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جامعة الأزهر
مركز صالح عبد الله كامل
للاقتصاد الإسلامي

المؤتمر الدولي الثروة السمكية والأمن الغذائي في الدول العربية والإسلامية في الفترة من ٢٢-٢٤ أكتوبر ٢٠٠٣م

التربية البحرية الرفيعة بالبيئة في مناطق الحيد المرجاني
الأردن، خليج العقبة، البحر الأحمر

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كلية الزراعة - جامعة الأزهر - مدينة نصر - القاهرة -

ت: ٤٠٢٤١٣٢-٤٠٢٤١٩٠ فاكس: ٤٠١١٧١٠

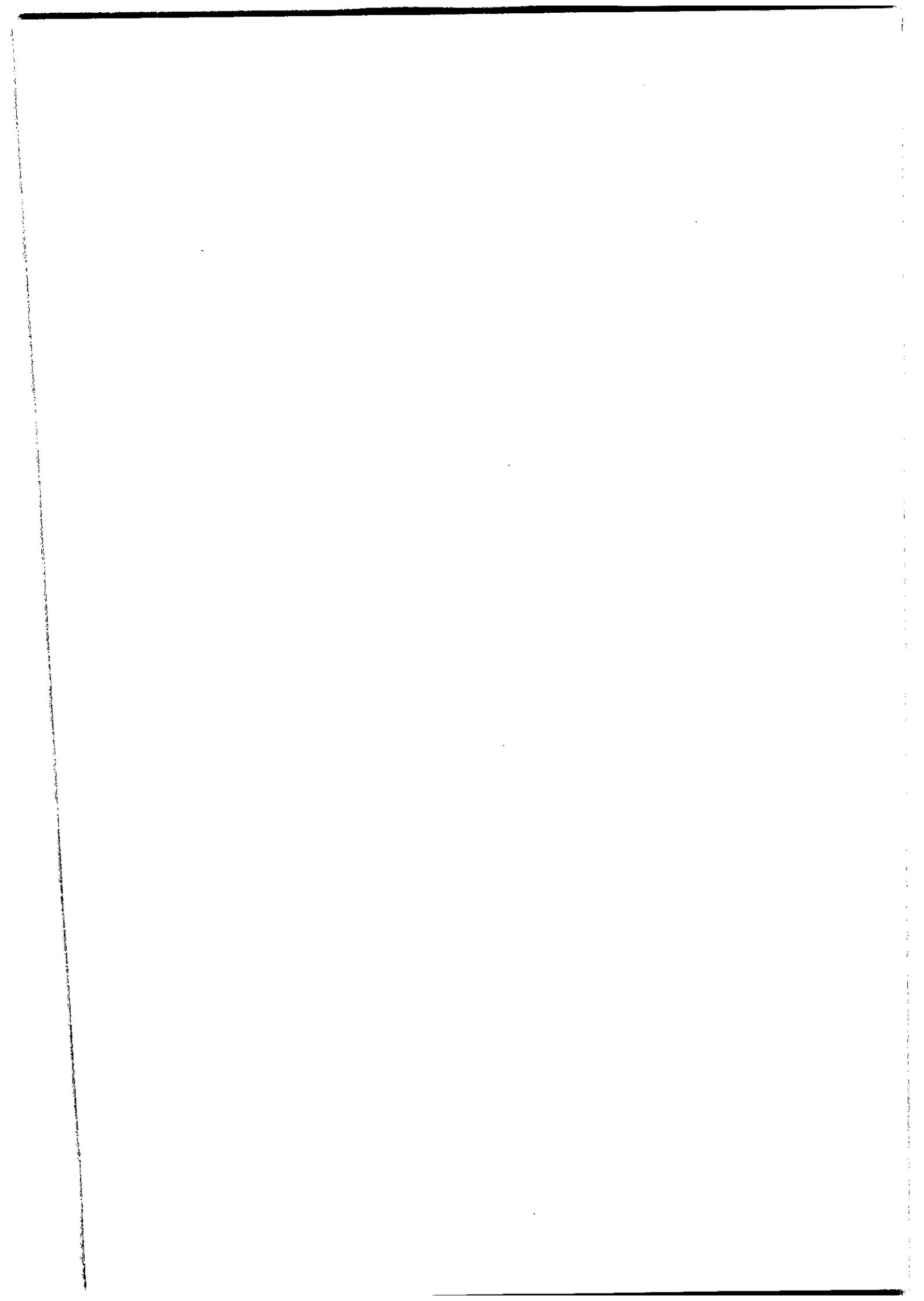
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ت: ٢٦١٠٣٠٨-٢٦١٠٣١١ فاكس: ٢٦١٠٣١٢

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التربية البحرية الرفيعة بالبيئة في مناطق الحيد المرجاني
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في عالم يعج بالمتغيرات والنمو المطرد للسكان تحت ظل محدودية الموارد البحرية، فإن قدرة هذه الموارد على الإيفاء بمتطلبات حاجات الإنسان تتراجع باستمرار.

