Analysis of Trends in Bermuda's Fishery Statistical Database from 1975 To 1990, with Reference to Fishery Management Measures Implemented During this Period

BRIAN E. LUCKHURST and JACK A. WARD
Division of Fisheries
P.O. Box CR 52
Crawl CR BX
Bermuda

ABSTRACT

The Bermuda fisheries statistical program provides a database for fishery management purposes. The analyses presented in this paper focus on overall catch trends in the past sixteen years. A rapid decline in reported landings of most species of grouper taken by the commercial fishery was documented between 1975 and 1981. This trend prompted management action. No new entrants were permitted into the commercial fishery after 1982 and a formal limited entry trap fishery was established by 1986. In addition, a phased reduction in trap allotments was initiated at this time.

Fish catch composition changed dramatically during the 1980s as mixed reef fish species replaced the larger groupers in the market. Total foodfish landings increased during this period, peaking in 1986 and fluctuating downward thereafter. Increased fishing power with traps brought about by technological advances in the fishery had a major impact on most reef fish stocks. At the same time, pelagic species such as wahoo and tuna found increasing acceptance and more line fishing effort was directed at these species.

Despite the limitations placed on the trap fishery, no substantial recovery in reef fish stocks was observed. Increasing public pressure stimulated radical management action. The trap fishery was closed in April 1990. Reported landings of mixed reef fish have declined dramatically since the closure, indicating the effectiveness of this measure in according protection to these fishes.

KEY WORDS: Landings data, Bermuda fisheries, fish traps.

INTRODUCTION

The monitoring of fishing effort and landings is fundamental to effective fisheries management. Without these data, it is difficult to evaluate the performance of a fishery and to detect trends in the various populations on which the fishery is based. In Bermuda, the 1972 Fisheries Regulations instituted the compulsory submissions of catch and effort statistics by commercial fishermen. The regulation required that fishermen keep a daily log of their fishing activities and submit these on a weekly basis. Prior to this, only anecdotal information and intermittant voluntary statistical submissions were available.

The fisheries statistical program has been fully operational since 1975, creating the database which is the focus of the present analysis. This database is, however, compromised by a lack of a systematic validation procedure in this self-reporting statistics scheme. This is an important factor when the database is used for management purposes and in-depth analyses at the species level are required. The verification process in artesanal fisheries, with multiple landing sites, is problematic and the validation requirement is not often met. Furthermore, whenever incentives exist for fishermen to misreport statistics, as has occurred in Bermuda (Frick *et al.*, 1989), these influences must be taken into account in the interpretation of the data. In light of these shortcomings, the present analysis is restricted to overall trends in annual landings of groups or species for the sixteen year period, 1975-1990. The interpretation of these trends in relation to fishery management measures or other documented events in the fishery is presented wherever sufficient information exists.

RESULTS AND DISCUSSION

Overall Species Groups

The 1975-1989 landings of the main fish species groups comprising Bermuda's commercial fishery (Figure 1) exhibit several clear trends. The most notable of these are the steep decline in the grouper landings, the steady increase in the miscellaneous (mixed reef fish species) category and an overall increase in the pelagics. The landings of jacks and snappers indicate more modest increases through the 1980s. The extent to which the overall species composition of the landings changed from 1975 to 1989 is graphically illustrated in Figure 2. Total grouper landings dropped from 47.6% to 18.7% while the miscellaneous category increased from 15% to 31.4%. Pelagics comprised almost 25% of total landings in 1989, an increase of over 10% from 1975.

These trends are a result of two factors: 1) an adaptive response by fishermen to a decline in the abundance of grouper stocks, and 2) ready acceptance in the market of previously underutilized species. The strong demand for local fish thus allowed fishermen to exploit alternate species in order to maintain, and sometimes enhance, profitability. These factors were most evident in the reef fishery where traps were used to catch both groupers and mixed reef species. As the original target species, groupers, declined in abundance, the previously underutilized species in the bycatch (*e.g.*, parrotfish, grunts) became the main object of the fishery. In this way, fishing pressure with traps remained high despite the reduced effort directed at groupers.

Landings of pelagic species showed a steady increase through the 1980s. These figures largely reflect increased acceptance in the market of wahoo and tunas following an active promotion of these species by fishermen in an FAO/Bermuda Government-sponsored project. Greater line fishing effort was

