Fisheries Management: The Kuwaiti Experience

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Introduction

Siddeek et al. (1991) discussed very briefly some recent developments in Kuwait's shrimp fishery, including an important increase in landings of the main commercial species, *Penaeus semisulcatus.* This increase coincided with a marked fall in landings of the other important species, *Metapenaeus affinis.* They thought that these changes were caused by a reduction in effort combined with a more or less simultaneous favorable environmental change for *P. semisulcatus* and an unfavorable environmental change for *M. affinis,* but did not give any unequivocal evidence to support this conclusion. The results they reported are, nevertheless, very important and may be relevant to scientists and managers in other parts of the world.

Mathews and Samuel (1991) summarized some of the important results produced in Kuwait, but they were interested only in the implications for future research in tropical fisheries, especially for penaeid trawl fisheries. They did not address any of the items raised by Siddeek et al. (1991), nor did they discuss any of the research on shrimp recruitment carried out previously in Kuwait, i.e., migrations or the possible interactions with the oceanographic environment. This article therefore examines some of the more detailed scientific results that were used to justify the management measures taken and discuss some of the successes and failures of shrimp fisheries management in Kuwait.

Impact of Wars on Kuwait's Fisheries

The Iraq-Iran war, which lasted from September 1979 until the autumn of 1988, frequently affected the distribution of fishing effort in Kuwait waters. The artisanal fisheries for pomfret, *Pampus argenteus*, taken in gill nets; snappers and groupers (mainly *Lutjanus coccineus, L. malabaricus, Epinephelus tauvina,* and *E. suilis*) taken with fish traps; and various species of trawled fish, were all excluded from fishing near the mouth of the Shatt-al-Arab for most of the war. The war also reduced or eliminated effort by artisanal trawlers on *M. affinis* nursery areas located near the mouth of the Shatt-Al-Arab, north of Failakka Island (area 3, Fig. 1). Industrial effort in this area (mostly by large Iraqi trawlers) was altogether eliminated. Reduction of artisanal and industrial trawler effort on shrimp grounds south of Failakka Island was not very severe or long lasting until September 1987 when security measures associated with the war excluded night fishing throughout Kuwait waters, with day fishing allowed in principle only 5–10 miles from the coast. In spite of these security problems, research and assessment work continued until the end of the Iraq-Iran war in 1988, and the government managed the penaeid fishery, often taking scientific advice into account.[1]

The disastrous invasion of Kuwait, which occurred on 2 August 1990 and lasted until the expulsion of Iraqi troops by U.N. forces in late February 1991, had much more severe effects. All research and assessments were suspended (Carpenter, 1992; Mathews et al., In press). Many fishing boats were moved to Iraq by conquering forces, and only a few have been returned so far. All equipment, databases, and scientific records were taken to the Marine Science Center, University of Barash, together with the Mariculture and Fisheries Department's library. None of these scientific resources have been returned. Although data collection was started some months after the end of the war, the significant stock assessment and management system installed before the war is not yet fully in place. Some data on landings and effort are available for

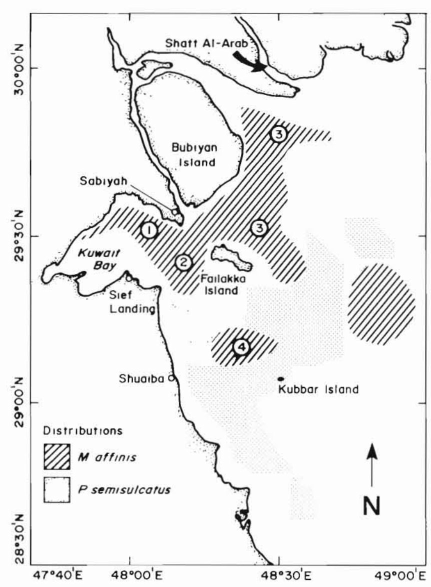

Figure 1. — Distribution of *Metapenaeus affinis* and *Penaeus semisulcatus* in Kuwait waters: 1, Kuwait Bay; 2, Rixa; 3, Bubiyan; and 4, Kubbar. After Farmer and Ukawa (1986).

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[1] Personal observations and communications from fishermen, government, and industry.

1992–93 (Kuwait Institute for Scientific Research: Personal commun.) but full recovery from the impact of the war has not occurred. It is likely to be some years before the important prewar capability is fully restored. Therefore it is important to make full use of the Kuwaiti experience, using all published data.[2]

Development of Kuwaiti Assessment Research

Shrimp assessment research began in Kuwait in 1977 at the Kuwait Institute for Scientific Research (KISR), and by 1979 adequate time-series data were available for preliminary assessment of the stocks with surplus production and dynamic pool models. These results, together with falling shrimp catches in the Gulf between Iran and the Arabian Peninsula, were used to justify a longer closed season aimed at protecting spawners. The available data did not, however, provide an unequivocal justification for these measures.