والأردن على وجه الخصوص، يعتبر من الدول الحبيسة جغرافياً. إذ ليس له سوى بوابة صغيرة لا تتعدى ٣٠ كم على الجانب الشرقي من أقصى شمال خليج العقبة. وبالتالي فهو يواجه وضعاً حرجاً فيما يخص موارده البحرية. وفي نفس الوقت، لا يملك الأردن أية مسطحات مائية داخلية يمكن أن ترفده ببدائل عن الزراعة البحرية.

يقدر الإنتاج الوطني من الثروة السمكية بما لا يتعدى ٣٠٠ طن متري سنوياً، حيث يشكل هذا الرقم حوالي ٣% فقط من الاستهلاك المطلوب في الأردن. ولهذا، فإن ٩٧% من المنتجات البحرية يتم استيرادها مما يزيد أعباء الخزينة من العملة الصعبة ويسهم بوضوح في اختلال الميزان التجاري. لذلك، فقد بدت الحاجة ملحة إلى استثمار البوابة البحرية الصغيرة في الزراعة البحرية، وهي البديل الأفضل لتحسين الإنتاج البحري من أجل الاستهلاك وكذلك التقليل من عجز الميزان التجاري للأردن. وتجدر الإشارة هنا أن موارد المصائد في الأردن محدودة جداً وأن عدد الصيادين الممارسين للصيد لا يزيد عن مائة يمارسون أساليب تقليدية بسيطة في عملية الصيد مما يؤدي إلى قلة العائد. وعليه، يمكن اعتبار هؤلاء الصيادين فئة مناسبة للاستفادة من أي مشروع لتطوير الزراعة البحرية في الأردن. فتوفير الفرصة لهم في تلقي التدريب يمكن أن يفسح المجال أمامهم ويشجعهم على ممارسة مهنة الزراعة البحرية ضمن مشاريع تعاونية صغيرة.

إلا أن هناك عقبة تواجه التربية البحرية في الأردن تتمثل في احتمالية التأثير السلبي على البيئة البحرية الممثلة بشكل أساسي بالشعاب المرجانية. ولهذا، فقد تم إقرار خطة استراتيجية للزراعة البحرية في الأردن تتكون من أربع نقاط رئيسية: أ- زراعة أحياء بحرية ذات قيمة اقتصادية عالية ولا تؤثر سلباً على البيئة مثل استزراع كائنات الحيد المرجاني والأنواع المطلوبة لمعارض الأحياء البحرية. ب- تجنب أي نشاط للزراعة البحرية باستخدام الأقفاص العائمة في البحر. ج- الوصول إلى معادلة متوازنة للتغذية تضمن تحول بيولوجي للنمو وبذات الوقت حداً

أدنى من المخلفات. د- المراقبة الحثيثة لحالة البيئة البحرية من أجل قياس القدرة الاستيعابية للنظام البيئي البحري في حال تزايد نشاط الاستزراع وذلك لمتطلبات الإدارة الساحلية الفعالة. بدأت أولى تجارب الزراعة البحرية في الأردن خلال النصف الثاني لعقد الثمانينات من خلال ما قامت به محطة العلوم البحرية في العقبة. حيث، تم إجراء تجربة استكشافية على سمكة القارووص والمستجلبة من بيئة البحر المتوسط بالتعاون مع فريق فرنسي (جوبير ١٩٨٩). أثبتت نتائج التجربة ملائمة الظروف البيئية في خليج العقبة لأغراض الزراعة البحرية، إلا أن ارتفاع التكلفة قد منع استمرارها وخاصة بعد إقرار الاستراتيجية الوطنية مما حدا بالمحطة البحرية إلى أن تقوم بتجارب استزراع تتماشى مع هذه الاستراتيجية مثل زراعة كائنات الحيد المرجاني والمحار العملاق (*Tridacna*). وقد بينت دراسة الجدوى الاقتصادية لهذه الأنواع وغيرها من أحياء المعارض البحرية إمكانية تسويقها في أوروبا وان هناك إطار قانوني بتصدير هذه المنتجات إما على قيد الحياة أو ميتة على أن تكون مستزرعة. ولهذا، فإن التجارب في محطة العلوم البحرية تركز على محورين، عملية الاستزراع بمجملها ومتطلبات البيئة البحرية من أجل حمايتها.

تقوم المحطة حاليا بالتركيز على زراعة المحار العملاق حيث يتوزع ضمن البيئة الطبيعية على طول الشاطئ الأردني لخليج العقبة. إن هذا النوع معروف بجماليته كأحد الأحياء المطلوبة للمعارض البحرية وكذلك قيمته الغذائية. وأن ما يميز هذا النوع أنه يتغذى بشكل أساسي على ترشيح العوالق وعن طريق الحياة التكافلية مع إحدى الطحالب المجهرية والتي تقدم ما يزيد عن ٥٠% من إنتاجيتها الأولية وبالتالي لا يحتاج المحار إلى أية تغذية خارجية. هذه المزايا جعلت من المحار العملاق نوعا مهما من الأحياء المستزرعة الرفيعة بالبيئة، وهو الهدف من أجل تطوير الزراعة البحرية في الأردن.