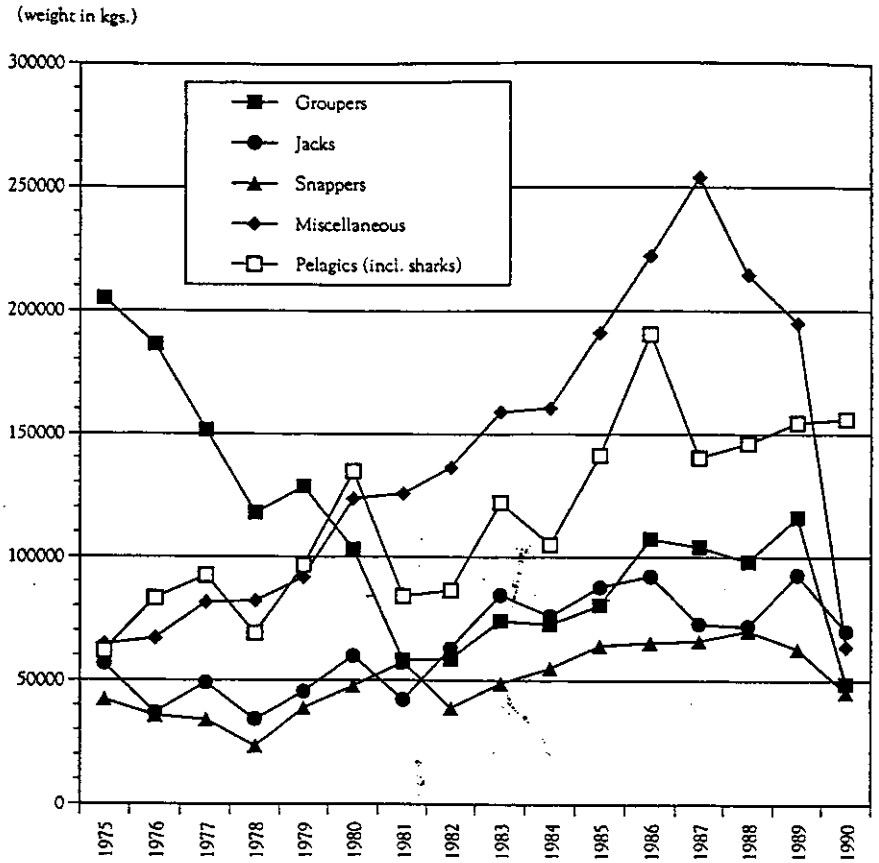

Figure 1. Landings of the five major foodfish groups from Bermuda's fishery statistical database.

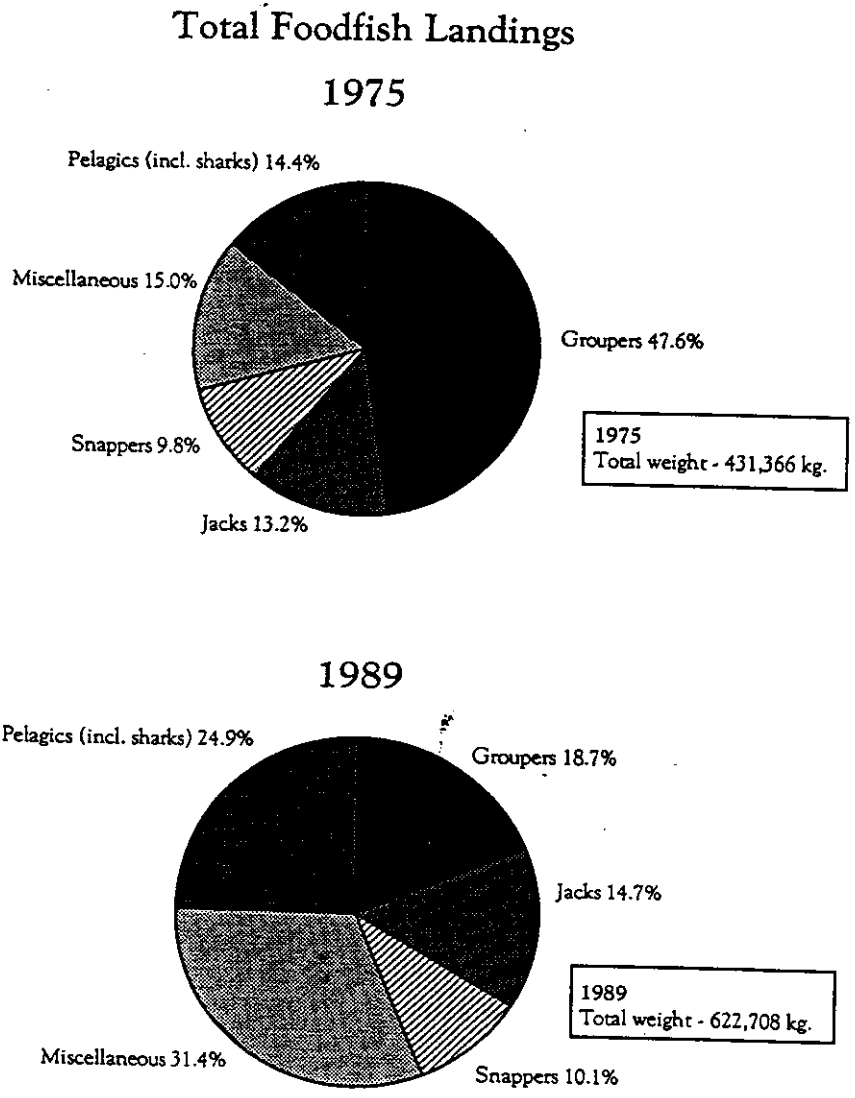

Figure 2. Comparison of the total foodfish landings composition between 1975 and 1989.

directed toward these species as they became well established in the market and commanded good prices.

Groupers (Serranidae)

The dramatic decline in overall grouper landings which occurred from 1975 to 1981 prompted management action. No new commercial fishing vessel licenses were granted after 1982. Further restrictions in the fish trap fishery and other management measures were introduced in the 1984 Management Plan (Burnett-Herkes and Barnes, this volume). A formal limited entry fish trap fishery was established by 1986. Although the grouper landings depicted in Figure 1 display a modest recovery in the period of 1982 to 1989, examination of the landings of individual grouper species (Figure 3) indicates that this increase was caused by rises in the landings of only three species: Black grouper (*Mycteroperca bonaci*), Coney (*Epinephelus fulvus*) and Creole-fish (*Paranthias furcifer*). Rather than recovering under this restrictive management regime, a number of previously important grouper species (*i. e.*, Yellowmouth, *Mycteroperca interstitialis;* Tiger, *M. tigris;* Nassau, *Epinephelus striatus;* and Red, *E. morio*), declined to commercial extinction. Presently, the fishery catches only four species: Black grouper; Red hind, *Epinephelus guttatus;* Coney; and Creole-fish, on a regular basis. A comparison of the species composition of the grouper landings in 1975 with those in 1989 (Figure 4) illustrates the extent to which this composition has shifted towards the smaller species (Coney, Creole-fish), so that they comprised almost 50% of total grouper landings in 1989.