In 1981, a detailed review of all available data and analyses was carried out by the KISR shrimp research team[3] (Mathews, 1982 a, b), and new assessments were provided. Yield per recruit (*Y'/R*) models justified:

1) An increase in the size at entry to the shrimp fishery (either through increasing mesh size or through establishing a longer and/or later closed season), and

2) A decrease in exploitation ratio (*E*).

The review also found that surplus production modeling justified a reduction in effort to a level of about 16–20 industrial boat-years (expending about 2,800–3,600 days per year). This measure would allow the fishery to operate at a much more profitable level. In spite of their more detailed assessments, the scientists involved chose not to recommend any management action, but did take care to inform managers of the scientific results and of their possible management implications (Mathews, 1982c).

In 1982, the KISR shrimp research team identified a new policy based on the separate management of the *P. semisulcatus* and *M. affinis* stocks, which have overlapping but largely separate fishing grounds (Fig. 1). These two species provide over 90% of the commercial landings by volume and value.

A study of *P. semisulcatus* spawning prior to the closure of the fishery showed higher than usual catch rates of sexually mature shrimp in 1982 which justified a later closure of the fishery: Fishing was allowed until early May 1982 instead of being suspended in late February (as was the case in 1981). This extension led to a significant enhancement of profits in the 1982 fishery.

At the same time the closed season was confined to the *P. semisulcatus* stock: Total closure of the fishery on *P. semisulcatus* was acccompanied by limited fishing on the *M. affinis* stock by industrial boats whose landings were monitored to ensure that no *P. semisulcatus* was taken. Fishing of *P. semisulcatus* was effectively forbidden by means of a strict ban on the landing and sales of the latter species (Mathews and Al-Ghafar, 1984).

Implementation on a trial basis of the two-stock management policy for 1983–85 led to total *M. affinis* landings during the closed season of about 1,000 t, worth about KD900,000 (i.e., about $US3,000,000), a sum markedly in excess of the total amount invested in shrimp assessment research during 1977–88. The success of the policy during its first year demonstrated the usefulness of fisheries management research to both government and industry and increased communication between them and the scientific research sector.

By 1983, the results being produced by the KISR research team were based on much more detailed analysis and preparation of data. Figure 2 shows the yield per recruit (*Y'/R*) model developed by Mathews and Al-Ghafar (1984, 1986); *A* shows the position of the fishery in 1982 (their reference year). The corresponding yield curve (*O'AO*) for that size at entry (18 mm carapace length) shows that very small changes in *Y'/R* will occur for any value of *F* from about $F = 1.5 - 6.0$; MSY for mean length at capture, Lc = 18 mm *CL*, occurs at about *A*. It is also clear that an increase in size at entry by any appropriate means would increase *Y'/R* from about *A* to *A''* at $F = 3.0$.

Figure 3 shows the surplus production curve these authors developed for the shrimp landed by the Kuwait Trawl Fishery. It may be compared with the yield curve (*O'AO*) developed from the *Y'/R* model, assuming that $F = gf$ (where f = annual effort in the trawl fishery in thousands of boat days per year, and g

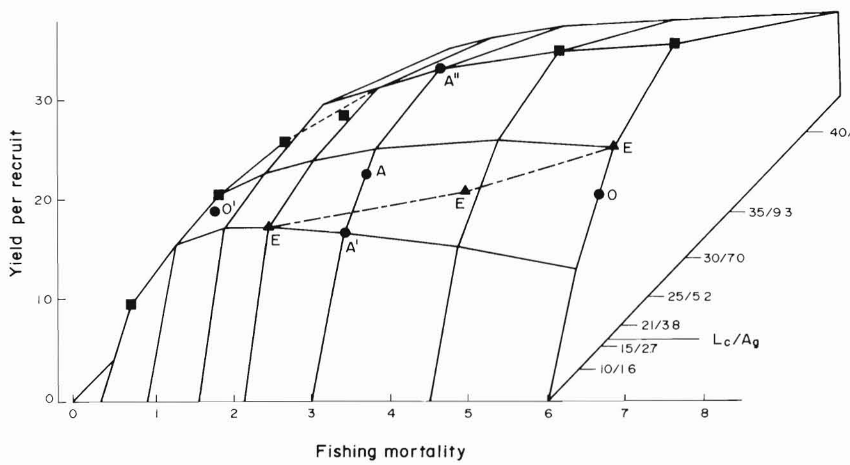

Figure 2. — Dynamic pool model of Kuwait's shrimp fishery. (Yield surface for *Penaeus semisulcatus*.) *Y'/R*: Yield per recruit; *Lc:* mean length at entry into the fishery in mm carapace length; *Ag:* mean age at entry to the fishery in months: 30/7.0 indicates 30 mm CL and 7.0 months old; *O* = *Y'/R* at present size at entry but higher effort; *O'* = *Y/R* at present size at entry but lower effort; *A* = *Y'/R* at present effort and size at entry; *A'* = *Y'/R* at present effort and lower size at entry. *A''* = *Y'/R* at present effort and higher size at entry. *E* = points on the eumetric curve; * = points at which *Y'/R* is highest for a particular effort level (*A'* is also one of these points).