التجارب التي أجريت لغاية الآن مشجعة جدا وتدل انه بالإمكان استخدام الأمهات ذاتها للتفريخ عدة مرات أثناء موسم التكاثر. وهناك أيضا العديد من الأنواع الأخرى التي يتم اعتبارها حاليا للاستزراع في الأردن.

أما الهدف من المشاركة في مؤتمر الثروة السمكية والأمن الغذائي في الدول العربية والإسلامية يأتي بالأساس من أجل تبادل الخبرات مع المعاهد والمؤسسات العربية والإسلامية والتي تعنى على وجه التحديد بالزراعة البحرية الرفيعة بالبيئة. وكذلك العمل على توسيع قاعدة التربية البحرية المستدامة.

**Environmentally Friendly Mariculture in Coral Reef Areas, Jordan,
Gulf of Aqaba, Red Sea**

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Abstract

Marine resources in Jordan are extremely scarce with the Gulf of Aqaba being the only sea outlet and the Jordanian coast not exceeding 27 Km. Typical of the general features of the Gulf of Aqaba, the Jordanian coast is strongly oligotrophic and hosts mainly coral reef habitats. This in terms of living resources has two main consequences, low biological productivity interpreted by low catch and considerable sensitivity towards establishing aquaculture. Therefore and under the pressure of the need for fish resources Jordan has to consider efficient and innovative techniques to introduce aquaculture in the coral reef environment in such a way that secures sustainability for both the ecosystem and the introduced investment and proves viability from the economic perspective. This automatically leads to the concentration on high value low environmental burden aquaculture, producing coral reef species. Table fish on the other hand cannot be ignored, but it can be considered only in systems efficient enough to survive the environmental and economic challenge. Inland polyculture is suggested herein as a main alternative. Aquaculture production of coral reef species in the Red sea area still needs significant research before it will become a routine profession, but early results of the experiments with the giant clam in Jordan show that such type of aquaculture can be economically rewarding and harmlessly introduced in the coral reef ecosystem

Introduction

In a rapidly changing and continuously growing world, characterized by limited marine resources, the gap between the capacity of marine resources and their capability to fulfill the human needs increasingly widens. Jordan, in particular, being a maritime geographically disadvantaged state, faces more critical conditions as compared to a global average. Apart from thirty kilometers on the northeastern most sector of the Gulf of Aqaba, Jordan is

totally land locked. Fresh water resources in Jordan are also scarce. The current national fish production from fresh and marine water resources is about 300 tons year⁻¹. This comprises only about 3% of the national fish consumption. The remaining 97% are imported, costing the country considerable amounts of foreign exchange and contributing to a significant fraction of the deficit in the trade balance. To this end, developments in mariculture will serve Jordan in two strategic ways; decrease the trade balance deficit and increase the national food security.

Marine fisheries in Jordan are extremely limited. The number of regular fishermen is about one hundred. They practice artisanal fishery methods and none of them can depend entirely on fishing to make living for his family. These can be a major target group for mariculture development. They have a good chance to receive training and once trained get encouraged to undertake small mariculture investments, possibly through cooperative groups.

A major disadvantage of developing mariculture in Jordan is the possible adverse environmental impact. Nutrient enrichment in a restricted space, where coral reef is a dominant habitat is a serious concern. Therefore the strategic planning of mariculture in Jordan is based on three main components (i) culture of economically valuable environmentally non demanding species, such as coral reef ornamentals and aquarium species (ii) avoid as much as possible floating cage culture (iii) ensure optimal feed conversion-minimal waste production and (iv) continuous monitoring and assessment of the environmental conditions to determine the system capacity and apply strict management controls.

Population and economic growth in Jordan

Jordan's population, expected to reach six million in the next six years, is straining the country's ability to provide basic services and leading to disequilibrium in the national economy. Jordan's continuous population growth has increased poverty and unemployment in the country. There has also been an increased demand on basic services leading to disequilibrium in the general structure of the national economy. Jordan's annual population growth of 3.4 per cent exceeds the country's present and future socio-economic resources; an obstacle to sustainable development. Population issues are core to sustainable development, and the integration of population objectives in development planning and regaining economic stability. Jordan's four-year-old National Population Strategy is responsible for public

