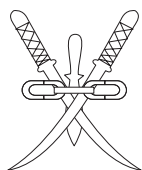


Report of the

TRILATERAL WORKSHOP ON LANTERNFISH IN THE GULF OF OMAN

Muscat, Oman, 7-9 May 2001



THE SULTANATE OF OMAN



THE ISLAMIC REPUBLIC OF IRAN



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PREPARATION OF THIS DOCUMENT

This is the report of the Trilateral Workshop on Lanternfish in the Gulf of Oman. The workshop was held in the Crown Plaza Hotel, Muscat, the Sultanate of Oman, from 7 to 9 April 2001.

The report comprises a record of the proceedings of the Workshop, including the summaries of the papers presented, recommendations and follow-up proposals of the working groups. The appendixes of the report comprise the programme of work, the list of participants and a list of publications and lecture notes circulated during the Workshop.

This report was prepared in draft by Sumaya Adam Eisa, who also translated into English some of the material. She had assistance in the secretariat from Ahmed Al Deghaish and Salim Bin Mohamed Al-Maskeri.

The recommendations, which are part of this report were discussed and adopted in the final plenary session of the workshop. The draft report was then edited by FAO staff, who incorporated comments to the revised draft from the Heads of the Iranian and Omani delegations in this final version.

Distribution:

Participants
FAO Fisheries Department
Marine Science and Fisheries Center, Oman
Ministry of Agriculture and Fisheries, Oman
Ministry of Jihad-E-Sazandegi Fisheries Co. of Iran
Fisheries companies

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ABSTRACT

This is the report of the Trilateral Workshop on Lanternfish in the Gulf of Oman, held in Muscat, the Sultanate of Oman, from 7 to 9 May 2001.

The Workshop was organized by the FAO Fishery Industries Division in cooperation with the Ministry of Agriculture and Fisheries, the Sultanate of Oman, and was hosted by the Sultanate of Oman.

The Workshop was attended by 43 participants from the Sultanate of Oman, the Islamic Republic of Iran and from FAO. The participants represented national fisheries administrations, fisheries companies and scientific institutions.

The main issues addressed by the Workshop included the situation of myctophid resources in the Gulf of Oman, their biology and stock assessment, estimation of the precautionary harvest levels, research activities for assuring their effective management, bycatch from lanternfish fishing, exploitation trials in the Gulf of Oman, efficient capture and handling, options for utilization, processing and the ecology of myctophids in the Gulf of Oman.

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1. INTRODUCTION

Globally, the pressure on conventional fish resources has intensified during recent years. Important fish stocks have declined dramatically over the years, and some have reached a state of full exploitation or even over-exploitation. Exploitation of underutilised fish resources seems to be among the possible solutions to increase global fish production and also to facilitate recovery of overexploited conventional fish resources. Mesopelagic fish, together with other under-exploited resources, like squid and krill, are the most promising potential resources in this respect.

The Gulf of Oman is relatively rich in fisheries resources, with considerable quantities of mesopelagic fish occurring on and outside the continental slope and distributed in the deeper zone of the Gulf of Oman waters. The Gulf of Oman has favourable oceanographic conditions for fish production as a result of the seasonal upwelling caused by the southwest monsoon in the northern part of the Arabian Sea. Considerable primary production occurs in these waters and a significant part of it is thought to end up as mesopelagic fish resources.

The mesopelagic zone has been defined in different ways based on depth, temperature and light intensity. Depth seems to be the best criterion and mesopelagic fish can thus be defined as species generally spending the day at depths between approximately 200 and 1000 m. Generally they perform a diurnal migration, coming to the upper 200 m or even to the surface during the night.

Species of many families will fall within this definition, but generally the family Myctophidae or lanternfish is dominant.

Mesopelagic fish are found in all oceans from the Arctic to the Antarctic, but the number of species and, in general, the annual production is highest in subtropical and tropical seas.

Fishmeal, fish oil and fish silage have been produced from lanternfish, and some species have also been fished in small amounts for human consumption.

The bulk of early work on mesopelagic fish was concerned primarily with taxonomy and distribution. There are still many unsolved problems in these fields, but recent literature has been mostly concerned with vertical distribution and migration and other aspects of the ecology of the group.

Knowledge about the food and feeding habits of mesopelagic fish has also increased, and their importance as vertical transporters of organic matter has been stressed.

In Oman research work on mesopelagics has been sporadic in spite of the relatively rich fisheries on other species in the Gulf of Oman. Starting in 1975, the R/V Dr. Fridtjof Nansen conducted a systematic survey of the resources in the Arabian Sea and Gulf of Oman. The whole Gulf of Oman (both Iranian and Oman sides) and the Gulf of Aden were covered again in 1979, 1981 and 1983. The total abundance of mesopelagic fish in the Gulf of Oman estimated on 5 cruises conducted during 1975-1976 ranged from 8 to 20 million tonnes.

2. OBJECTIVES OF THE WORKSHOP

This workshop was organised with the overall aim of exchanging information and experiences on myctophidea resources and its exploitation with the neighbouring countries Oman and Iran. The specific objectives of the workshop were to:

- explore the possibilities for co-operation between the concerned countries to estimate the stock of lantern fish in the Gulf of Oman and ways to exploit the same on an economical and sustainable basis;
- enhance understanding and knowledge of lanternfish biology, places of abundance, feeding, migration, reproduction and fishing season;
- determine the technical requirements needed for the exploitation of lanternfishes (fishing technology, vessels, processing equipment, etc.);
- analyse the impacts of lanternfish exploitation on other fish resources.
- determine the total quantity of catch that can be exploited without negatively affecting the stock;
- by catch problems in the fishery on lanternfish;
- discuss the possibilities for contribution by international organisations, particularly FAO, in the assessment of lanternfish stocks and to provide answers to questions raised in this regard.