[2] Personal communications, including information from eyewitnesses.

[3] See Acknowledgments.

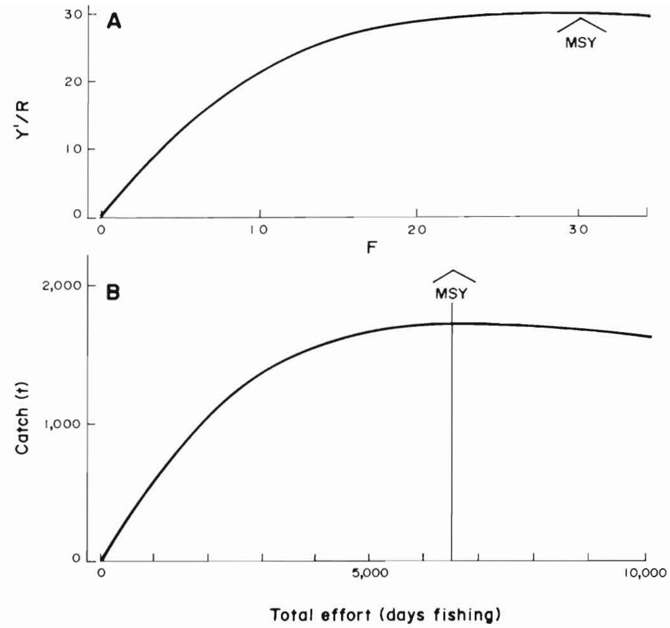

Figure 3. — A = Yield per recruit model of Kuwait's shrimp fishery at *Lc* = 18 mm CL (from Fig. 2). B = Surplus production model of Kuwait's shrimp fishery (Mathews and Samuel, 1991).

is the catchability); and placing $F = 3.0$ at an effort of 6,500 industrial boat-days per year. The two curves are very similar to each other, and any differences between them are more likely to be due to data problems and analytical problems, rather than to significant biological differences between the models.

Both models show a very long right hand limb with very small changes in catch corresponding to large changes in effort. The curve applies to a time period for which it is believed no change in size-at-entry occurred (but no data are available). Of course, changes in recruitment have occurred (e.g., Morgan and Garcia, 1982), but they seem to have been much smaller from about 1970 to the late 1980's than may have been the case in the late 1960's (Mathews and Al-Ghafar, 1986). This is why the Siddeek et al. (1991) observations (if correct) are so interesting.

Figure 4 (from Mathews and Al-Ghafar, 1984, 1986; Mathews and Samuel, 1991) shows a simple bioeconomic model developed from the surplus production model shown in Figure 3: Net profit is maximized at about 3,000 days per year, and MSY will be obtained at about 6,500 days per year.

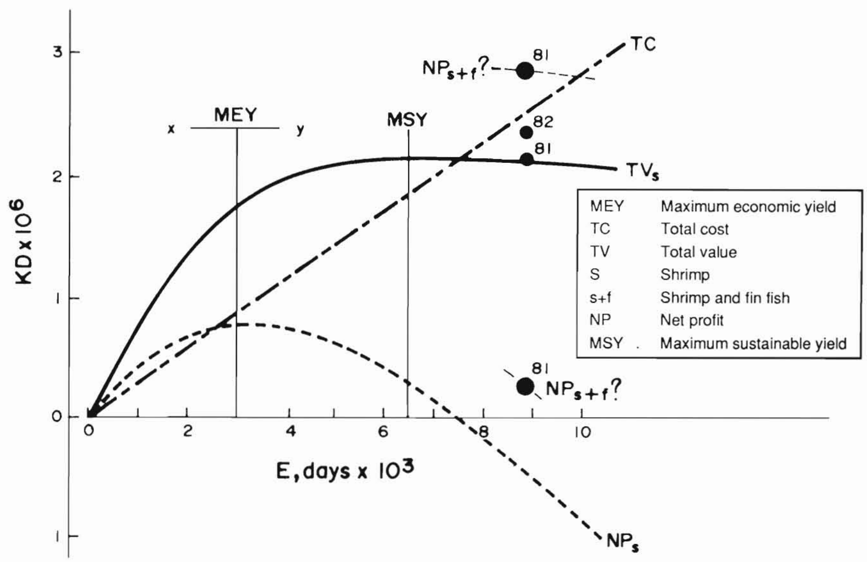

Figure 4. — Bioeconomic model of Kuwait's trawl fishery used to assess the profit structure of the fishery and to justify effort reduction (Mathews and Samuel, 1991). Numbers 81 and 82 indicate limited data including finfish as well as shrimp for 1981 and 1982, respectively.