Black grouper is the only species of large grouper to display a steady increase in landings through the 1980s. This may indicate that there are elements of its life history pattern which are sufficiently different from other groupers to have allowed it to be more successful. There is insufficient information on the life history patterns of most groupers to indicate what the important differences might be. However, reproductive ecology is likely to be one of the significant factors.

The decline in landings of groupers following the fish trap ban in April 1990 is dramatically illustrated in Figure 3. An analysis of grouper landings by gear type for the three year period of 1987-1989 indicates that between 79% and 83% of all grouper landings were taken by fish traps. A comparison of landings figures between 1989 and 1990 for individual grouper species (Table 1) confirms the significance of fish traps in the fishery for large groupers as the three species of *Mycteroperca* (Yellowmouth, Black and Tiger) and Red Grouper showed large declines. The smaller species (Red Hind, Creole-fish and Coney) showed lesser declines. This is an indication of their greater susceptibility to the line fishing effort which was directed toward them after the fish trap ban.

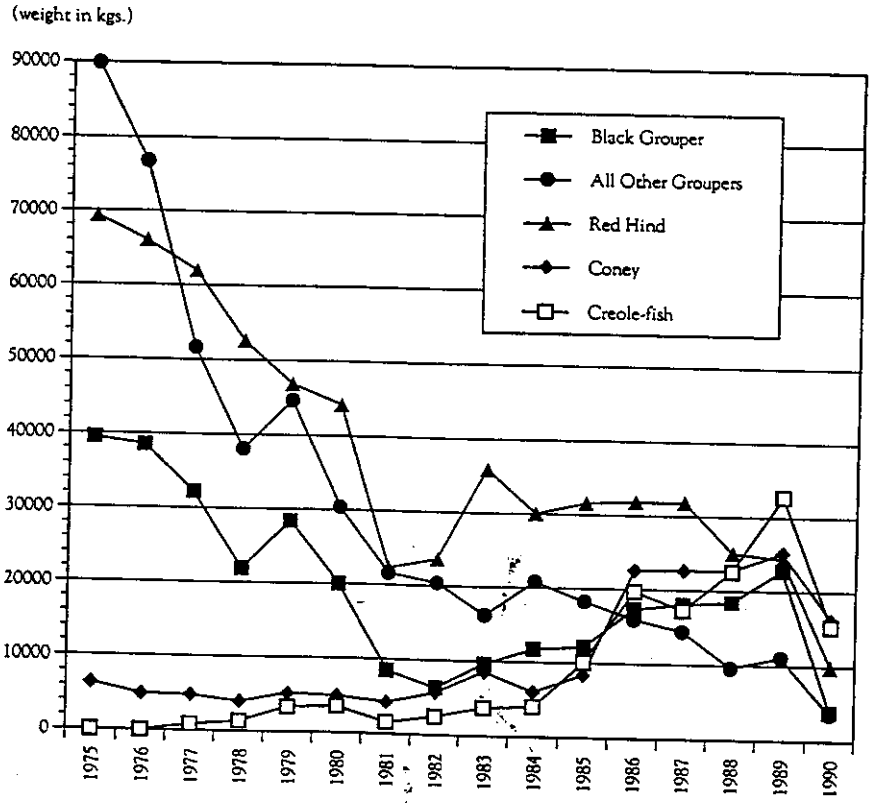

Figure 3. Landings of selected species in the Grouper category. See text for details of "All other groupers" category.