3. ATTENDANCE

The workshop was attended by 43 participants from the Sultanate of Oman, from Iran, and from the Food and Agriculture Organization of the United Nations (FAO). Participants from the Sultanate of Oman were from the Ministry of Agriculture and Fisheries, the Marine Science and Fisheries Center, the Sultan Qaboos University, the Fish Quality Control Center, the Directorate General of Agriculture, Animal Wealth and Fisheries in Batina Region, the Quriyat Aquaculture Company, the Anees Trading Center, the Oman Fisheries Company and the Oman Center for Projects, Investment and Export Development. Participants from Iran were from the Iran Fisheries Company, the Iranian Fisheries Research Institute, the Oman Sea Research Center and the Shrimp and Fish Feed Co.

4. PROCEEDINGS

4.1 Opening Ceremony

The workshop was opened under the auspices of HE Dr Saud Bin Nasir Al-Riyami, Vice Chancellor of Sultan Qaboos University with a recitation from the Holy Koran.

Dr Younis Bin Khalfan Al-Akhezami, the Director General of Fisheries Resources, delivered the welcome address of the Ministry of Agriculture and Fisheries, the Sultanate of Oman. The text of Dr Younis's opening address is provided in Appendix E.

Mr Ebrahim Maygoli, Director of Lanternfish Development and Managing Director of the Hormozgan Fishery Company delivered the opening address for Iran. This was followed by an opening address from FAO, by Mr John-Willy Valdemarsen, Chief, Fishing Technology Service. Texts of the FAO and Iran opening addresses are provided in Appendices F and G.

4.2 Introduction to the workshop and organizational arrangements

Mr Saud Al-Habsi Assistant Director General for Fisheries Research and Extension was elected as the Chairman for the Workshop sessions. Mr Ibrahim Maygoli from Iran was elected as the Vice-Chairman, and Mr John-Willy Valdemarsen from FAO was elected as the Rapporteur of the Workshop. The programme of work was reviewed and some amendments were made. The participants introduced themselves by name, occupation and place of work.

The programme that was adopted is provided in Appendix A. Papers discussed during the working sessions and the list of documents circulated during the Workshop are provided in Appendix C.

4.3 Working Sessions

4.3.1 Myctophids in the Gulf of Oman by Mr Ahmed Al-Mazrooei, Director of Marine Science and Fisheries Center (MSFC).

Ahmed Al-Mazrooei the director of MSFC provided a historical review of the geographic distribution and classification of Myctophids, and pointed out that the Gulf of Oman is rich in fisheries resources, particularly in lanternfish resources. He defined the mesopelagic zone as the middle pelagic zone of the ocean where there is some light and it extends between 200-1000 m depths. Ahmed Al-Mazrooei then talked about the chemical composition of lanternfish, and that the fishmeal produced from lanternfish is of good and high quality. The main results of previous surveys were then highlighted. Bio-ecological aspects and exploitation of myctophids were also highlighted in the report.

Ahmed Al-Mazrooei concluded his presentation by stating that lanternfish resources are found worldwide in all the oceans and that large amounts of lanternfish occur in the Gulf of Oman. He stressed the need for further studies to determine the impact of myctophid harvesting on other species, which consume myctophids and which support important fisheries. These fisheries will be sensitive to large myctophid catches and unlike myctophids which presently can only be converted to fishmeal, these other fisheries provide fish for human consumption.

Queries were raised on the predators of lanternfish and the commercial species in the bycatch.

4.3.2 Biological aspects and stock assessment of myctophids in the Gulf of Oman by Dr Tooraj Valinassab, Head of Demersal Resources Section at the Iranian Fisheries Research Institute.

A brief account of previous surveys was given: starting in 1975 the RV Dr. Fridtjof Nansen conducted systematic surveys of the resources in the Arabian Sea and Gulf of Oman. The Northern Arabian Sea was investigated five times during 1975-1976. The whole Gulf of Oman (both Iranian and Oman sides) was covered. The Gulf of Oman was covered again in 1979, 1981 and 1983. The total abundance of mesopelagic fish was estimated from cruises conducted during 1975-1976 at between 8-20 million tons in the whole Gulf of Oman with high fluctuation in the estimated biomass.

During 1989-90 the Korean RV Jeng Bang San surveyed the Iranian side of the Gulf of Oman. In 1990 the Norwegian RV Rastrelliger surveyed the Oman side of the Gulf of Oman.

Two cruises were carried out. Since 1991, the RV Ferdows I carried out 7 cruises in the Iranian waters off Oman.

Dr Valinassab also gave a brief summary of the biology of myctophids, indicating that the main species (*Benthoosema pterotum*) is found throughout the Gulf of Oman, living at the end of the continental shelf and at the beginning of the continental slope. During daytime the species *B. pterotum* exhibits a distribution pattern characterized by two layers, and during night time it migrates towards the surface to form one layer. Fishing has been successful mainly on the upper layer (D1) during daytime.

Regarding the size composition of (*B. pterotum*) Dr Valinassab explained that the total mean length and total mean weight for *B. pterotum* were between 40-60 mm and 0.45-0.9 g respectively. Reproduction, growth parameters, food and feeding, bycatch, reaction to light, quality of fish and fishmeal were highlighted. The presentation was aided by graphs, photographs and echo-sounder images.