The KISR shrimp research team communicated these results to management (e.g., Mathews, 1984) with the suggestion that a serious policy of effort reduction should be contemplated. Al-Hosseini et al. (1984) showed that it was impractical to manage the shrimp fishery by means of mesh size, further justifying the chosen policy of changing the opening date as the best means of increasing size at entry to the fishery.

The economic consequences of an effort limitation policy were explored in detail during 1985 (Mathews et al., 1986) and confirmed the above bioeconomic analysis. The following broad policy was recommended:

1) Reduction of effort from the high effort level of about 10,000–13,000 days fishing (1983–86) per year to about 3,000 days, for a policy of maximizing net profit (Fig. 4).

2) Establishment of buy-back policy so that effort limitation could be carried out. This was designed to make a policy of maximizing net profit feasible as well as technically possible.

3) Continuation of the two-stock management policy.

4) Delay in the opening of the shrimp fishing season from 1 July to 1 October so as to a) increase the value of the landings by increasing the average size of the shrimp landed, b) increase the size of the spawning biomass so that autumn spawners (spawning in September) were protected as well as spring spawners (FAO, 1982), and c) increase the catch rate of the spring spawners at the end of the fishing season, recommended to last until the end of January so as to

reduce total effort and to protect the spring spawners (spring spawning occurring in about February to April; FAO, 1982).

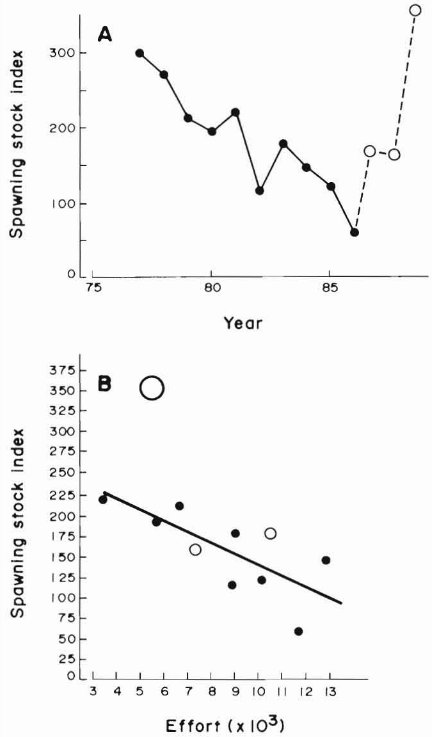

Figure 5. — A = Changes in the index of spawning abundance for *P. semisulcatus* over time (kg/standard day's fishing in January and February of each year). Dots are from Morgan (1989); circles = new data from Siddeek et al. (1991). B = changes in the index of spawning abundance (same units in the ordinate as Fig. 5 A). Dots are from Morgan (1989); circles = new data from Siddeek et al. (1991); large circle = datum for 1988–89 from Siddeek et al. (1991).

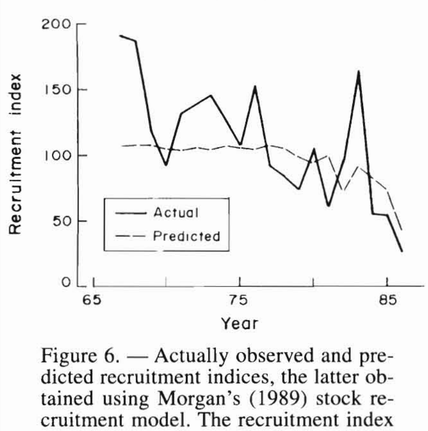

Figure 6. — Actually observed and predicted recruitment indices, the latter obtained using Morgan's (1989) stock recruitment model. The recruitment index used is the catch rate divided by *Y/R* at the relevant size at entry, and assumes that L_∞, *K*, *Lc*, and *M* are all constant (see text for limits on these assumptions).

5) Other possible and alternative strategies were identified for management choice, including a policy of harvesting at or near MSY at an effort level of about 6,000 days per year, increasing somewhat the profitability of the fishery, and reducing fishing costs substantially (Fig. 4).

In 1987, Morgan (1989) presented evidence relating recruitment and spawning biomass to effort expenditure (Fig. 5, 6) and showed that recruitment was probably reduced because of excessive effort expenditure (Fig. 6). He also related a probable decline in spawning biomass to the excessive expenditure of effort (Fig. 5).