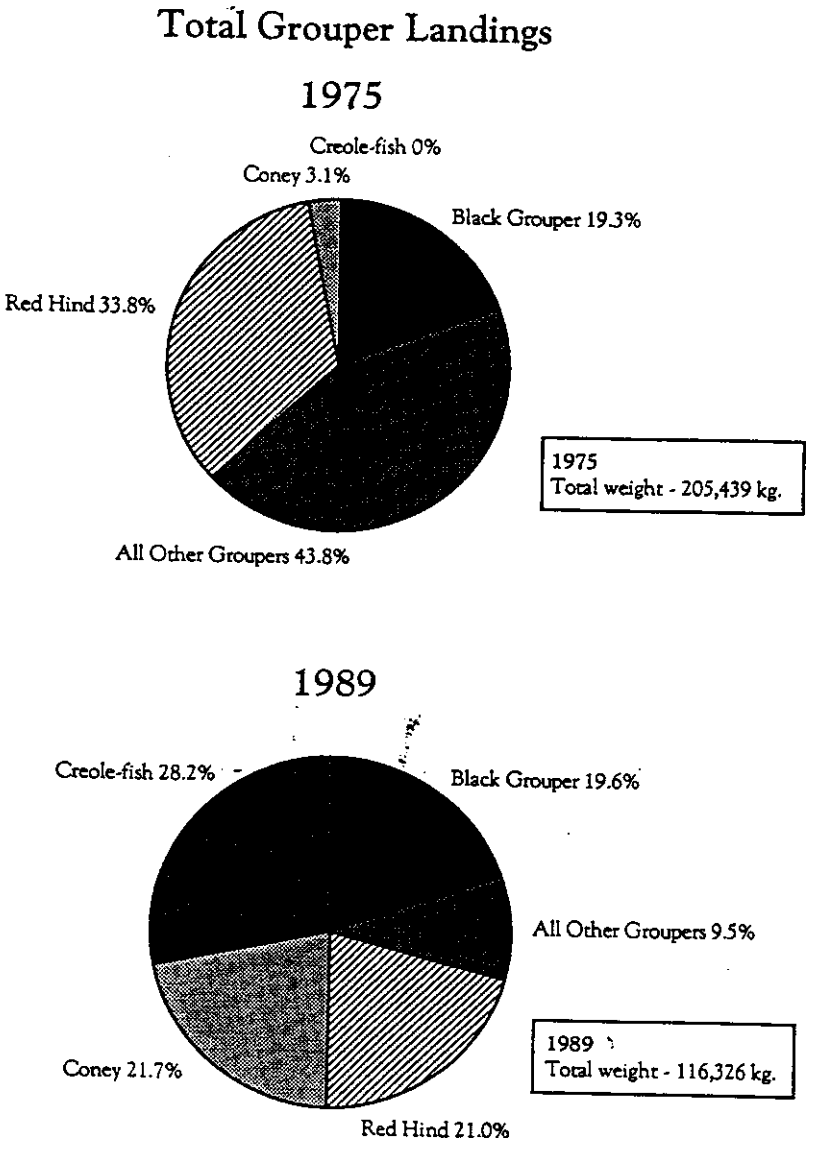

Figure 4. Comparison of grouper landings composition between 1975 and 1989.

Table 1. Comparison of the landings of species in the Groupers category showing the decline as a percentage change.

Species	Landings (kg) 1989	Landings (kg) 1990	Decline (%)
Black Grouper	22716	3856	83
Other Groupers			
Yellowmouth	3517	1002	72
Tiger	2009	188	91
Red	1794	322	82
Nassau	794	501	37
Red Hind	24362	9883	59
Coney	25182	16195	36
Creole-fish	32758	15294	53

Jacks (Carangidae)

Whilst the landings of individual species of Jacks (Figure 5) generally fluctuate, several species show a rising trend from the early 1980s. In particular, landings of Greater Amberjack (*Seriola dumerili*) and Almaco Jack (*S. rivoliana*) increased substantially over the past decade. The Gwelly Jack (*Pseudocarnax dentex*) also increased from 1980 to 1986 before starting a steady decline. The increased landings of these schooling species may be attributed in part to the greater usage of large dimension arrowhead fish traps (up to 2.4 m x 2.4 m x 1.2 m) which became reasonably common with technological advances in the fishery in the 1980s. These traps were extremely effective in catching large numbers of jacks which schooled over the reef. The vertical height of the trap was considered to be a critical factor in the increased fishing power of these traps for the above-named jack species. The effect of conspecific attraction in schooling species (Luckhurst and Ward, 1987) in these large volume traps, where schooling behavior could be maintained, was dramatically illustrated. Fishermen using these traps reported catches of up to 175 kg, often dominated by one species, in a single haul.

Both Greater Amberjack and Almaco Jack are also readily taken by hook and line and, following the fish trap ban, considerable line fishing effort was directed at these species. The maintenance of landings of Amberjack in 1990 is probably a reflection of this fact. In contrast, anecdotal information suggests that the drop in landings of the Gwelly Jack over the past four years may be an indication of a true decline in stock abundance.

Snappers (Lutjanidae)

The fluctuations in the landings of yellowtail snapper (Figure 6) are probably the result of a combination of natural variation in abundance and changes in fishing effort. This species was taken both by fish traps and line fishing and was increasingly sought after during the 1980's. Demand for white-meat fish was strong as the market sought to replace the increasingly rare larger groupers. The drop in yellowtail landings between 1989 and 1990 is likely the result of the combined effect of the fish trap ban and the seasonal closure of sizeable portions of prime fishing area instituted under the 1990 Fisheries Management Plan (Burnett-Herkes and Barnes, this volume). These closed areas are known to be very productive through the summer months, particularly along the edge of the platform.

Landings of Gray snappers (Figure 6), which were caught primarily in fish traps, increased through the 198's before levelling off and then plummeting in 1990, a clear result of the fish trap ban. They remained abundant during the 1980s despite heavy fishing pressure, probably due to their inshore habit combined with the closure of the inshore areas to fish trapping. A prohibition on taking gray snappers with nets was enacted in 1983 and still remains in effect.

The graph for the red snappers category (Figure 6) depicts the total reported landings of three species; Silk snapper (*Lutjanus vivanus*), Queen snapper (*Etelis oculatus*), and Wenchman snapper (*Pristipomoides macrophthalmus*). The five fold increase in landings from 1980 to 1981 is the result of the introduction of a new fishing gear type; the vertical longline. The technique was demonstrated to local fishermen through a United Nations FAO-sponsored project in 1980 and there followed a rapid expansion of this fishery in 1981. Anecdotal information and catch sampling from this fishery indicated that the great majority of the catch in 1981 was made up of Queen and Wenchman snappers as the vertical longlines were set in deeper water (220-350 m depth) than had previously been fished for Silk snappers (110-175 m depth). Catch rates were initially high as these were almost virgin stocks. However, as these species were confined to relatively narrow depth strata and, as effort was intensive in these bands around the island, the stocks were particularly vulnerable to overfishing. As a result, this fishery for deep-water snappers collapsed in less than two years and has shown little sign of recovery to date.

Miscellaneous Reef Fish

The most striking aspect of the landings data for the taxa in the miscellaneous reef fish category (Figure 7) is the rapid increase in parrotfish (*Scarus* spp., *Sparisoma* spp.) landings followed by a precipitous fall when the fish trap ban came into effect.

