientific evidence not on guesses to be well functioning. Unfortunately, with regard to the abalone fishery the regulations have little or no scientific evidence to back them up. Therefore, over-utilization and continuously declining catches are unavoidable consequences of such measures.

VI- An Integrated Regime to Abalone Management and Development

Management is defined in a dictionary of American English as " the art or practice of managing [directing] some thing, e.g. a business or a money. Or it is the people in charge of a firm or a business." Management in relation to fishery resources, in the other hand, could be played to balance the forces influencing the resource environment and the human economic and social settings. Fisheries management could take two fundamentally different forms. First, the role of fisheries management could be to resolve conflicts between different user groups and different uses of the same or similar fish species as well as coastal space. In doing so, fisheries authorities could use effective management tools, such as zoning. This management tool, among other things, segregates different user groups, or conflicting uses of the same or similar fisheries resources spatially.

The second and most important role of fisheries management in the context of the Omani abalone fishery is economic development. In fact, economic development as well as upgrading living standards of the publics including fishing communities are among traditional functions of coastal governments. Today one of most complicated dilemmas confronting governments is economic prosperity and the creation of income generating activities. Currently, on the individual level one needs to work more and more each year just to keep his or her current living standards. In relation

to the Sultanate, there also a need to diversify the national economy, which is mainly dependent on the export of crude oil. Herein this section presents a regime for the management and development of the abalone fishery utilizing an integrated policy approach to development of the resource as well as a management regime, which is compatible with the norms, rules and values of the fishery communities. This compatibility along with economic development well save many of the public financial resources, conserve the abalone stocks, provide employment opportunities, increase the level of public participation in the decision making process and well contribute to the process of decentralizing the government.

Basically, fishery management authorities around the world in performing their daily management activities are normally charged with two major tasks. The first is to protect the fishery resources from harm by the activities of fishers and others. Second, they are responsible for fostering the best utilization of the resource in a manner which will result in the greatest benefit to both fishery communities (current users) and the nation's economy including future users.

This may usually be interpreted to mean that the fisheries authority should encourage the fishery to take as much of the resource as economical, but not so much as to damage it. As such, the management must walk a narrow path between under-utilization and over-exploitation.

The fishery management authority should also consider social, economic, and political implications of a fishery management program.

The competent authority should establish a plan, whereby all users of the abalone resources would be informed of their role and limits of participation. The abalone fishery industries, i.e. fishermen, divers, and merchants, need to know the size of the harvest they will be allowed to pursue and the areas and conditions placed on their participation.

The government would require estimates of revenues generated through the fishery enforcement requirements (license fees, royalties, contribution to GDP), and the political and economic implications of management options. Integrated cooperative actions and agreements between the fisheries' competent authority and other government agencies would need to be established for support of management programs, such as the judicial system, exclusive economic zone enforcement, and fisheries surveillance.

Cornerstone to the planning process, the fishery planner would require information on the management priorities and policies. Is the plan to maximize catch in the short term, maintain harvest levels in the long run, increase catch, maximize participation by fishers, restrict participation, create more employment opportunities in abalone supportive and ancillary industries? What are the goals? These policies would affect the stock and