In accordance with processing of myctophids it was concluded that they can be utilized for the production of fish meal. Some primary observations show that they may be suitable for direct human consumption.

Dr Valinassab indicated that Iran is in the process of establishing a programme of aging for myctophids during this coming year.

He drew the attention of the participants to the high fluctuations of biomass, which he said, needs more research work. On the Iranian side it fluctuates from 4 million tons in spring to only 1 million tonnes in the autumn, he added.

4.3.3 Desirable research activities for the effective management of myctophids resources in the Gulf of Oman and Northwest Arabian Sea by Ross Shotton of FAO.

Mr Shotton was unable to attend this workshop; Mr John Willy Valdemarsen of FAO therefore read the paper on his behalf.

The paper indicated that, while several surveys had been conducted in the past 25 years, mesopelagic resources had not been covered comprehensively and he called for cooperation between Iran and Oman to carry out fisheries research on myctophids in the Gulf of Oman. He advised against the expression of results of surveys in terms of tonnes or biomass. He recommended instead that the actual units of what is measured, and total echo intensity should be expressed in terms of scattering cross section per m³. He stressed that estimating the absolute abundance of myctophids, i. e. the relation between the volume scattering coefficient and the sonified biomass, will require careful in situ experiments.

Mr Ross Shotton's paper went on to draw the attention of participants to the importance of information on the population structure of myctophids in the study region. The population parameters, physical and oceanographical requirements are also needed, he added. Initiatives to identify important oceanographic factors, which may determine the overall biological productivity, are also important.

Finally he called fisheries managers to address the issue of sustainable exploitation.

A meeting to list a future research programme and to examine scientific issues in relation to future possible management of this resource should be held and FAO could provide necessary assistance, he concluded.

4.3.4 Review of the status of bycatch in lanternfish fishing and its economic importance by Mr Abdul Mahdi Iran – Oman Sea Research Center I.R.I, Bander Abbas- Iran.

During experimental fishing operations carried out in the last two decades, it was found that in some fishing grounds other epipelagic or mesopelagic fish species were also caught. Ribbonfish, squid, small shrimp, tuna and several other species in smaller quantities have been reported. The ratio of bycatch recorded in different studies varied from 1 to 10% in accordance with different studies. Bycatch composition analysis showed 63% on average belonged to ribbonfish and squids. Analysis of the stomach contents of all bycatch species shows that they fed on Myctophids. However, the latest results on tuna fishes, revealed no traces of myctophid in their guts. It is believed that myctophids find their way there accidentally during tuna feeding as soon as they are caught along with other fishes.

The participants raised many questions and concern was expressed about bycatch composition and whether it contains larvae or juveniles of other important fish species.

Mr Abdul Mahdi Iran explained that most myctophid fishing takes place in offshore waters, and did not interfere with the fish larvae and fry settlement. No juveniles of ribbonfish were noticed.

Queries were raised about the interruption to the food chain of other fish, particularly tuna when harvesting myctophids.

Mr Abdul Mahdi Iran indicated that in his 22 years experience in fishing industry he never noticed the presence of myctophids in the stomach of tuna. Myctophid photophores were never noticed in the food contents of tuna stomachs. The only specimens found in tuna stomachs were fresh and it is believed that they found their way there accidentally. He stated that myctophids are not in the food chain of tuna. He agreed, however that tuna might be affected by myctophid fishing, if tuna eat these fish that depend on myctophids for food.

Night fishing and attraction to light were discussed. Night fishing yielded lower amounts of myctophids. He also reported that myctophids react negatively to light, i. e. they avoid light.

4.3.5 Experience of exploitation of lanternfish in the Gulf of Oman by Mr Abbas Ali Nodehi-Iran

The report published by the Institute of Marine Research in Bergen in May 1983, was the result of surveys carried out on lanternfish research in the Gulf of Oman at that time. In this regard, Gjosaeter reported during 1975 - 1977, while working on R/V Dr. Fridtjof Nansen in the northwest of the Arabian Sea that there were large interesting resources of mesopelagic fish. This work was followed by other research in 1979 and 1981, which confirmed that huge resources of lanternfish were available in the Gulf of Oman. Therefore R/V Dr. Fridtjof Nansen carried out further research operations in 1983. Afterwards seven other vessels namely: Jeng Bang Sang, Voyager K, Ferdows I, Jehad Fanos, Greek stern trawler,

Rastrelliger, Oman Pride have conducted research and experimental fishing in the area. Two of these seven vessels were operated from the Sultanate of Oman and the remainder were operated by the Iranian side.

None of these vessels were designed for lanternfish fishing and processing activities. However the midwater trawls using small mesh used on these vessels were appropriate for catching myctophids

4.3.6 Efficient capture and handling of lanternfish by Dr Wilfried Thiele and Mr John Willy Valdemarsen, Fishing Technology Service, Fishery Industries Division, FAO.

The paper addressed some of the technical aspects related to capture of such small fish partly based on experience from experimental fishing for lanternfish in the Gulf of Oman and partly based on knowledge about general behaviour of small fish, particularly their swimming capabilities. Several aspects of trawl design and fishing operations as well as requirements for gear control and fish detection equipment were highlighted.