This increase mirrors the market demand which developed for mixed reef fish fillets through the 1980s. As parrotfish typically comprised the largest

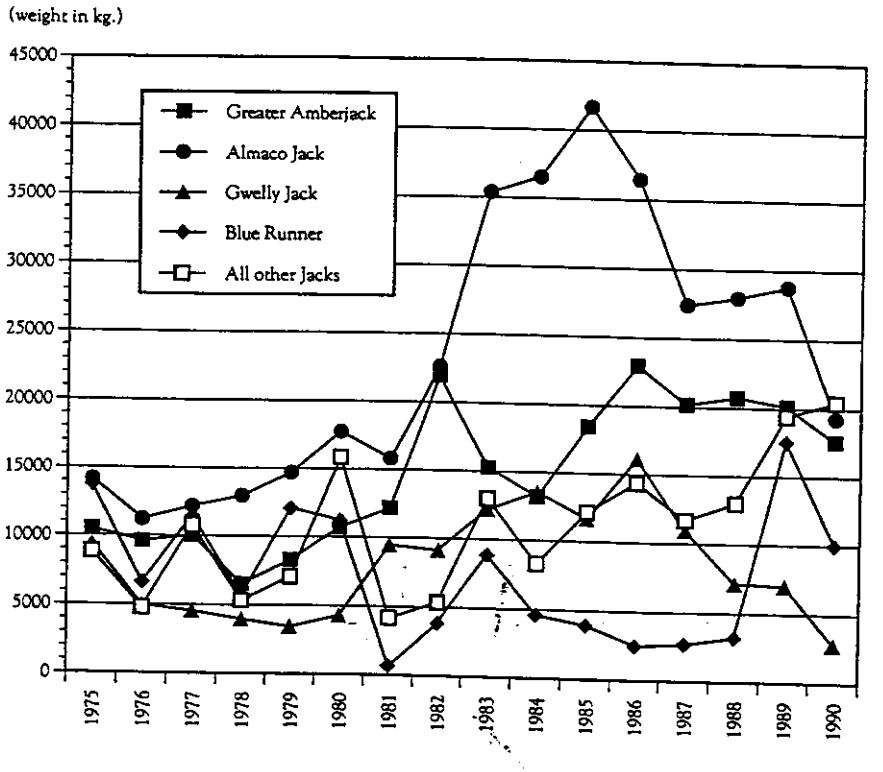

Figure 5. Landings of selected species in the Jacks category.

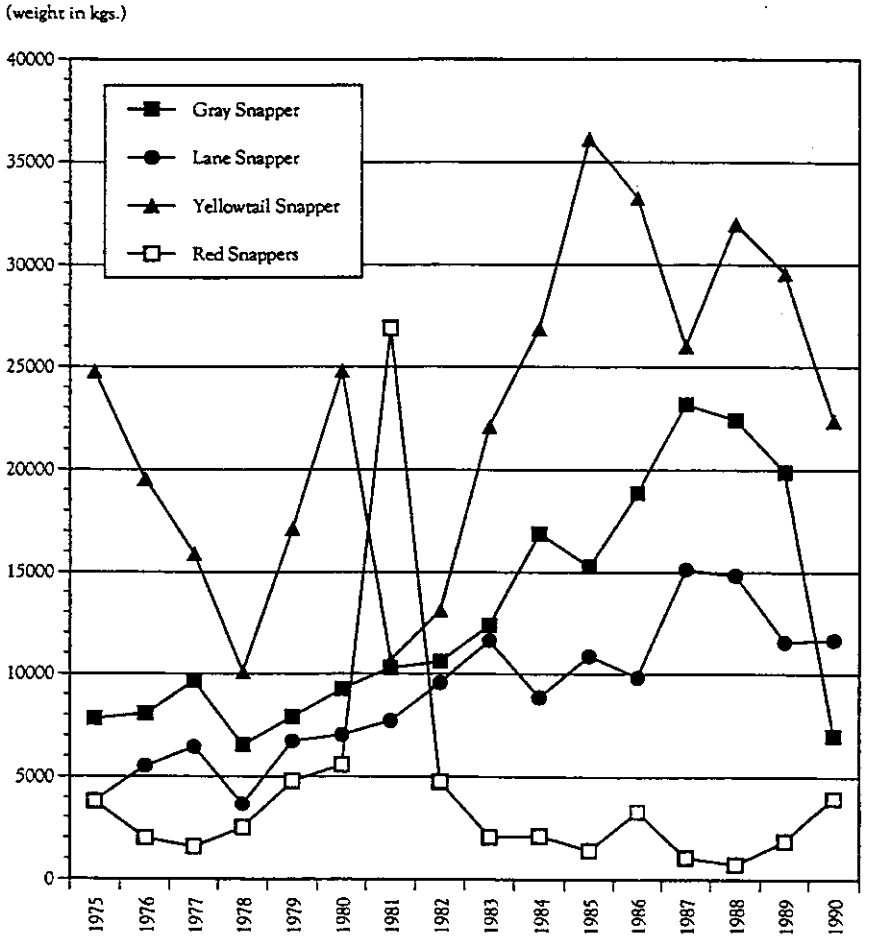

Figure 6. Landings of selected species in the Snapper category.

component of mixed reef fish species from shallow water fish traps, this group dominated the miscellaneous category. The landings of Grunts and Bermuda Chub followed a similar pattern but were of smaller amplitude. Gray triggerfish, although historically taken by fish traps, are also vulnerable to line fishing and the decline in their landings is less marked after the fish trap ban than for other species (Table 2). Landings of the Jolthead Porgy (*Calamus bajonado*) and the Saucereye Porgy (*C. calamus*) are combined in the database. These landings remained relatively steady over the years. Saucereye Porgies were caught mainly by hand lining. A significant decline in total porgy landings occured following the fish trap ban. This appeared to confirm anecdotal evidence that considerable numbers of the smaller Saucereye Porgy were taken in shallow water fish traps. It is interesting to note that an earlier decline in landings in 1983 corresponded with the occurence of the epizootic which virtually wiped out the population of the sea urchin *Diadema antillarum*, a preferred food item of Jolthead Porgies. After the sea urchin die-off, fishermen reported that the catch of Jolthead Porgies was down and that the fish were generally in poor condition.