awareness campaigns on the impact of family planning on sustainable development in the country. Approximately 55 per cent of the Kingdom's own 4.8 million population is below 20 years old. Jordanians are Arabs, except for a few small communities of Circassians, Armenians, and Kurds, which have adapted to Arab culture. The official language is Arabic, but English is used widely in commerce and government. About 70% of Jordan's population is urban; less than 6% of the rural population is nomadic or seminomadic. Most people live where the rainfall supports agriculture. About 1.5 million Palestinian Arabs registered as refugees and displaced persons reside in Jordan, most as citizens. Jordan is a small Arab country with limited natural resources in addition to poverty and unemployment are fundamental problems. As only 4% of the land is arable, agricultural production is subject to the vagaries of a limited water supply, currently compounded by a 3-year drought. A water protocol with Israel has eased the situation to a certain extent, and the country is currently exploring other ways to expand its supply. Jordan depends on Iraq for most of its energy needs, although a pipeline that will bring natural gas from Egypt is completed. While Jordan's economy has traditionally been centered on phosphates, potash, fertilizer derivatives, overseas remittances, tourism, and foreign aid, the government hopes to reinvigorate economic growth by focusing on information technology, tariff-free export areas such as the Qualified Industrial Zones (QIZ) and the Aqaba Special Economic Zone (ASEZ), as well as expanding tourism. Real GDP, which grew 3.2% in 2000, is expected to increase by 4.1% in 2001. Jordan's high population growth rate has fallen to 2.8%. The official unemployment is at 16% but may well increase as the impact of the tourist slump ripples through the economy. Inflation continues to be low, and monetary stability remains a priority of the Central Bank of Jordan. While pursuing economic reform and increased trade, Jordan's economy will continue to be vulnerable to external shocks and regional unrest. Without calm in the region, economic growth seems destined to stay below its potential. Other ongoing challenges include fiscal adjustment to reduce the budget deficit and broader investment incentives to promote job-creating ventures. But, there have been some broad economic reforms that were undertaken in a long-term effort to improve living standards.

Social and employment structure of fishermen of Jordan

Aqaba fishermen literacy levels are either non-educated or elementary school. Very few were of high school level. Neither Fishermen Society nor

the government provides health and life insurances for fishermen. The fishery sector employs very small number of people. There is a noticeable trend of fishermen leaving the fishing to work in other disciplines (**Fig. 1**) such as the Port, Tourist activities and Industries. Reasons cited for leaving fishing include limited fishery resource and ground, in addition to inadequate fishing related facilities. Fishermen are having an average of living standard below the normal average standard of the local inhabitant of the city. It is understood from interviews that most of the boats are operated by their owners. However, in some cases ownership is shared between two or more fishermen and in others boat owners who do not take part in fishing and appoint others against small salaries. For artisinal fishermen, 1/3 of the catch earning goes to the boat owner, the 2/3 is distributed equally to the crew and workers and some part of amount goes to operational cost. There are no studies available in Aqaba on the living standard of fishermen, but the outcome of the present study in addition to the visual observation with their entire shortcoming would significantly help understanding this issue. Very few of the better-off fishing families own cars and have good houses. At the end of the scale there are many poor fishing families with very low incomes, thus live at subsistence level.

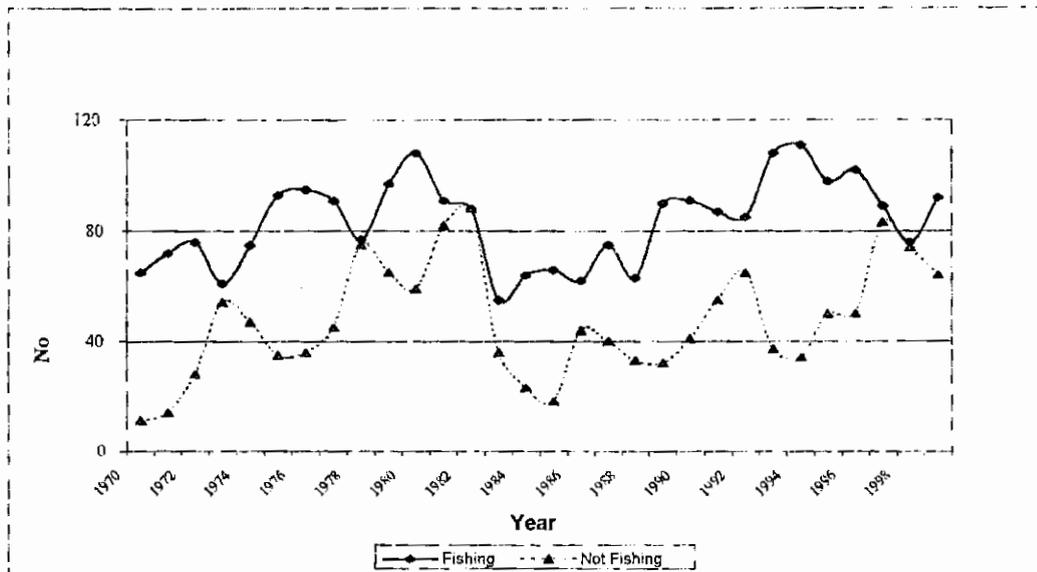
Scarcity of fish resources

The fishery in the Jordanian Gulf of Aqaba is quite small and artisanal in nature. Products are utilized in the local market and types of processing could not be seen. The fishery is small due to the limited size of the available fishing grounds (27Km of coastline). Nevertheless, the results of the present study showed that the fishery resources in this considerably narrow area support a diverse fish group to include several fish families that have commercial value. The availability of such wealth of resources is related to a number of reasons to include biotic and abiotic factors and the geographical setting in the subtropical region of the Red Sea. Such regions are located in warmer climatic zones and have highly productive and species rich habitats and marine communities.