A basic statement in the presentiaon was that fish of 3-4 cm length has not sufficient swimming capability to be efficiently herded by large meshes as used in the front part of very large mid-water trawls. Therefore trawl designs having a larger belly part of relative small meshes would be more appropitrate for efficient capture of lanternfish.

Several options for fishing operations, including handling of catch were discussed in the paper. These were:

1. Single boat midwater trawling with onboard processing of the catch.
2. Single boat midwater trawling with onboard processing of the catch supported by additional catcher vessels.
3. Single boat midwater trawling with storing and transport of the catch to a shore based fish meal factory.
4. Pair trawling where both vessels handle the trawl gear with storage space and transport the catch to a shore based factory.
5. Pair trawling where both vessels handle the trawl gear and a third vessel takes the catch onboard and transports it to a shore based fish meal factory.
6. Pair trawling where one vessel handles the trawl whereas the second vessel only tows the trawl and also takes the fish onboard and transports it to a shore based fish meal factory. This option will benefit from a third vessel with the same function as the latter described vessel.

The authors feel that pair trawling is a promising option that should be tested in this fishery, particularly involving several vessels (3-4) fishing in a group. Pair trawling can more easily be used for close to surface fishing during darkness and thus increase the effective fishing period. Fish should be stored in bulk, chilled with ice and the catch should be landed at a fish meal factory within 1-1.5 days after capture. At this stage of development the authors will not recommend that large vessels with a fish meal factory onboard are used as the operation costs of such vessels seem unreasonably high, at least with the catch rates obtained with the present catching technology.

4.3.7 Technology of harvesting mesopelagic fishes by Dr Harry Stengel - the Sultanate of Oman

Dr Stengel stated that the demand for aquatic products with high protein concentration continues to increase. As the major fisheries of the world have been fully- or even over-exploited, the demand for marine protein will have to be met from sources under exploited hitherto. Mesopelagic fish species could be one of these unexploited resources.

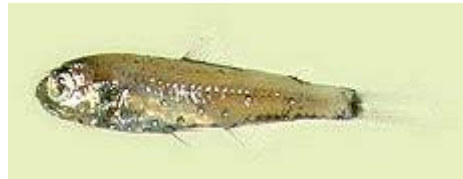
He drew the attention of the participants to questions related to the technology of harvesting mesopelagic fishes. Based on data about the daily vertical migration of mesopelagic fish he concluded that mid-water trawls are most appropriate for harvesting small fish at varying depths.

Details of two different types of mid-water trawl differing in the net panel, codend, otter board and rigging for harvesting mesopelagics were presented. Examples of catch amounts obtained in different areas were indicated.

Hints were given on how to adapt the trawl size to the bollard pull, given knowledge of the gear used on an existing fishing vessel.

4.3.8 Options for utilization of lanternfish (*Benthoosema pterotum*, Myctophidae) in the Gulf of Oman by Mr Frans Teutscher of FAO

The paper from FAO dealt with options for the utilisation of lanternfish. With an average size of 4 cm the fish is very small (see picture). Assuming that fishmeal will be the main product and that processing takes place on shore, it was recommended to preserve the catch in bulk adding ice at the same time that the fish is pumped from the net into the fish hold. The proportion will depend on catch rates, hold capacity, temperature, storage life, distance to port and delays before processing. It was expressed that more research is needed on utilization aspects of lanternfish and the planned fishing activities in Iran give a good opportunity to carry out such research. An important subject for research should be handling and preservation of the catch on board as it has major implications for the technical and economic feasibility of fishing operations and processing. Since the fish is very small there is a need for adaptation of technologies including pumping (loading and unloading), water separation, preservation of the catch (mixing with ice), transport to factory, holding at factory, and processing. Yields of fishmeal obtained in processing plants on-board were rather low and it should be possible to increase



Real size picture of *B. pterotum*

Elements of a proposed post-harvest research programme

Handling	<ul style="list-style-type: none"> • Stowage rate and bulk density • Fresh fish characteristics by location and by season (fish temperature, air temperature, water temperature, size, composition,...) • Cooling rate • Bulk behaviour in different media (without ice, with ice, RSW, CSW, RSW+CSW) • Storage life • Pumping conditions and pumping rates • Dissolved and dispersed solids in the aqueous phase during storage • Solids losses during pumping
Processing	<ul style="list-style-type: none"> • Yields and losses of fishmeal and fish oil • Other products
Product utilization	<ul style="list-style-type: none"> • Product diversification • Composition • Quality and safety • Nutritional and feeding data
Economics	<ul style="list-style-type: none"> • Development of a computerized economic model of a myctophid fishery

the yield. Like most lanternfish *B. pterotum* contains wax but previous tests have not indicated any adverse effect of the wax on animals fed with the fishmeal, but it was recommended to monitor and compare growth rates with conventional fishmeal and with *B. pterotum* fishmeal. A research programme was suggested on handling, processing, product utilisation and economics (see Table). Furthermore it was suggested to establish a database where all old and new information would be easily accessible to managers, researchers and the private sector. Although it is expected that fishmeal will be the main product, also other products should be tested such as dried, boiled-dried, fermented (fish sauce, silage), etc.

4.3.9 Handling and processing of lanternfish by Mr Gh. Moradi-Iran.

According to previous reports, it is possible to produce oil and meal from lanternfish, and composition of this fish and its fishmeal is within the range of oil and meal obtained from other common fish throughout the world. Shelf life of this fish at about 23°C has been determined as 8 hours. Shelf life can be increased to 12 days if the myctophids are held in ice or in CSW. The yield of fishmeal varies from 13 to 20% depending on the method used. A likely value is from 18 to 20%.