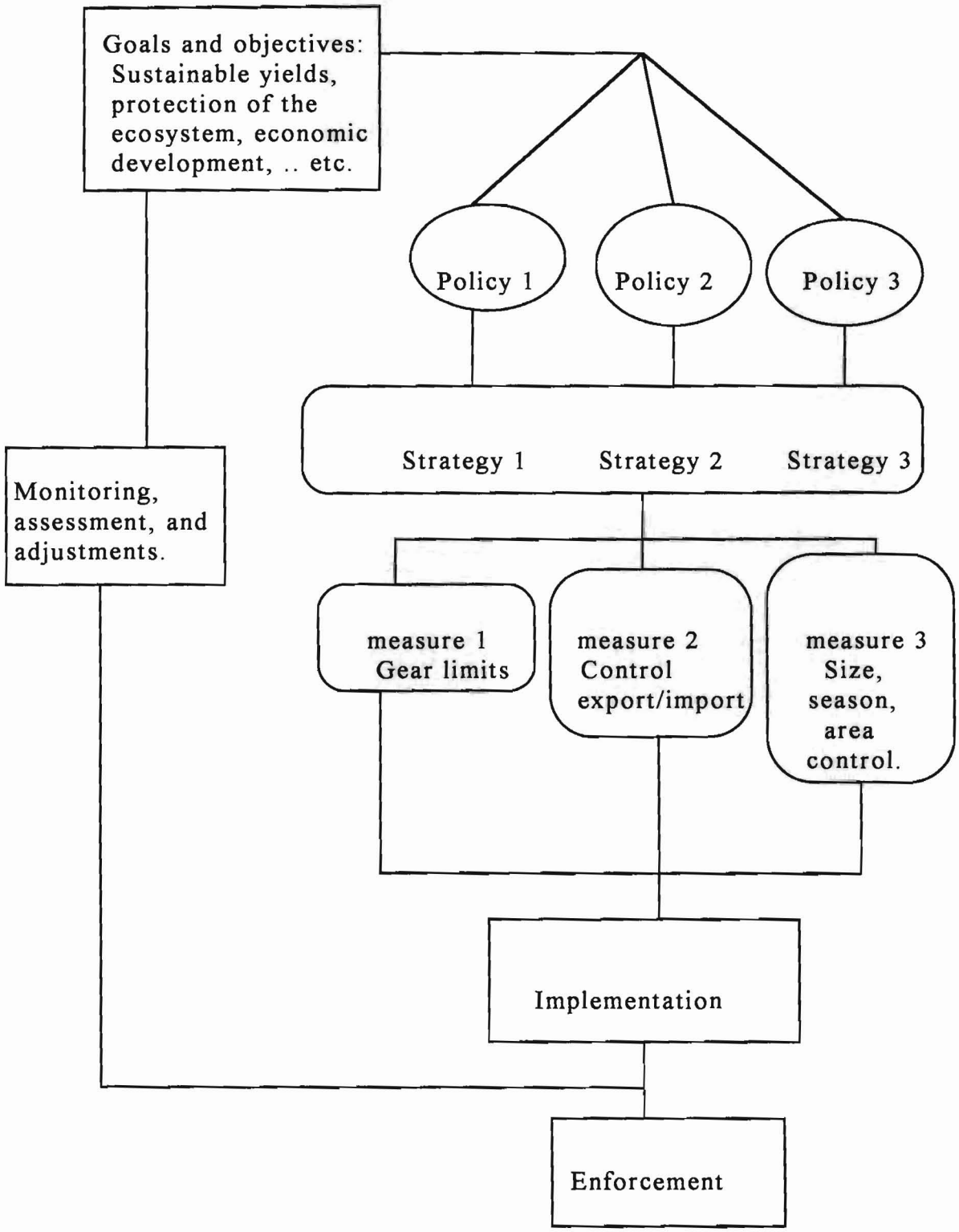
the fishermen, and would set up the management response to the industry as well as the fisheries private sector reactions to the management system?

Generally, management of fisheries resources is based on measures, strategies, policies, goals and objectives(see figure 7). First of all, a set of clear goals in relation to the development and management of the abalone fishery is required to, among other things, set the priorities. That is, to clearly explain what does Oman as the owner of the abalone resource wants to do with it ? Second, management measures, which could be defined as actions of control over the resource utilization taken by the management system, are established, analyzed, and coordinated. Third a basket of measures could form a strategy, which in turn is to execute a specific policy. In the other hand, policies may represent drivers that are initiated to reach some desired goals and objectives.

However, no matters how good the planning phase is, the management output will be dependent on effective implementation and strict enforcement. The above mentioned management measures should be scientifically justified, politically accepted, and economically feasible. For example, abalone management measure - like a minimum size limit (90 mm) - could be based on scientific evidence when is to protect sizable parental stock of the harvested population from over-utilization and the size limit estimate is reached following acceptable scientific procedures. Political acceptance may be achieved when the majority of users including divers are happy with such restriction and practically implementing it. Economic

Figure 7.

A model of fisheries policy flow.



feasibility could be reach if the consequences of imposing the minimum size limit are positive, that is the divers receive more money for their high quality large abalone, and exporters make higher financial profits.