Table 2 dramatically illustrates the extent to which the fish trap ban affected landings of the principal species in the miscellaneous category. The figures include the landings of these species by all gear types (including fish traps for the first four months of 1990). Despite this inclusion, the declines are generally large and clearly indicate the effectiveness of the fish trap ban in affording protection to these populations. In particular, landings of parrotfish, grunts and hogfish which were principal target species of the fish trap fishery, all show massive declines.

Table 2. Comparison of the landings of the species in the miscellaneous reef fish category showing the decline as a percentage change.

Species	Landings (kg) 1989	Landings (kg) 1990	Decline (%)
Porgies	29224	13615	53
Bermuda Chub	17039	8895	48
Hogfish	17738	3793	79
Parrotfish	54957	10403	81
Grunts	26525	5969	77
Gray Triggerfish	22013	13624	38

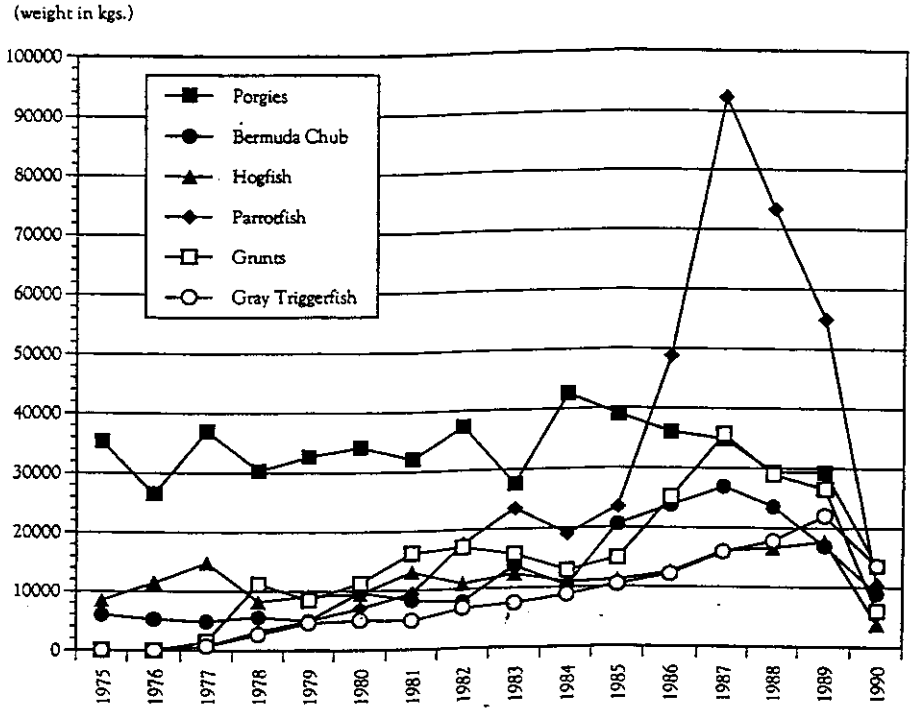

Figure 7. Landings of selected species in the Miscellaneous reef fish category.

Pelagics (mainly Scombridae)

An analysis of the landings of the principal pelagic species of commercial importance (wahoo, *Acanthocybium solanderi* and yellowfin tuna, *Thunnus albacares*) provide some evidence for a three year cycle in landings (Figure 8). This pattern may be related to oceanographic phenomena but there is insufficient data at present to make an assessment. Wahoo have gained a pre-eminent place in the market during the past decade and there has been a steady increase in effort directed toward them. It has become the most important commercial species in Bermuda in terms of landed weight. Landings of Yellowfin tuna have fluctuated over the past years but have undergone a steady decline since 1987. This is not the result of reduced effort but is rather an indication of a real decline in local stock abundance. The landings patterns of other pelagic species (Blackfin tuna, *T. atlanticus*; Barracuda, *Sphyraena barracuda*; Atlantic Black Skipjack, *Euthynnus alletteratus*) have remained relatively steady with no clear trends evident. Black skipjack are netted seasonally in inshore waters when abundant and landings are therefore effort related.

Baitfishes

As many of the baitfish species are short-lived, annual abundance tends to fluctuate widely, with favorable environmental conditions apparently producing increases in population abundance (Figure 9). The five fold increase in landings fry (which includes an endemic, the Bermuda anchovy *Anchoa choerostoma*; dwarf herring *Jenkinsia lamprotaenia* and reef silverside, *Allanetta harringtonensis* pooled together) can probably be attributed to two factors: 1) natural increase in population abundance over this period and, 2) increased demand for fry for "bag bait" for the fish trap fishery. At the height of the fish trap fishery, the most successful fishermen used two or three, 2.5 kg plastic bags of fry in each trap when they set their traps in deeper water (shallow water traps were generally not baited). The massive decline in fry landings in 1990 is probably a direct result of reduced demand due to the closure of the fish trap fishery in April of the same year. The landings of Spanish sardine (*Sardinella anchovia*), which in Bermuda is called anchovy, shows a more modest increase during this same period followed by a slow decline. The landings of Atlantic thread herring (*Opisthonema oglinum*) and Redear sardine (*Harengula humerlis*), known locally as pilchards, have not achieved appreciable levels since the database commenced. This may be due, in part, to limited local demand for these species.