Implementation

By late 1987 a series of significant research results had been presented to the industry and the Kuwait government at seven annual fisheries management workshops (e.g., Mathews, 1986a, b). The previous successful implementation of flexible closed seasons and closed areas, and the justified discarding of mesh size as a management tool, had led government and industry to accept that fisheries management was technically possible, and that it could reduce the risks and enhance the profits to fisheries entrepreneurs. This led government to rely on management-oriented research to assist in identifying possible management options. The combined research output described above therefore led to a reappraisal of Kuwait's fisheries management strategies and options. The following management actions were eventually taken:

1) Implementation of effort limitation, identified originally in 1981, confirmed in 1984, and reconfirmed in 1985, was delayed in 1986 and 1987 while the results were verified by Gulland[4] and Gulland (1989) who confirmed the potentially beneficial effects of effort reduction. Eventually, a reduction of effort was accepted in 1987, to about 5,000–6,000 days per year.

2) The delay in opening the fishery was confirmed but modified in detail. Opening on 1 September instead of 1 October maximized the benefit from increasing the mean size at capture (Gulland, 1989) but eliminated most of the potential for protecting the autumn spawners.

3) The two-stock management policy was discontinued, causing a definite economic loss to the *M. affinis* fishery of about US$1,000,000/year on average, which could have been harvested successfully (Mathews, 1989). This decision was made because of the impossibility of controlling the landings of *M. affinis* from artisanal boats during the closed season for *P. semisulcatus,* and the difficulty experienced in allowing industrial boats to fish while preventing artisanal boats from doing so.

4) The buy-back policy was delayed indefinitely or rejected because of its cost (estimated at about $3,000,000; Mathews et al., 1986).

Policy Effects

Background

In October 1987 the military/security situation imposed a night curfew on fishing which was effectively confined to Kuwait Bay and a narrow coastal zone near the Kuwait shore about 10 miles wide until the end of the Iraq-Iran war in late 1988 (Siddeek et al., 1991; Mathews[5]).

In November 1987 the ninth annual (occasionally twice yearly) "Shrimp and Finfisheries Management Workshop," uniting senior management personnel, fishing entrepreneurs, and scientists (e.g., Mathews, 1986b) was held. It was known that the security measures being enforced would markedly reduce the total effort that the combined fleets could expend. Therefore, a reduction to about 5,000 days per year was inevitable. Because of this, a much longer fishing season (until April) was allowed compared with previous years. The question of whether it was desirable to reduce the effort to around 5,000 days was never seriously discussed as no alternative was possible. Opposition by

[4] Gulland, J. 1987. Unpublished manuscript not available at KISR since the Iraq-Kuwait war.

[5] Mathews, C. P. Personal observations and discussions with fishermen.

fishing entrepreneurs to the large effort reduction recommended by scientists and endorsed by the managers of the fishery, which had been very vigorous and effective, was dropped.

Effects on Catch Rates

Shrimp landings in 1988–89 increased dramatically by about 300% (from 1,697 t to 5,023 t of *P. semisulcatus*). This led to a very sharp increase in profitability: 958 kg/standard boat/day of whole fresh shrimp (composed mostly of very high value *P. semisulcatus*), compared with a very much lower amount in earlier years (e.g., 237 kg/boat/day in the previous year, 85.9 kg/boat/day in 1985–86, and 73.9 kg/boat/day in 1984–85). Figure 7 shows these changes in *P. semisulcatus* catch rates.

Effects on Recruitment and Behavior

It is unlikely that landings were increased solely by reduction in effort. The surplus production and dynamic pool models (Fig. 2, 3) both predicted that total landings would not increase markedly even if effort were to be reduced substantially. It may therefore be argued (e.g., Siddeek et al., 1991) that a marked increase in recruitment must have taken place. Figure 6 can be interpreted to imply that a reduction in effort would lead to an increase in recruitment, and so to an increase in landings. This increase could have been caused partly or entirely by an increase in spawning stock. Figure 5 also shows the latest data for the spawning biomass index, and suggests that, for a decrease in effort to about 5,000 days per year, there would have been an increase in spawning index from about 150 kg/standard boat/day at the end of the fishing season (at an effort of about 7,000–10,000 days/year) in 1986–87 and 1987–88, to about 200 kg/day in 1988–89. The remaining increase (from about 200 kg/day to about 359 kg/day) (Fig. 4) could therefore be due to a change in recruitment (a more rigorous analysis is not possible because of some inconsistencies between some data points given by Siddeek et al. (1991) and Morgan (1989); e.g., 1981–82 spawning biomass is given as 305 kg/day by the former and is much lower in Morgan (1989), e.g., Figure 5). No unified data base was established (see below).