The Jordan's Gulf of Aqaba fisheries exploitation is limited to fish only and other groups of organisms such as shellfish, crustaceans, echinoderms and molluscs are not considered. This is related to the fact that the quantity products are limited. Fish is the main marine product, which is included in the Jordanian diet, and this is even limited to those who have access to markets of fresh fish such as Aqaba town and adjacent areas. Fishery yield is heavily

dependent on the ease with which resources can be exploited. Consequently fisheries within this area is mostly dependent on artisanal fishing methods

Fig.1. No. of practicing fishermen in Aqaba-Jordan for the period 19970-2000



which operate on a small scale with small boats and inexpensive fishing gear. The catch of fish stocks using artisanal methods appears to be largely reliant on the difference in catchability of the fish rather than abundance. The current results indicated that local fish production did not meet the market demand for fish in Jordan especially in recent years. This is reflected by the fact that fish imports have substantially increased. (Fig. 2)

shows the annual fish imports from 1966 to 1996. The figure clearly indicates that fish imports have increased continuously in Jordan. The percentage of fish per head (capita) of imported and fresh fish in Jordan during the period from 1970 to 1996 is given in (Fig.3). The figure indicates that the highest fish consumption per head in Jordan was 3.4 kg in 1993, while the lowest was 0.6 kg in 1981. The last decade recorded maximum fish imports into the country and thus it may be concluded that local production has not been able to meet the market demands. This is probably because the catch has been unstable both in its landing and also probably in its catch composition. In order to supply the market demand a stable supply

must be guaranteed and it seems that this has been supplied mainly from imports as indicated by their gradual and steady increase (Fig.2). Prior to 1980 imports were quite low and this may be attributable to limited foreign trade, as the local fresh fish production was more or less sufficient between 1970 and 1982. However, after then importation of fish become necessary in order to meet market demand. The catch per import ratio, however is lower now than between 1992 and 1994 and this could be observed from the average fish consumption (Kg head⁻¹ year⁻¹) in Jordan. This is lower than the world average (13 Kg head⁻¹ year⁻¹) and even lower than the average reported for many Arab countries (Juma *et al.*, 1981) such as in south Yemen (51.6 Kg head⁻¹ year⁻¹), Oman (22 Kg head⁻¹ year⁻¹) and Saudi Arabia (4.2 Kg head⁻¹ year⁻¹).

Fig.2. Fish consumption both locally caught and imported for the period 1960-2000