This report aims to review different methods of handling and processing of lanternfish based on the available information. At the present, some of the local vessels, selected to begin the fishery are about 40 m long, 6.5 m breadth and with a cold storage capacity of 90 tons. These vessels can freeze nearly 3 t of fish per 4 h using their blast tunnels. They have engines with 850 hp. Based on the distance between fishing ground and the shore, catch, dimensions of the fishing vessels, different approaches to handle and process lanternfish were considered.:

- Holding fish on board fishing vessels and landing (natural conditions)
- Producing fishmeal on board of a factory vessel and collecting fish from other fishing vessels.
- Freezing on board, handling and landing.
- Handling of fish in CSW or with ice.
- Handling fish in CSW and use of pipes to land fish.
- Fishmeal production on board factory ship.

The final method is more profitable than other methods but would require use of a big ship.

4.3.10 Identifying an ecological window of opportunity for myctophid fishery in the Gulf of Oman by Dr C.P Mathews - the Sultanate of Oman

- 1) A review of data from Oman on the myctophid stocks of the Gulf of Oman was carried out using published data from (i) surveys carried out by RVs Nansen and Rastrelliger, and (ii) from a survey of other electronic and hard copy publications. Assessments were carried out using these data and different estimates of precautionary sustainable yield were obtained:
 - the TEPL (Trophic/Ecological Precautionary Level), a level of landings that will probably exclude (a) myctophid landings in year t impacting myctophid landings in year+1, and (b) any effect in year t+1 on landings of fish that are ecologically or trophically dependent on myctophids. The TEPL was identified as around 375,000 t/year of fresh myctophids for the whole Gulf of Oman.
 - the SSPL (Single Species Precautionary Level), a level of landings that will probably exclude myctophid landings in year t impacting myctophid landings in year+1, but will not protect the landings of any stocks or fisheries that depend ecologically or

trophically on myctophids. The SPL was identified as around 1,260,000 t/year of fresh myctophids for the Gulf of Oman.

- Estimates of TEPL and SSPL are sensitive to values of natural mortality (M), and more accurate values of M should be researched urgently.
- 2) The ecological place of myctophids is described using available data from Oman and from other sources, and a possible ecological window of opportunity for a myctophid fishery is identified. This window identifies a small myctophid fishery (no more than 375,000 t/year) combined with substantial landings of predatory fish as the ecologically likeliest opportunity. A large myctophid fishery will be based on the ecologically unlikely assumption that most of the myctophid biomass is dispersed trophically as detritus, rather than being passed on to higher trophic levels where it may be harvested as fish for human consumption. A large myctophid fishery will also exploit the lowest trophic level possible. Fishing down to the bottom of the fish food web is normally a last, not a first, choice.
 - 3) Catch and effort data for myctophids from previous surveys in Oman, and their interpretation, are critically reviewed. Implications for identifying a feasible and economic fishing strategy are explored.
 - 4) No economically viable myctophid fishery has yet been established: to be successful, i.e. to be bioeconomically sustainable, a myctophid fishery needs to start with clearly identified and internationally accepted:
 - a) Ecological window(s) of opportunity;
 - b) Key biological reference points (that will trigger automatic and protective precautionary measures as soon as they are reached);
 - c) Catch targets that will be:
 - Economically satisfactory,
 - Without reducing the landings of already established large pelagic, small pelagic and demersal fisheries.

A provisional ecologically, oceanographically and climatologically sound strategy for exploiting the Gulf of Oman myctophid stock is identified, but available data are sparse and often weak, and results of the analyses presented cannot be used to justify a fishery. They should instead be used as a heuristic departure point for the critical research needed to confirm or revise and expand this provisional strategy. Such research will provide a more solid and less risky basis for establishing the world's first myctophid fishery.

4.4 Recommendations

For the purpose of preparing the recommendations two working groups were formed. The recommendations of each working group were discussed in plenary and the recommendations below were adopted by the workshop. The composition of the working groups is provided in Appendix D.

1. Oman delegation feels that more research is needed for gathering biological and ecological information and data. Research activities are also required on fishing technology of lanternfish in both countries. Furthermore, research is required on post-harvest handling, processing, marketing and utilization. FAO supports that more research in these areas is needed and Oman requests FAO to provide technical assistance.

2. While Iran believes that sufficient research activities have been conducted to justify embarking on pilot commercial fishing activities, technical support by FAO is still needed to improve fishing techniques, handling, processing and utilization of lanternfish.
3. It is agreed to establish a coordinating working group consisting of 6 members (3 from each side). This group will coordinate a joint research programme in the following fields:
 - a) Stock assessment, biology and ecological research.
 - b) Technology of fishing.
 - c) Handling, processing and product utilization.
4. Oman and Iran requested FAO to collaborate in:
 - a) Drawing up the work plan of the joint research programme.
 - b) Drawing up a draft proposal for a project in support of the work of the joint research programme.
5. FAO recommends:
 - a) Mid-water trawling as the most appropriate fishing gear. Existing gear designs need to be improved.
 - b) Pair trawling as the most promising fishing method.
 - c) Pumping for discharging the catch from codend to fish hold and from fish hold to shore.
 - d) Bulk icing for preserving the catch.
6. The participants agreed that large super trawlers with existing fishing technology do not seem to be appropriate.
7. Previous trials in Iran have shown that bycatch of ribbonfish is not a major problem for the myctophid fishing operation. During the execution of the upcoming experiments in Iran the problems reported by "Oman Pride" with ribbonfish bycatch should be taken into consideration.
8. With a view to promoting sustainability of resources, investigations should be carried out on possible environmental impact of the myctophid fishery, including non-target species.
9. The workshop recommends that both countries should aim to have specialists in each of the following fields to support the work on myctophids:
 - a) Biology, stock assessment, and ecosystems.
 - b) Fishing technology.
 - c) Post-harvest handling, processing, and product utilization.
10. The workshop recommends the establishment, with FAO's assistance, of a database on the myctophid fishery in the Gulf of Oman.