In addition, prior to implementation and enforcement of management strategies a phase of constituency building should commence. This constituency building phase is meant to establish beliefs in the needs and effectiveness of those strategies among the abalone utilizing communities as well as civil servants responsible for implementation and enforcement of the management program. One way of achieving this is through conducting workshops or symposiums for key elements of the management system, community leaders and individuals. In such gatherings, scientific papers with scenarios fully analyzing the implications if those strategies are implemented and other scenarios provide analyses of the status quo with the clear need for change, should be presented. These efforts must be aided by visual simulations, videos, and photographs to foster smother understanding.

1- Abalone development and management goals and polices

Governments in all social settings set the rules of the game, i.e. what is permissible and what is not and under what conditions and who is allowed to benefit from the fisheries ? The art and skill of governance including the civil service which operates in a democratic system and free-market

environment is to be diverse and holistic while maintaining direction. Cornerstone to government system success and sustainability is the perceived public representation and the subsequent support.

Public support, however, is vital to the success of fisheries management programs, especially the ones dealing with easily accessible coastal fisheries, such as abalone. Policy in general could be many things, but most importantly it is a guideline for management and a framework for planning and development. Thus, policy should express the people's needs, wants, norms, and customs. After all it is for the people and will be implemented by those same people, so it should be developed with especial consultation with the relevant people, who are in this case divers, fishermen, and abalone beneficiaries.

The followings are very laudable national goals, which set a general policy frame for abalone management and development.

- Diversify the national economy.
- Upgrade the social and economic standards of the traditional fishermen and their communities.
- Continue the development of fisheries infrastructure.
- Protect the abalone stock from over-utilization and depletion of their habitats.

These are general policy statements that will provide the first step towards the formulation of a detailed plan for the management and development of the abalone fishery. Such plan should be developed in consultation with all current users and should provide sufficient flexibility for future users and uses. The above mentioned goals tell you where the fishery should go, i.e. what should be done, but do not say any thing regarding how these desirable objective can be achieved. The following is an explanation of the how.

A- Diversify the national economy

The abalone fishery as previously mentioned provide seasonal employment opportunities as well as important incomes for remote coastal towns and villages. Such employment could, however, be all year around and benefit from the abalone resources could be maximized. The additional jobs will not be in the field of direct exploitation of wild abalone, but abalone farming. Besides abalone farming industries abalone mother of pearl and abalone shell crafting industries should be created. These industries will provide income generating activities for indigenous expertise, foreign hard currencies for imports, will initiate the farming technologies including abalone pearls farming as well as shell crafting and fine jewelry techniques, and on top of all will increase public awareness regarding the abalone resource and its habitat.

B- Upgrade the social and economic standards of the traditional fishermen and their communities.

This objective is very important, as the sustainable development and sound management of the abalone fishery are to benefit the coastal fishing communities. It is also compatible with the previous goal, that is to diversify the national economy. In fact, the government is not expected to get any revenue from this fishery in the short run. Upgrading the social public awareness of the marine environment, the abalone resources, abalone farming and processing techniques, marketing strategies, and others could be achieved following a number of strategic actions. First of all, the fisheries extension division of the ministry should be reinvented. Fisheries extension personnel must work hand to hand with fishermen and the fisheries private sector including the supportive industries, such as boat manufacturing.

Second, the fisheries extension must introduce the abalone fishery community to innovative fishing, handling and processing methods. They also should work hand to hand with the information and public relations division of the ministry to produce posters, videos, and publications which should emphasize, among other things, habitat conservation; improved fishing and processing methods; introductions to abalone farming strategies; and mariculture engineering techniques. These educational

publications should be made public to all fisheries interests at affordable or no costs.

Third, the fisheries extension division should fully cooperate with the fisheries industries and marketing division of the ministry to help in creating the information and know how needed to foster the abalone fishery. Currently, abalone is marketed in a chaotic fashion, thus, the ministry should step-in and organize this activity for divers and merchants. When this goal is achieved, the ministry must step out and leave the marketing completely to the divers cooperatives or the private sector.