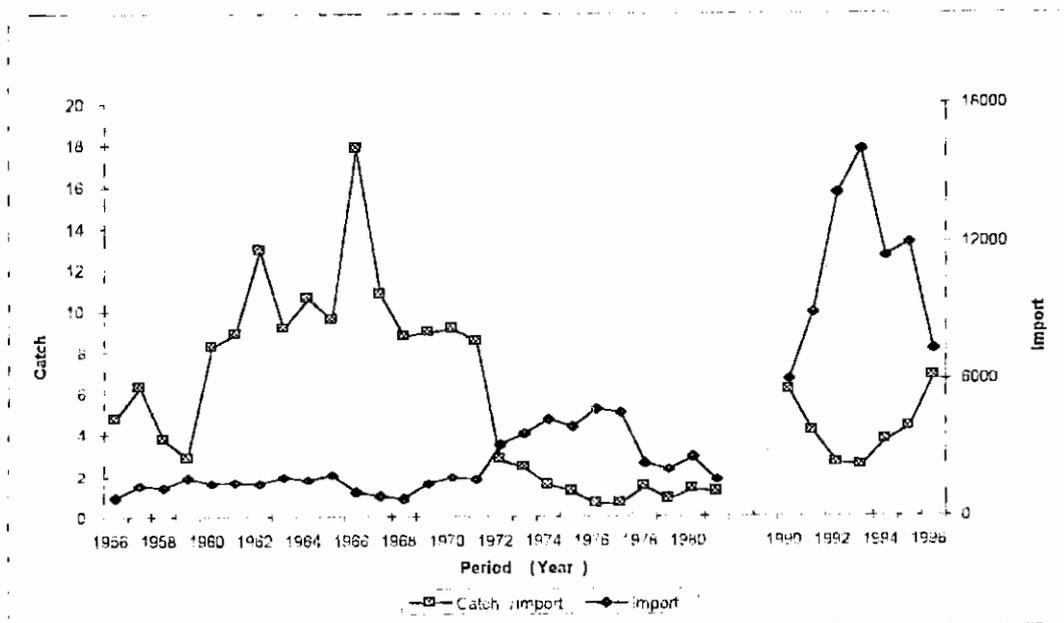
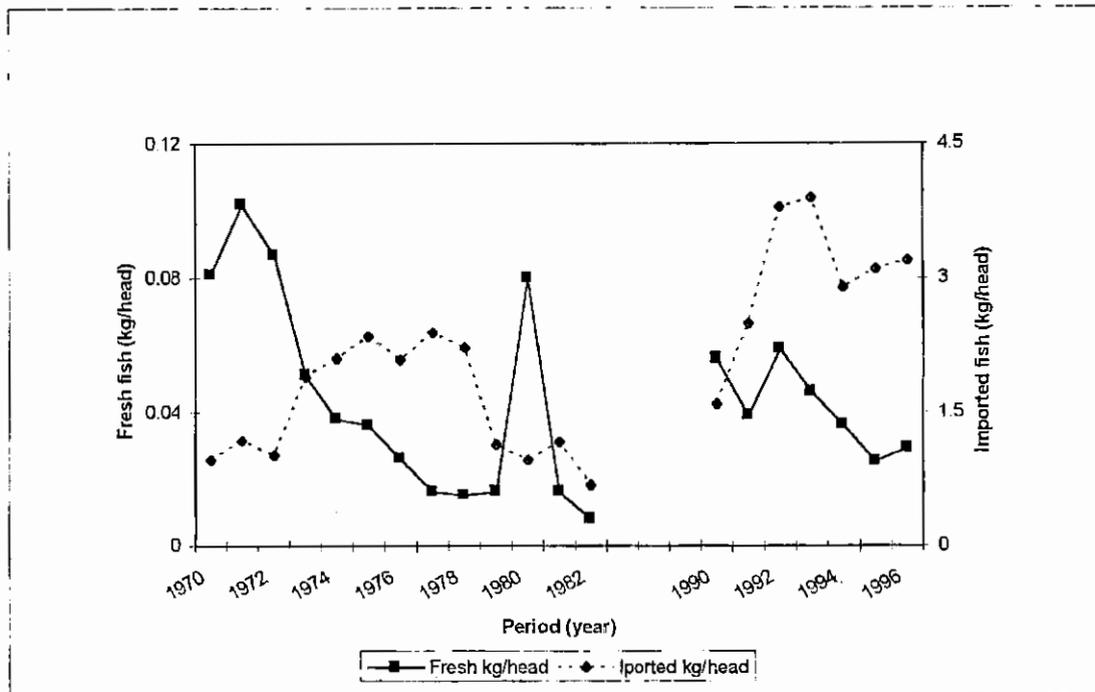


Fig. 3. Average per capita consumption in Jordan for the period 1970-2000



Characteristics of the Jordanian coast

The Jordanian coast is short not exceeding 27 Km, yet it is quite diverse and hosts several habitats. Sea grass beds inhabit the northernmost part and flourish on the sandy bottoms in this area. The Northernmost section of the Gulf of Aqaba is a mouth of a major valley Wadi Araba. This has historically supported the development of extended sand beaches. In fact this part is the only part of the Gulf of Aqaba that has a continental shelf and a gentle slope.

About 8 Km south of the northernmost tip of the Gulf of Aqaba starts the existence of corals. These appear as sporadically distributed heads at the northern edge then develop in fringing reefs further south. Corals on the Jordanian coast are mainly of the Scleractinian type. Coral reefs of Jordan are disturbed by inlets of small valleys that result in some kind of discontinuity. The number of coral species exceeds 170 soft and hard coral reef building species. These harbor with them another big number of associated fauna. Fish distribution on the Jordanian coast follows that of the

coral reef. The well developed reefs host higher numbers of fish species than elsewhere. These are mainly coral reef fish of high beauty and better scenic and ecological value than table value. The sea grass beds have some characteristic species and serve as nursery grounds for a good number of sedentary and pelagic fish. The good table value fish are mainly pelagic, yet due to the sharp slope of the Gulf of Aqaba they exist in a very close vicinity of the coral reef. However it is to be emphasized that the biological productivity in the Gulf of Aqaba is low due to its oligotrophic nature.

The Gulf of Aqaba is the eastern northernmost extension of the Red Sea. It is semi enclosed and connected to the Red Sea by the narrow Strait of Tiran. It lies in the arid Syrian African rift and receives no major river inlets. Rainfall is also limited and the winds are gentle. As a result the Gulf experiences two main seasons a well water mixed winter and a water stratified summer. This in turn results in variable biological productivity, where winter witnesses high primary production resulting from availability of nutrients and summer witnesses low primary production limited by scarcity of nutrients.