Lobsters

Two species of spiny lobster are fished commercially in Bermuda, the Caribbean spiny lobster (*Panulirus argus*) and the spotted spiny lobster (*P.*

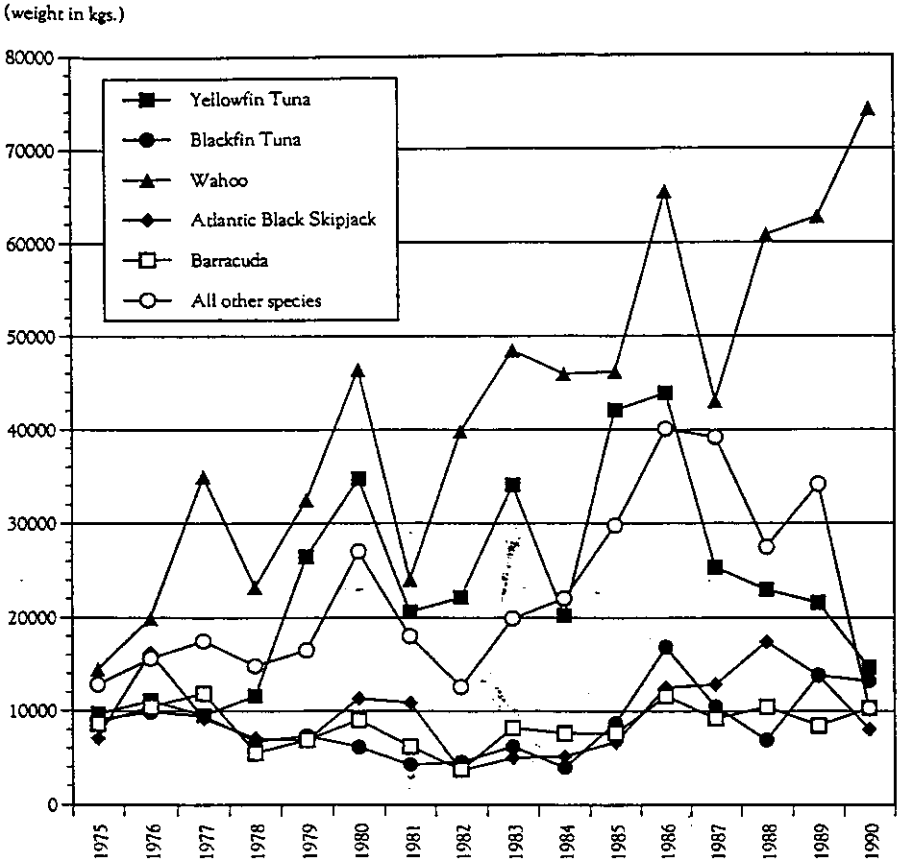

Figure 8. Landings of selected species in the Pelagics category.

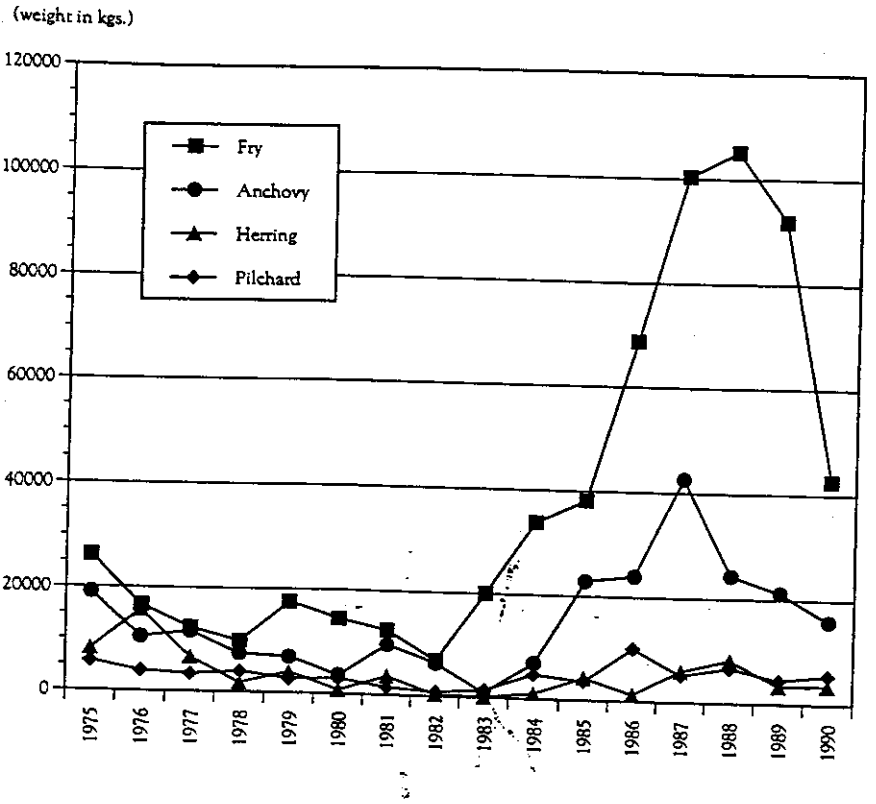

Figure 9. Landings of selected species in the Baitfish category. See text for details of fry composition.