Finally, once the above described steps are followed the economic and social status of fishermen and their communities should reached at least a step towards full upgrade. The abalone fishery along with other supportive industries should provide sufficient employment opportunities for indigenous expertise as well as a sizable expatriates, thus, leaving some flexibility for Omanization in the future. These industries should provide enough financial resources for coastal communities to achieve all of their needs and some of their wants.

C- Continue the development of fisheries infrastructure

The role of fisheries has always been of prime importance to the economy of Oman. The rapid economic transformation that the country has witnessed as a direct result of the production and export of oil, which

began in 1967, and the major political changes of 1970 have had serious consequences on the development of the fisheries infrastructure. Starting in 1976 the country has embarked into five years development plans and the government's strategy for promotion of non-oil resources and reduction of the economy's dependence on oil has included special policies aimed at developing the country's infrastructure and strengthening the traditional fisheries[1].

Nevertheless today, the fisheries infrastructures are far from being completely suitable to accommodate fisheries development needs. Specifically, along the abalone coast many essential fisheries facilities, such as fish processing plants, harbors, ice making factories, boat and nets manufacturers, training institutions, modern transportation systems, and others are lacking. It should be understood that industrialization and fisheries industries will not initiate in vacuum.

There should be some minimal level of knowledge as well as infrastructure to accommodate and enhance this know how. The policy statement of continuing the development of fisheries infrastructure is completely compatible with the previous goals. Lack of fisheries infrastructure, such as ports, have many negative implications on the coastal fisheries, especially the abalone fishery. Fishermen make their benevolent quest of making living through fishing. When they can not

[1]Fisheries development in Oman, a report to Development Council Technical Secretariat, Directorate General of Planning, by El-Rikaishy A. N., July, 1980.

access offshore fisheries they are forced to turn to coastal resources. The accessibility to offshore fish resources, like tuna and large pelagics, is well enhanced by the presence of full facility fisheries ports and the availability of offshore going fishing boats. When these are in place the market forces are likely to initiate the necessary environment for many other supportive industries, such as net making, to emerge.

D- Protect the abalone stock from over-utilization and depletion of their habitats

Conservation of living marine resources is one of the necessary pillars of sound management and sustainable development. Fishery resources including abalone are renewable natural resources, nevertheless, in the event of exploitation a situation of over-utilization and even depletion may occur. Fishery scientists as well as fishery authorities are confronted with a challenge of maintaining fish harvest at levels equal to or less than the natural growth levels. Thus, forcing the fisheries to function at the maximum sustainable yield, where the maximum benefit from the fisheries is achieved on an annual basis.

The abalone fishery was able to continue for many decades with neither government intervention nor management. However, the fishery was under sound community management as were most aspects of Omani life in the past. Before the recent discovery and export of oil and the subsequent

initiation of a complex governmental structure, the fisheries including fishing communities had experienced negligible governmental influence and control. Then how was the abalone fishery managed to thrive in the absence of governmental laws? The answer to this question is not simple, but it is a combination of sound management based on the social structure, a strict enforcement by the users of the resource since the laws are theirs.

Conservation of the abalone resources could be achieved through a combination of management measures that should be first closely coordinated with all significant interests. These management measures could be closed areas and seasons with minimum or maximum size limits, and others. The regulations should be based on scientific findings, not on the mood or desires of any one.

2- Abalone management - the alternative regime

Fishery management in general consumes lots of public financial resources with little or no returns on the investments. For example, the costs of fishery research, fisheries surveillance activities, enforcement supportive needs, such as courts, and others. The best fishery management system is the one, which will provide sustainable development and sound management in economically efficient way, that is, the management system will generate benefits equivalent to or more than its costs. This is near to impossible using imposed laws and regulations. Besides that imposed

legislation has little or no constituency among not only the users, but also significant fisheries personnel. There only constituency is among top level government officials who decree them and others with hidden agendas.

In the Omani context, the decreeing of fisheries legislation should not commence until significant steps are taken. First of all, scientific research should be the basis of all fisheries regulations. Second, a phase of community and public participation should be established. This is a very important step as herein significant community rules and practices including territorial rights must be institutionalize in the fisheries management system. This incorporation of norms and customs of fishing communities will result in, among other things, cheaper fisheries enforcement, increase public participation in the decision making process thus more perceived political representation and internal security and stability.