4.5 Discussion and adoption of the workshop report

During the closing session, the recommendation was discussed and adopted by the participants. As the full report of the workshop was not finished it was agreed that the Omani Secretariat should finish the draft text and send it to FAO for revision and amendment. FAO should then send the revised draft to the head of delegations for their final approval, after which the final report should be published by FAO as a Fisheries Report.

On behalf of the organizers of the Workshop Mr John-Willy Valdemarsen, FAO expressed appreciation for the active participation of all participants and of their contributions to the achievement of the objectives of the workshop. He also expressed gratitude to the Sultanate of Oman for the excellent organizational arrangements, which ensured a conducive, and pleasant workshop atmosphere.

The workshop concluded by participants and organizers expressing a strong interest and commitment to cooperate in the implementation of the recommendations of the workshop and the suggested follow-up activities. It was decided to hold the next meeting in October 2001 in Bander Abass, Iran.

APPENDIX A**Programme of the workshop**Monday, 7 May

- 9:00 - 9:15 Recitation of the Holy Koran
- 9:15 - 9:30 Opening Address of the MAF - Dr Younis Bin Khalfan Al-Akhzami, Director General of Fisheries Resources.
- 9:30 - 9:45 Opening Address of Iran by Ebrahim Maygoli, Director for lanternfish and Managing Director for Hormozgan fishery.
- 9:45 - 10:00 FAO's Opening Address by John-Willy Valdemarsen, Chief, Fishing Technology Service
- 11:00 - 11:45 Opening of the workshop, review of objectives, election of the chairperson and rapporteur, adoption of the workshop programme and arrangements for the session.
- 11:45 - 12:15 Myctophids in the Gulf of Oman by Ahmed AL-Mazrooei, Director of MSFC, Oman.
- 12:15 - 12:45 Situation of Myctophidae Resources in the Gulf of Oman: by DrT.Valinassab Pouri, Iran.
- 12:45 - 13:15 Desirable Research Activities for the Effective Management of Myctophid Resources in the Gulf of Oman and N.W. Arabian Sea by John Willy Valdemarsen, FAO.
- 14:45 - 15:15 Review of the Status of Bycatch in Lanternfish Fishing and its Economic Importance: by Mr Abdul Mahdi, Iran.

Tuesday, 8 May

- 8:30 - 9:00 Experience of Exploitation of Lanternfish in the Gulf of Oman: by MrAbbas Ali Nodehi, Iran
- 9:00 - 10:00 Efficient Capture and Handling of Lanternfish by: Wilfried Thiele, FAO.
- 10:30 - 11:00 Technology of Harvesting Mesopelagic Fishes: by Harry Stengel, Oman.
- 11:00 - 11:30 Options for Utilization of Lanternfish (*Benthoosema pterotum*) in the Gulf of Oman: by Frans Teutscher, FAO.
- 11:30 - 12:00 Handling and processing of Lanternfish: by Gh.Moradi, Iran.
- 12:00 - 13:00 Identifying an Ecological Window of Opportunity for a Myctophid Fishery in the Gulf of Oman. C.P. Mathews, Oman.
- 15:00 - 18:00 Group discussions

Wednesday, 9 May

- 8:30 - 10:00 Presentation of Working Groups Recommendations.
- 10:30 - 14:45 Meeting of the drafting Committee
- 14:45 - 16:00 Adoption of the Report.

APPENDIX B

List of participants

NAME	TITLE	ADDRESS	E-MAIL
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Abbas Ali Nodehi	Advisor to MD and In	Iran Fisheries Co.	

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FAO			
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APPENDIX C

List of papers presented at the workshop and list of publications, papers and lecture notes circulated during the workshop

Papers presented at the workshop:

1. Myctophids in the Gulf of Oman (by Ahmad Al-Mazrooei, Oman)
2. Biological Aspects and Stock Assessment of Myctophids in the Gulf of Oman (by Tooraj Valinassab, Iran)
3. Desirable Research Activities for the Effective Management of Myctophids Resources in the Gulf of Oman and N.W. Arabian Sea (by Ross Shotton, FAO)
4. Review of the Status of Bycatch from Lanternfish Fishing and its Economic Importance (by Abdul Mahdi Iran, Iran)
5. Experience of Exploitation of Lanternfish in the Gulf of Oman (by Abbas Ali Nodehi, Iran)
6. Efficient Capture and Handling of Lanternfish (by Wilfried Thiele and John Willy Valdemarsen, FAO)
7. Technology of Harvesting Mesopelagic Fish (by Harry Stengel, Oman)
8. Options for Utilization of Laternfish in the Gulf of Oman (by Frans Teutscher, FAO)
9. Handling and processing of lanternfish (by Gh. Moradi, Iran)
10. Identifying an Ecological Window of Opportunity for a Myctophid Fishery in the Gulf of Oman (by C.P. Mathews, Oman)

Publications, papers and lecture notes circulated during the workshop:

1. Efficient Capture and Handling of Lanternfish (Table of Catch Rates of “Oman Pride”).
2. Information paper: Surveys of Mesopelagic Fish in the Northern Arabian Sea (1975-84).
3. Consent paper for publishing in the Ministry’s Journal- the Sultanate of Oman.