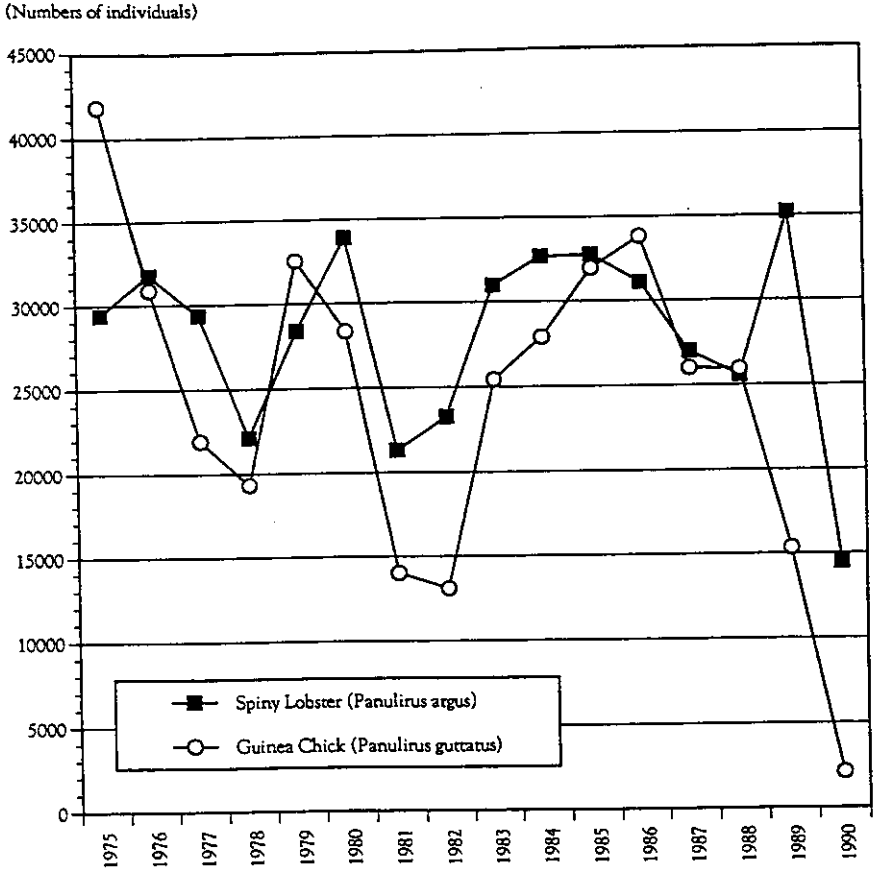

Figure 10. Landings of two species of spiny lobster (Palinuridae). See text for details of decline in lobster landings in 1990.

guttatus), known locally as the guinea chick. The slipper lobster, *Scyllarides nodifer*, is also taken commercially but in small numbers. Caribbean spiny lobsters are subjected to a suite of fishery management measures including a closed season (April 1 to August 31), minimum size (92 mm carapace length) and a prohibition on taking berried females. In contrast, guinea chicks are not actively managed (no closed season or minimum size) and the stock is basically monitored through the database. The overall pattern of landings for *P. argus* (Figure 10) indicates that the stock has remained healthy over the years with landings since 1983 varying in a relatively small range, suggesting that the stock is in equilibrium. In fact, 1989 was the year with the highest recorded landings since the database was begun. The large drop in 1990 is due to the fact that the landings figure is from only three months (January to March). The fish trap ban in April 1990 eliminated the gear which was used to catch both fish and lobsters. In the wake of the fish trap ban, a lobster-specific trap has been developed to allow the commercial harvest of spiny lobsters to resume (Ward and Luckhurst, this volume).

Landings of guinea chick lobsters have oscillated with greater amplitude than spiny lobsters and provide some evidence of a two-year cycle in the first half of the database. As with spiny lobsters, landings appeared to be more stable starting in 1983 before sharply declining in 1989, a year in advance of the fish trap ban. This decline may have been effort related but there is insufficient detail on directed effort in the database to confirm this statement. Landings in 1990 are insignificant and, as with spiny lobsters, represent only the period before the trap ban.

SUMMARY

The analyses presented in this paper indicate that Bermuda's fishery statistical database generally reflects the realities of changes which have occurred in the fishery over this sixteen year period and that the effect of fishery management measures which have been implemented during this time can be assessed, at least in part, by examining trends in the database.

ACKNOWLEDGEMENTS

We thank Ms. Stephanie Comber, Bermuda Government Information Services, for her willing assistance in the production of figures.

LITERATURE CITED

Burnett-Herkes, J. and J. Barnes. This volume. Banning the use of fish pots and other management methods introduced in Bermuda to manage declining reef fish stocks.

Frick, B., N. Simmons and J.A. Ward. 1989. The establishment, maintenance and use of statistical monitoring programs for artesanal fisheries: The case of Bermuda. *Proc. Gulf Carib. Fish. Inst.* 39: 193-201.

Luckhurst, B.E. and J.A. Ward. 1987. Behavioural dynamics of coral reef fishes in Antillian fish traps at Bermuda. *Proc. Gulf Carib. Fish. Inst.* 38: 528-546.

Ward, J.A. and B.E. Luckhurst. This volume. Development of a lobster-specific trap in Bermuda and fisheries management considerations for the re-establishment of a commercial lobster fishery.