Human activities on the Jordanian coast

Up to mid 1950s Aqaba was a small fishing village providing sufficient fish catch for its small community. Development of the Ports was the first major industry to establish on the Jordanian coast. Ports spread rapidly and covered about 30% of the Jordanian coast. Other coastal investments that followed were mainly tourist oriented and industry based on the Jordanian phosphate rock. However early in the planning strategy the ecological aspects were considered. The Marine Science Station was established in mid 1970s to study, monitor and report on the environmental conditions along the Jordanian coast, in order to help decision makers adopt appropriate management tools based on scientific judgment. One of the most significant management tools adopted in Jordan is the declaration of 7 Km , 25% of the Jordanian coast as a marine reserve. This has pronounced benefits for the marine environment, but creates tremendous pressure on the fishermen community because it limits their already extremely limited fishing grounds.

Early mariculture experiments in Jordan

It is becoming increasingly commonly practiced recently to subsidize for lack of natural fish landings by aquaculture. Some fresh water culture ventures are coming up successfully in the Jordan valley and in Azraq.

Mariculture in Jordan on the other hand has not well yet developed. Early experiments in mariculture have started in Jordan (Marine Science Station, Aqaba) in mid 1980s. A major pilot experiment was conducted in collaboration with a French team (Jaubert, 1990). The purpose of this pilot experiment consisted in providing with data required to explore the technical and economical feasibility of industrial scale farming activities. The Mediterranean species sea bass *Dicentrarchus labrax* was introduced into the Jordanian Gulf of Aqaba. The experiment was heavily based on imports. The expertise, fry, raw material and feed were all imported from France, which resulted in high costs. We aimed in particular at comparing the advantages and inconveniences of the farming condition respectively provided by cages and raceways. The experiment, proved that the environmental condition at Aqaba were suitable for the development of mariculture. This however took place before the strategic plan mentioned above. Therefore the experiment was not repeated both for the high cost and environmental concerns.

Limitations of mariculture in coral reef environments

Aquaculture has been advocated as a way to enhance the supply of fish and shellfish and, hence, to release the fishing pressure off the wild stocks. However, production practices and their impacts on marine ecosystems vary widely. Some deleterious practices have been shown to diminish, rather than enhance, the revenues from the marine system (Naylor et al. 2000). Finfish production started in Elat, in 1988 and is now operating at a commercial scale. Mostly non-indigenous species high in the food web are targeted. These are stocked at high densities in cages and are supplied with all nutritional and medical requirements. Lucrative profits are possible with such *intense* farming practices, but there is growing concern that profits are generated by externalising potentially much higher environmental costs to society due to the generation and spread of waste products and pathogens, alteration of food-web interactions, introduction of exotic species, habitat deterioration, etc. (Naylor et al. 2000). Such fears are underpinned by the alarming degradation of Israeli coral reefs in recent years (Fishelson 1973, Loya 1975, Loya 1986). While cause and effects are still under debate, it has been shown that pollutants from local farms may potentially affect the entire region (Abelson et al. 1999). It could be generally said that mariculture results in enriching the seawater with nutrients, whose elevated levels may be intolerable by corals. This has alarmed also the neighboring countries which depend heavily on healthy coral reefs for the development of their

growing tourist industry. In Jordan, attempts to explore the potential of aquaculture have therefore gained little support by the Authorities, and aquaculture proposals by marine scientists and industry have been shelved.

Development of environmentally friendly mariculture

Environmentally friendly aquaculture practices that allow for the generation of high-value commodities without harming the environment do exist. One such approach is the *polyculture* of species belonging to different trophic levels. In this ecosystem approach, the 'wastes' generated by one trophic level are used as resource for the other. Semi-intensive polycultures have a long tradition in freshwater carp farming (Tacon & De Silva 1997) and are becoming implemented also in mariculture (Naylor *et al.* 2000). A second approach is the culture of species at the base of the food web, such as algae, macrophyte- and plankton feeders. Such *extensive* systems rely on ambient supplies of materials and energy and thus produce no excess nutrients.