APPENDIX D

Composition of the working groups

Working Group No. I: Fishing methods of lanternfish

Chairperson: Ebrahim Maygoli -Iran

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|----------|--|--|
| Members: | <ol style="list-style-type: none"> 1. Dr C.P. Mathews 2. Tooraj Valinassab 3. Hamed Al-Aofi 4. Hilal Al-Shaqsi 5. Saud Al-Habsi 6. M. Tngraja 7. Yaquooob Al-Busaidi 8. Ali-Al-Alwi 9. Salim Al Hasni 10. Abdulla A. Al-Harthy | <ol style="list-style-type: none"> 11. Shama Zaki Aldeen 12. Valdemarsen , John-Willy 13. Thiele, Wilfried 14. Juma Al-Maamary 15. Abbas Ali Nodehi 16. Ahmed Khalid AL-Isari 17. A.Nodehi 18. A.M. Nori 19. S.Secqcl 20. S.Ben Meriem |
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Working Group No. II: Processing and utilization of lanternfish

Chairperson: Frans Teutscher (FAO)

- | | | |
|----------|---|--|
| Members: | <ol style="list-style-type: none"> 1. Moradi 2. Nada F. Al-Yawer 3. Sabra Al-Mughairi 4. Fatma Al-Kayoumi 5. Aliya Al-Ghabshi 6. Ranjan De Silver | <ol style="list-style-type: none"> 7. Adil Gindy 8. Stephen Goddard 9. Farha Al-Kindy 10. Ahmed Al-Mazrooei 11. Ahmed Said Al-Souty 12. Lubna Al-Karousi |
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APPENDIX E

Opening address of the Sultanate of Oman by Dr Younis bin Khalfan al-Akhezami, Director General of Fisheries Resources, Ministry of Agriculture and Fisheries

“In the name of God, Most Gracious Most Merciful,
and blessings and peace be upon our prophet Mohammad, the guiding and the faithful.”

H.E Dr Saud bin Nasir Al-Riyami
Vice-President of Sultan Qaboos University, the patron of this ceremony
Your Excellencies
Our distinguished guests

A’ssalmo aleykom

The fisheries surveys conducted in Oman have indicated that seas of Oman are rich in different species of fish including demersal, pelagic, crustacea and other fish species. Oman fishermen, since old days and until now, are depending in their living on the abundant marine resources. But the harvesting, since then, has concentrated on the exploitation of certain species of fish specially those known of their economic and commercial importance like kingfish, groupers, tunas, shrimps and other known fish species.

For decades before now, Omanis did not know much about the nutritional or commercial value of lobsters, and in most of times, they used to discard such species and retain only the species they know. But now the situation is different, as all fishermen wait, with patience, for the opening of the lobster-fishing season, to get the maximum benefit from this valuable resource.

Oman seas are also rich in other species, like the myctophids, the subject of this workshop, and since little work has been done on lanternfish, this workshop intends to study this important potential economic resource and discuss the possibilities for their exploitation. This is especially relevant since the world is concentrating, nowadays, on the harvesting of unexploited fish resources in order to release pressure on the known economic species which are extensively exploited to the extent that many of fish stocks have been badly affected and some species have disappeared completely from world seas.

Different studies indicated that Oman seas are highly abundant in lantern fishes. The fisheries survey conducted by R/V “Dr. Fridtjof Nansen” in 1975 estimated the lanternfish stock in Oman waters at 20 million tons, whereas the biomass estimate made by the R/V Rastrelliger has been reduced to 4.5 tons. Whatever the correct figure is, or whatever the need for further and extensive long term study on the same, to determine the size of the stock more accurately, it is also important to know the economic importance of such resource and how to exploit it on a sustainable basis.

Dear Attendants

This workshop is one in a series of workshops and other activities which the Ministry of Agriculture and Fisheries is organizing and hosting with participation of experts and concerned personnel from the region and from international and regional organizations, with

the aim to exchange information and experiences with others, assist in fisheries management, exploitation, and sustainability. The Ministry of Agriculture and Fisheries has previously organized, in 1994, a scientific workshop on the same subject of lanternfishes, in which many countries participated.

Our present workshop aims at the following:

- (i) Discuss the possibilities for cooperation between the concerned countries in estimating lanternfishes stock in Gulf of Oman and ways of exploiting the same on economic sustainable basis.
- (ii) Enhance understating and knowledge on lanternfish biology, places of abundance, feeding, migration, reproduction and fishing season.
- (iii) Determine the technical capabilities needed for the exploitation of lanternfish (fishing equipment ... etc)
- (iv) Discuss the impacts of lanternfish exploitation on other fish resources.
- (v) Determine the total quantity of catch that can be exploited without negatively affecting the stock.
- (vi) Determine the percentage of lantern fish by catch in commercial catch.
- (vii) Discuss the possibilities for contribution by international organizations, particularly FAO, in assessment of lanternfish stock and in providing answers for the questions raised on this regard.
- (viii) Discuss the possibilities for the participation of the public sector in the optimum exploitation of these resources.