Third the fisheries management system should be transparent in the sense that the causes, benefits, needs, implications and objectives behind the fisheries control laws are fully explained to the public through the mass media. Next, a phase of constituency building should be established to key elements of the fisheries management system as well as commercial fishermen, divers, and the fisheries industrial sector. Then, once the legal system is in place fisheries enforcement must be strict and equitable.

The fisheries authority is established to help the fisheries sector including fishermen, not to place constraints and burdens on their participation in the development of the country. Thus, the ministry should give a helpful hand to all fisheries interests without discrimination. No one fisheries company, fishing group or fisherman should be allowed to monopolize the sector. The creation of freely competitive market place is one of the foundations of free market economies.

However, the abalone fishery should be managed using, among other things, significant community rules and norms. For example all commercial divers have refused to use modern SCUBA diving equipment in harvesting abalone following community consensus. Since it is a rule established by the abalone interest community, it is fully enforced and respected by all commercial divers without any government intervention. There could be other community laws that will benefit fisheries conservation and management activities. There is another example of community collective actions from the shrimp fishery of Mahout Island, where shrimp fishermen refused the introduction of trawlers in the fishery.

The abalone resources should be completely given to inhabitants of the abalone coasts. That is exploitation of wild abalone resources should not be on an open access status, but should be limited to fishermen living on those remote coastal fishing villages and towns. This will help maintaining a sustainable harvest as the number of efforts will significantly be cut down

and commercial divers will have their old sense of ownership of the resource as well as the territorial access. Thus, aliens to these communities as well as non-fishing and non-diving groups will be excluded by the communities themselves through their social and tribal organization. Therefore, government intervention should continue to assume, among other things, supervisory role.

The ministry should develop an abalone fishery policy and, in doing so, consider several needs. First of all, the government after conducting Oman's first population census late 1993 should have all or most of the information necessary for development planing needs. The government will find in these information the number of families participating in the harvest of abalone and from fisheries statistical reports the government can get historical records of amounts of abalone landed by each diver as well as each family. Once the abalone resources are declared to be reserved for the benefit of the abalone coast inhabitants, then the ministry should use historic data on landings and divers to, among other things, set up quota system if find necessary to do so.

Second, the ministry should sponsor a one year research program to discover the reproductive season of abalone and the size at which fifty percent of the population are sexually mature. The Marine Science and Fisheries and Center is capable of conducting such research if well structured and motivated. Also, the ministry should encourage and

establish abalone farming industries and research. This will be discussed in more details in the next section. The fisheries competent authority should also take all necessary measures to reduce fishing pressures on the coastal high value fish resources including the abalone.

3- Mariculture

The development of commercial mariculture in the Sultanate Oman has been very limited to only a single shrimp farm that have been established in the early 1980s, but by the late 1980s the whole operation was history (personal communication). The collapse of Oman Sea Farm can be attributed to many factors. First of all, the farming operation relied on imported Taiwanese post larvae of the shrimp, Penaeus monodon, which is a common species of prawn in the Omani waters though not dominant. The imported post larvae may have suffered high level of stress caused by local environmental conditions. This could explain the high rate of mortality, which have been experienced during the farming operation of the imported shrimp post larvae.

Moreover, Oman Sea Farm have used imported shrimp feed as well as high cost foreign expatriates, which both have skyrocketed the cost of farming shrimp and in turn contributed to the economic unfeasibility and the consequent collapse of the farm. Other factors, such as managerial

problems, may have contributed to the failure of the first large scale commercial farm in the country.

It is worth mentioning that Oman's inland fish resources are currently of neither significant nutritional nor commercial value. Also, the country has little inland water resources, which significantly limits inland fisheries development including aquaculture.

A- National planning for mariculture development

The principal economic goals of fisheries development including mariculture in the country is to reduce economic dependence on the export of crude oil and to diversify the national economy, while fostering a traditionally important economic sector. The later objective has, also, political goals. The fact that mariculture is a new and emerging industry in the Sultanate dictates the formulation of national mariculture plan for, among other things, the orderly development of the techniques and methods for farming marine organisms.