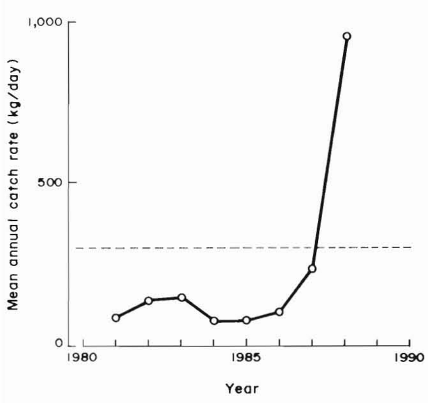

Figure 7. — Time series of mean annual catch rate for Kuwait's shrimp fishery (kg/day's industrial fishing). Calculated from data in Siddeek et al. (1991).

An alternative explanation for the increase in landings is possible: Penn (discussion in Farmer, 1981) and Penn (1984) suggested that *P. semisulcatus* may have formed large schools which would have been very much more vulnerable to fishing (and would provide much higher catchabilities) than would any *P. semisulcatus* caught while in a more dispersed, demersal phase. He drew particular attention to the difficulty in applying catch and effort models to Arabian Gulf data, should schooling have occurred in earlier years (e.g., the late 1960's) characterized by high catch rates. Hamdan et al. (1982) documented the incidence of exceptionally large catches of penaeid shrimp from both anecdotal experience and from scrutiny of catch data on KISR's RV *Asmak 4*, and concluded that it was likely that schooling occurred in *P. semisulcatus* at low effort levels. It is not clear what causes the change from schooling to demersal phases, but the cause may be related to interference by fishing at fairly low effort levels and the effects that this may have on the behavior of the shrimp. It would appear to be a stepwise effect rather than an effect that is proportional to effort.

Both Morgan's (1989) recruitment index and the spawning biomass indices are in fact simple catch transformations. The recruitment index consists of the annual (or other period) catch divided by *Y'/R* at the size at first capture, assuming that L_∞, *K*, *Lc*, and *M* (von Bertalanffy growth parameters, size at first capture, and natural mortality) are constant. Mathews and Samuel (1991) suggested that, contrary to this assumption, *M* may have varied substantially over the study period. The spawning index consists of the mean monthly *C/E* (in kg/standard boat/day for the 1- to 2-month period at the end of the closed season, immediately prior to the opening of the fishery). If a behavioral change of the type suggested by Penn (1984) and Hamdan el al. (1982) occurred, it would have increased the recruitment and spawning indices used by Morgan (1989) and Siddeek et al. (1991) without any real increase in numbers of recruits having taken place. Siddeek et al. (1991) suggested that the increased spawning index provided evidence that an improvement in recruitment had occurred, but there is in fact no proof of this.

Environmental Effects on *P. semisulcatus*

Since the increased catch rates (and their derived indices of recruitment and spawning) in 1988–89 and 1989–90 cannot provide any basis for proving the existence of an increase in recruitment, the hypothesis that an environmental change caused improvement becomes speculative. It is currently unproved and untestable. So is the suggestion that behavioral changes actually caused schooling, although this has been shown to occur in other penaeid species elsewhere and probably occurred in the Gulf stocks of *P. semisulcatus* in the past.

Environmental Effects on *M. affinis*

The evidence for an environmental cause of the fall in *M. affinis* catches (Siddeek et al., 1991) is lacking. No salinity or other oceanographic data for Kuwait waters have been provided to test this idea objectively.

Mathews' (1989) study of the biology and management of the *M. affinis* stocks shared by Iraq and Kuwait suggested that the migration of *M. affinis* postlarval and/or juvenile stages in August and September to the Iraqi marshes was inhibited by the fast flow of the Shatt Al Arab at this time. The slower current velocities in winter were less likely to do this for the spring recruits, which did reach the brackish water marshes and grew to the size at which sexual maturation occurs. In the Iraqi marshes, salinities of about 6‰ occurred and were hypothesized to be too low for sexual maturation. The large shrimp migrated from the marshes back to the spawning grounds to mature sexually and to spawn. The lowest salinities observed in northern Kuwait waters during oceanographic surveys (e.g., Lee, 1984) reported a minimum of 36‰ near the mouth of the Shatt Al Arab, and there is no evidence that salinities ever fell to lower levels on the Bubiyan fishing grounds (Fig. 1, area 3, northern section). Some very low salinities were reported (about 32‰, Mathews[6]) in the mouth of the Shatt Al Arab but were of very short duration and have not been confirmed.