Our Dear Attendants

I would like to express my sincere thanks to all the participants from the Islamic Republic of Iran and FAO, and I hope them a nice stay in their second country, Sultanate of Oman.

We pray to God to culminate our efforts with success and we look forward to the realization of the objectives for which we are gathering to day.

My thanks are also extended to all of you.

APPENDIX F**Opening address of the Islamic Republic of Iran by Mr Ebrahim Maygoli**

We would like to thank FAO and the host country Sultanate of Oman for organising this important Workshop on lanternfish. Lanternfish resources are one of the largest unexplored resources so far. Iran feels it is important to realise exploitation of these resources to develop fishmeal production for poultry and agriculture sector.

Today we feel we have all the data and information needed for starting lantern fishing but some research on handling and transportation of the fish will be needed. We have conducted a lot of experimental fishing operation and success of the commercial fishing is obvious.

We will embark on commercial fishing this year by utilising four commercial trawlers from private sectors. The Government of the Islamic Republic of Iran supporting financially and technically the fishing development as well as the required industry. It will be started by those four vessels and after three months commercial fishing trail then the number of vessels will be increased. The need for fishmeal in poultry industry as well as aquaculture urged the Government to increase production.

We request FAO to assist us technically and if possible financially through shared projects for fishing, handling and processing of myctophid fish. We are in the position to propose any technical assistant to the Sultanate of Oman in stock assessment as well as other required data and information.

Finally as I have mentioned we are seriously trying to exploit this important resource. I would like to thank FAO for organising this workshop and the fisheries department of the Sultanate of Oman for hosting this fruitful and successful workshop.

APPENDIX G

Opening address of FAO by Mr John-Willy Valdemarsen

Dear Excellencies, ladies and gentlemen. It is a great honour for me on behalf of the Director General of the FAO J. Diouf, to congratulate the Sultanate of Oman for organizing this important and timely trilateral Workshop on lanternfish in the Gulf of Oman jointly with the Islamic Republic of Iran and my own organization.

For me as a Norwegian citizen it is a special pleasure to give this opening statement on behalf of FAO, knowing that my home country among others has been an important player in the process leading up to the topic for this workshop.

To start with, the Norwegian Research vessel “Dr. Fridtjof Nansen” during its surveys in 1975-77 in the region for the first time estimated that the biomass in the area consisted of several million tonnes of lanternfish (myctophids or Mesopelagic fishes).

Since then several attempts have been made to start a commercial fishery on this resource. Several Norwegian experts and companies have also been involved in this exercise, and some of their experience will be discussed during this workshop. In this connection I want to mention the fishing trials by FF “Voyager K” in 1992 that resulted in the very impressive catch rates of 30 tonnes per fishing hour. Trials that were done to commercialize these results by another Norwegian-owned vessel “Oman Pride” in 1996 were, however not as successful.

I mention these events, which I have first hand knowledge about, to highlight the fact that there is no doubt a fishable concentration of lanternfish in the Oman Sea but that we have not yet reached the stage where we have developed a commercially viable fishery for this resource.

Global marine capture fisheries are now at the stage where production can hardly be expected to increase. The present exploitation level of around 90 million tonnes can most likely only be increased if hitherto unexploited and lightly exploited resource are harvested more than at present. From what is known, such resources are limited to organisms low on the marine food chain. Represented by planktonic crustacean, like krill, some oceanic squid species and Mesopelagic fishes. FAO has as one of its regular programme activities a project aimed at increasing production from such a resource.

The latter group is what the Gulf or Oman produces in large quantities and in densities that have not been found elsewhere. This group of fish is certainly a food source for other marine organisms in the area, but if the estimated annual production of several million tonnes is correct, an annual removal of say one million tonnes from fishing activities will most likely be sustainable. As the state and dynamic of the lantern fish stocks in the Gulf of Oman is still poorly known, it is recommended, however, that a precautionary catch limit is aimed at from the start of any fishery for this resource.

But the situation at present as said before, is that a fishery for this resource has not yet developed and the purpose of this workshop should therefore more than anything else define the ways towards a development of an economically viable fishery. Through a careful review of the past experiences from already executed fishing trials it is my hope that we in this workshop can come closer to this goal. FAO will in particular encourage the coastal states in

the region to cooperate in both research concerning the state and dynamic of the lanternfish stock but also as far as possible conduct joint efforts to develop a commercial fishery. FAO will contribute to this with advice and technical support. As the industry from both Iran and Oman is represented in this workshop the interest and actions as a follow up to the workshop will more than anything else decide whether such a fishery can be developed in the region or not.

Finally, I will take this opportunity to thank our host for the excellent preparation they have done to prepare for this workshop, not least with the excellent facilities they have selected for the meeting. My colleagues and I are hoping for a successful outcome of our three days' meeting.

The Trilateral Workshop on Lanternfish in the Gulf of Oman was held in Muscat, the Sultanate of Oman, from 7 to 9 May 2001. The workshop was organized by the FAO Fishery Industries Division in cooperation with the Ministry of Agriculture and Fisheries, Oman. It was attended by 43 participants from Oman, the Islamic Republic of Iran and from FAO. The participants represented national fisheries administrations, fisheries companies and scientific institutions. The main issues addressed by the workshop included the situation of myctophid resources in the Gulf of Oman, their biology and stock assessment, estimation of the precautionary harvest levels, research activities for assuring their effective management, bycatch from lanternfish fishing, exploitation trials in the Gulf of Oman, efficient capture and handling, options for utilization, processing and the ecology of myctophids in the Gulf of Oman.