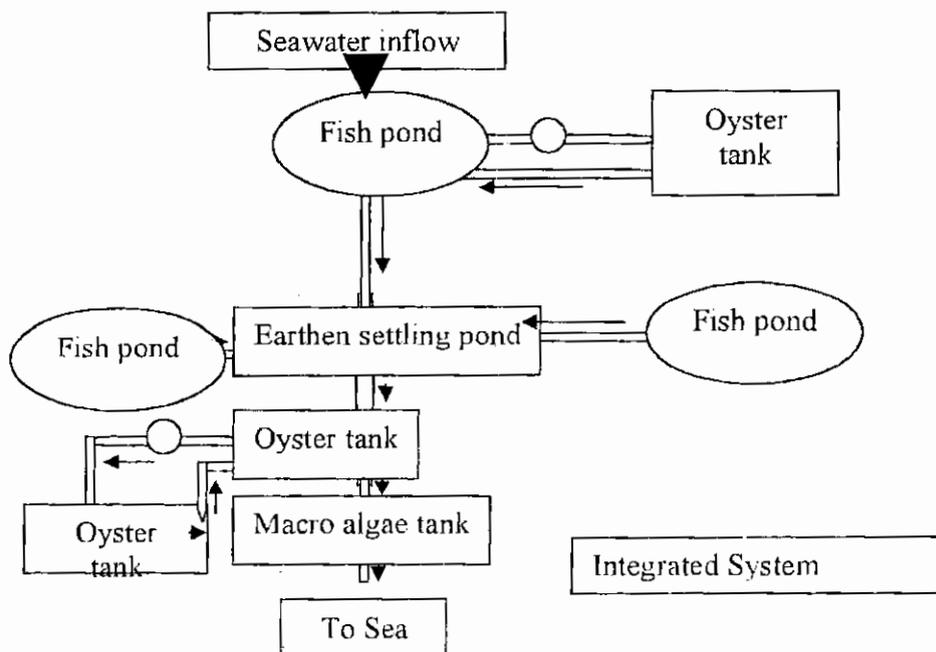
- (i) **culture of ornamentals and coral reef species** A combination of the two is the mariculture of giant clams (Tridacnidae) which exploits (i) the effective recycling of material between two trophic levels embodied within one organism -the animal host with its algal symbionts (zooxanthellae)- and (ii) the natural supply of energy and material to the clam-symbiont association. The mixotrophic life-style enables giant clams to tap different nutrient sources and achieve high growth rates in spite of low ambient concentrations. This makes them particularly amenable, conceptually, for integrated farming with other marine ornamentals in closed systems - but to the best of our knowledge this has not yet been attempted. Marketability studies show that clam farming is generally profitable, particularly if a suite of clam products, e.g. shell, mantle and adductor muscle, are sold (Leung *et al.* 1994). The costs of providing giant clam seed, both in relation to labor and capital costs are non-linear and highly scale-dependent (Tisdell *et al.* 1993). One centralized hatchery can therefore provide the basis for community-based grow-out of spat, sustaining and expanding existing stores of natural capital in the region. To the best of our knowledge, giant clam farming has not been attempted in the Red Sea area, in spite of the occurrence of indigenous brood stocks of *T. maxima* and *T. squamosa*, which are suitable for aquaculture (Kilada, 1994). Non-polluting integrated systems are

still in their infancy and use mostly non-indigenous species instead of local ones (Shpigel et al. 1996). Giant clams could play an important role in the design of polycultures for indigenous Red Sea species on ecological models that result in zero waste. Through effective recycling of both, nutrients and suspended organic matter, they could be used as boilers in such integrated systems, with positive feedbacks on both water quality and clam growth. The pilot plant shall thus form the building block for a regional center for the integrated culture of Red Sea coral reef animals. It should adapt established culture methods for giant clams and other popular molluscs of marine "reef" displays to the conditions prevailing in the Red Sea. It will further provide the seed for additional grant money for basic and applied research in this novel scientific field. Profitability, acceptance and environmental impact of clam farming shall be monitored. Positive evaluation of the socio-economic and environmental impact assessments shall provide the basis for an industry-based scaling-up to a commercial farm. Research and application within this project shall complement display and public education by the Red Sea Museum, planned to be built on the MSS campus during the coming year.

- (ii) **polyculture** Mariculture is a growing industry that carries with it a growing problem of environmental pollution due to nutrient waste. Deterioration of the water quality especially in land based mariculture certainly limits the intensification as well as the environmental sustainability which all are directly linked to economical viability. One approach of minimizing environmental problems would be to predict the impact prior to development and relate the prediction to predetermined standards. Models have been developed for predicting major processes such as nutrient (Shpigel, 1996) and eutrophication (Gowen, 1994), which in turn helped in estimating the carrying capacity of the site and area. Efforts undertaken recently for proper site selection as well as carrying capacity prediction in relation to environmental needs to avoid any impacts has been considered. If we know that more than 70% of protein nitrogen that usually ingested by the products of fish farm are released to the environment. This mean that under the oligotrophic nature of the Gulf of Aqaba development of sea cages is of serious concern due to the nutrient load, especially with the presence of zero discharge policy that has been enforced strictly

within the Jordanian sector. Therefore, it is becoming increasingly obvious that any advancement in efficient mariculture production generated by the feed's protein should be a long-term major research and development objective. Jordan has started when considering the co-management of resources in coastal and inland waters to build its capacity in the development of integrated systems. Such systems contribute greatly to the finfish production in several parts of the world. Polyculture could be part of these systems. It partly mimics the natural state of an ecosystem. Different species are incorporated though, each of them contribute relatively small numbers to yield. Such system are replicating bio-habitat in terms of diversity, achieve high level of recycling of nutrients and at the same time minimizing losses of the resource. A trial of pilot experiment of this system is under estimation at MSS. Fish, bivalves and seaweeds are incorporated together and the different relevant parameters to the system are being measured (Fig.4).

Fig.4. Schematic diagram of in land integrated poly culture system



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