Mathews (1982a, 1989) did not identify the exact spawning grounds of *M. affinis,* but he did show (1982b, 1991) that mostly very small and very abundant *M. affinis* occur on the Bubiyan fishing ground (Fig. 1, area 3), whereas mostly very large, sexually mature *M. affinis* occur in Kuwait Bay (Fig. 1, area 1). It is likely that Kuwait Bay and Rixa are important spawning grounds and that the northern Bubiyan area (most susceptible to influence by Shatt Al Arab waters) is a major nursery area for large juveniles. In a series of descriptions of the oceanography of Kuwait waters, Lee (1984) showed (contrary to Mathews et al., 1980; Mathews et al., 1982) that the salinity and chemical composition of Kuwait Bay waters was not influenced by the inflow of Shatt Al Arab water to the Gulf through the very shallow gap between Sabiyah and Failakka Island. Therefore incursions of lower salinity waters from the Shatt al Arab need to enter the areas south of Failakka Island and penetrate through the mouth of Kuwait Bay if they are to affect spawning. Shatt Al Arab waters rarely if ever reach this far, and the marked changes in salinity needed to impact spawning have not been observed in Kuwait Bay or Rixa. Therefore the Kuwait Bay and Rixa *M. affinis* populations would probably not be affected by the postulated environmental changes (Siddeek et al., 1991), even if such changes were strong enough to reduce spawning on the Bubiyan grounds (where most of the *M. affinis* are small and sexually immature). There is no evidence that the salinities of 36‰ and above characteristic of the Bubiyan grounds would increase mortality of the juvenile *M. affinis* living there prior to migration to the spawning grounds, nor that they would inhibit spawning of any mature *M. affinis* that occur there.

It is well known that the fishing companies in Kuwait usually chose a strategy of targeting *P. semisulcatus* whenever possible (e.g., Mathews, 1984) because of the higher price for any given commercial size grade and the much higher sizes usually obtained for this species. *M. affinis* was usually fished only when *P. semisulcatus* was unavailable or when *P. semisulcatus* catch rates were very low. The very low landings of *M. affinis* (90 t) reported by Siddeek et al. (1991) are therefore consistent with the exceptionally high catches of *P. semisulcatus.* With only 5,243 days fishing in 1988–89, there would have been no spare effort to fish the *M. affinis* stock. Without any indication of the effort distribution of the artisanal and research vessel effort in 1988–89, and without data on the inflow of the Shatt Al Arab (usually kept as a military secret by Iraq) compared with that in previous years, there is no way to test the hypothesis of environmental effects on the northern Gulf prawn stocks.

Discussion

Hindcasting and the Usefulness of Simple Bioeconomic Analysis

The effort limitation policy finally implemented in Kuwait's trawl fishery in 1987–88 was in fact identified as early as 1981. An unpublished study on the bioeconomics of Kuwait's prawn fishery by Mathews and Burgess[7] (who amplified the analysis of Mathews and Samuel, 1991) showed that the cost of not following that strategy from 1981 to 1985 was about KD6,500,000 (i.e., about $US23,000,000) for a fishery valued at about $US5,000,000 to $US6,000,000/year. The fishery actually experienced a small net loss instead of a significant profit. Neither the scientists nor the managers and entrepreneurs involved had sufficient confidence in the results to apply them in 1981. The scientists decided in about 1985–86 that the new strategy was feasible. A modified effort limitation policy was not accepted by the fisheries managers until 1987.

Simple bioeconomic analyses appear to be more powerful than biologists or managers believe, and their results should be treated with less skepticism and more respect. Nevertheless, the delay in accepting an effort limitation policy was reasonable and acceptable by current standards of the scientific evidence needed to justify strong management measures.

Therefore, 1) research should focus on the usefulness of simple bioeconomic models as tools for managing fisheries in developing countries: These models may be much more powerful than many suspect, and their results may usefully be applied at an earlier stage than is usually the case. And, 2) scientists and managers should be more aggressive in seeking to apply the results of bioeconomic analyses.

Problems in Implementing New Fisheries Management Strategies

Kuwait has traditionally tended to choose rather conservative, perhaps environmentally aware, policies for managing its fisheries. On occasion, concern for the well being of the stocks has been used to justify a decreased effort when even environmentally aware scientists recommended an increased effort. Kuwait also has a well developed structure for identifying management options for its fisheries, and it has the resources to fund research and management.

[6] Unpublished data no longer available from KISR since the war.

[7] Mathews, C. P., and T. P. Burgess. 1988. The bioeconomic basis for the management of Kuwait's fisheries. Unpubl. manuscr., 76 p., unavailable at KISR since the war.