Therefore, it is most desirable for Oman to have a national mariculture plan defining objectives, policies and strategies that are most suited for achieving the selected goals. Such mariculture plan should be fully integrated with the national fisheries development plan. The plan should, also, clearly explain the limits, incentives, and constraints that a mariculture entrepreneur will have to adhere to or benefit from. The plan

should clearly state the amount of governmental control that will be placed on participants including coastal dwellers. The plan must be streamlined through out the relevant governmental agencies. The stagnant routine must be eliminated and the response time to farming requests must be fast, accurate, and encouraging.

Nevertheless, there are things that the management system should make besides the mariculture plan. First, suitable sites for different mariculture methods and species should be identified and mapped. This information should be coordinated through out relevant governmental agencies. Second, suitable farming equipment should be made locally available to investors. Third, research and trials on best farming methods that suite different marine organisms should be the responsibility of the MSFC. Then, the ministry should make these information publicly available to interested investors. Also, the government should encourage the development of fish feed industries, that utilize local raw materials and minimize imports. There are other factors that the management system should consider, but do not fall in the subject of this study.

B- General concerns

Abalone mariculture should be planned to integrate within the framework and dynamics of the existing fishery, thus, preventing unnecessary competition in the fisheries market place whether national or international. It is more desirable for Oman abalone farming activities to

target and serve international fish markets, especially the huge fish market of the orient. Goods and sea food commodities should be marketed in places where they are valued the most. For sea food products Japanese along with the Chinese fish markets are the best in the world. There are also other important fish markets, like the European and the United States fish markets, but abalone is not valued the most in these markets.

Consequently, abalone marketing channels and systems should be established with especial efforts to continuously investigate the know how in terms of consumer preferences and packages. In addition, the abalone farming activities in the Sultanate should be designed for multi-production and uses. That is a single abalone farm should be capable of producing high quality abalone for direct human consumption, abalone pearls for jewelry and valuables making, abalone mother of pearl, abalone seeds for wild stocks enhancement, and fine abalone shells for artifacts crafting and buttons making. These products would provide the raw materials for either export of the formation of subsidiary industries to abalone farming, thus magnifying the economic multiplier and creating a local monetary cycle with many positive economic implications. These economic implications may include imports savings, earning foreign hard currencies, establishing the technologies and knowledge, and increasing the public awareness.

4- Measures designed to reduce fishing pressure on abalone

Abalone are renewable natural marine resources as mentioned previously and have a limited carrying capacity. That is abalone would provide annual sustainable harvest at the right level of exploitation. Nevertheless, economic and political factors complicate the decision making process as does scientific uncertainty. In turn this produces an environment that detrimental to abalone sound management and sustainable development. Thus, there is a need to alter fisheries exploitation practices and reduce the fishing pressure on abalone. This is an acute and innovative idea, while connecting adequately to the general development of the country.

Consequently, reducing utilization and harvest pressure on abalone and other high value coastal species lies in the development of offshore fisheries, fish processing and fish products manufacturing industries, development of fisheries transportation systems and general fisheries facilities, and establishment of fish marketing channels and systems. However, the ministry should take the lead role in bringing these projects to reality. Projects plans should be strategically planned, integrate with the social and economic settings of the country, and continuously monitor and adjust implementation.

VII- Conclusion

The Omani abalone species, which is comparable with high value international commercial abalone, is large and provides tender white meat and an iridescent shell. It also produces beautiful abalone pearls that could in turn form ancillary industries to abalone mariculture. The abalone fishery in southern Oman has been in existence for many decades providing remote coastal fishing villages and town with prime incomes. This fishery has existed without government regulations, but with complex community rules that stem from the social structure and which have been enforced through the community organization.

However, in the recent years as the Omani nation becomes more mobile and the coastal towns of southern Oman are more settled and developed, the ancient social structure is deteriorating. Thus, collective social action may only come from the government, where the Ministry of Agriculture and Fisheries is the lead agency. Consequently, the ministry should give higher priority to the management and development of the abalone fishery. Abalone management and development should be based on scientific facts and should occur within an interdisciplinary decision making environment. In this endeavor, the concepts and guidance of integrated policy, integrated management, and sustainable development should be utilized. The ministry should view the management and development of the abalone fishery as a

matter that ties-in with, among other things, the general development of the country, its internal security, and establishment and transfer of modern fisheries technologies.

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