Nevertheless, the recovery of Kuwait's shrimp fisheries documented by Siddeek et al. (1991) was not due to any major reduction in effort imposed by the government. The policy to reduce effort by about 50–70% identified in 1984 and 1985 (and confirmed in 1986), was not implemented in 1987 because there was a decision to discard the suggested buy-back/buy-out policy which would have motivated less efficient fishermen to leave the fishery. Without this motivation, it was impossible to convince fishermen to withdraw because they would have had no alternative use for their vessels.

In 1988, effort was indeed reduced drastically but it is unlikely that this could have been achieved without the pressure for security imposed by the Iraq-Iran war. Therefore, it is reasonable to conclude that only a major war persuaded government and industry to reduce effort sufficiently to bring about benefits anticipated by scientists.

Despite the inability to enforce the chosen policy of effort reduction, Kuwait had all the monetary and scientific resources to enable it to manage the fishery in the most environmentally friendly and economic manner. Perhaps, therefore, it is also reasonable to conclude that no other developing country is likely to be able to do this better. Indeed, in highly developed areas such as northern Europe, all the fisheries research carried out before World War II failed to lead to major improvements in the North Sea stocks of finfish. Yet Beverton and Holt (1957) documented major improvements in the stock condition of some North Sea finfish stocks due to the cessation of fishing in World War II (1939–45) which were slowly dissipated due to uncontrolled effort expenditures in the 1950's.

The Kuwaiti experience is not unique, and shows that even the establishment of high quality research and management mechanisms and procedures does not by itself enable the implementation of any management measure that requires a major departure from the established bioeconomic equilibrium. In Kuwait, effort levels in the trawl fishery were established by inappropriate management policies in the early 1960's when high catch rates attracted heavy overinvestment in the fishery (Mathews et al., 1986). By the early 1970's, companies which faced uneconomic catch rates amalgamated or withdrew from the fishery, but the high effort levels were never reduced by government action until the war imposed much lower effort levels on government and industry.

It is reasonable to ask whether fisheries scientists can, under the current governmental/research/industry/exploitation models, ever succeed in doing more than fine tuning an existing strategy. Perhaps it is possible to identify strategies for radically improving a fishery, while it is still impossible to implement such strategies. If true, this may be because of the different time frames in which scientists (who may think of the indefinite exploitation of a stock) and managers and entrepreneurs (who may live in a 1- to 2-year time frame) are locked into. It is usually managers, often highly responsive to industry, who set long-term research and management targets.

Patterson (1991) suggested that "... the real management goal in most fisheries is a complex maximization: The point of least political pressure on the fisheries manager. In most situations this is achieved by maximizing access at the expense of the profitability of participants." If true, this will usually lead to harvesting stocks at very high effort levels and low biomasses, especially at low sexually mature biomass (e.g., Mathews 1991). In practice this would often lead to ignoring advice aimed towards conserving stocks subjected to either recruitment or biomass overfishing. In a world where most stocks are heavily fished or overfished, this must imply the effective rejection of most fisheries management advice.

If Patterson's analysis is correct, there is a need to identify some new way of making fisheries management decisions. Some key criteria could be to:

1) Include for each stock legal requirements that sufficient spawning biomass be maintained (e.g., using general criteria developed by Goodyear, 1989, for temperate fish, and by Mathews, 1991, for tropical fish and prawns), or adopt some other strategy aimed at avoiding a recruitment collapse. This policy is likely to maintain economically viable populations and fisheries indefinitely, and would protect fisheries managers from the pressures identified by Patterson (1991). This type of policy has been used successfully in the California current area (e.g., Parrish and MacCall, 1978).

2) Change the common access laws and customs for all fisheries so that a single organization is the owner or the effective exploiter, therefore allowing the exploiter to aim for maximum net profit without losing profit to other entrants. Such a policy could be equitable if combined with a system of periodic bidding for the rights to fish, thus dispersing the economic rent and allowing the principle that anyone may attempt to enter a fishery.

3) Attempt to carry out the kind of ecosystem studies, e.g, ECOPATH based (Christensen and Pauly, In press; Mathews, In press), that can provide the means of describing quantitatively the structure of, and the fisheries based on, a particular marine ecosystem. Such models may eventually allow comparison of both real and simulated "before" and "after" scenarios for whole ecosystems (including the fisheries they support) that will provide the means of managing fisheries more easily than before, and will provide the heuristic tools needed to facilitate communication between managers and scientists.

It is clear that the first of these suggestions requires a scientific consensus that has not yet been achieved, and that the second would require a political change and consensus that is even more unlikely to be achieved in the near future.

It is equally clear that adoption of the third alternative is not immediately feasible (some may even argue it is not desirable), and in any case it would result in the abandonment of the possibility of managing fisheries now when the technical basis for doing so is already available for many stocks but is not being applied. These are questions that should cause serious concern to all managers, scientists, and governmental agencies involved in living resource management, and not only in developing countries.

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