هيئة أبحاث البيئة والحياة الفطرية وتنميتها
Environmental Research and Wildlife Development Agency

Biological reference points, resource status and management options for the key demersal species of Abu Dhabi Emirate.

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1. Executive Summary

Background

This report was produced as part of the activities of the 'Fish Landings and Population Dynamics Project' which is implemented by the Marine Environmental Research Center in pursuit of ERWDA's strategic goal of developing a management regime for the fisheries of the Emirate of Abu Dhabi. The principal aims of the project are to establish and monitor the status of the key fisheries resources and provide the scientific and technical information required for resource management purposes. Stock assessments, biological reference points and management options are presented here for the following species; *Acanthopagrus bifasciatus* (Faskar), *Argyrops spinifer* (Kowfar), *Carangoides bajad* (Jash), *Diagramma pictum* (Farsh), *Epinephelus coioides* (Hamour), *Gnathanodon speciosus* (Zuraydi) and *Lethrinus nebulosus* (Sha'ari).

Results

Resource status. Resource status indicators showed that *E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus* were all exploited at rates in excess of the target and limit biological reference points. The fishing mortality rates were particularly high for *E. coioides* and *D. pictum*, being more than seven times the optimum levels for these species during 2001-2003. Conversely, for *A. spinifer*, *A. bifasciatus* and *C.bajad* fishing mortality was less than optimum levels over the same period (Fig I).

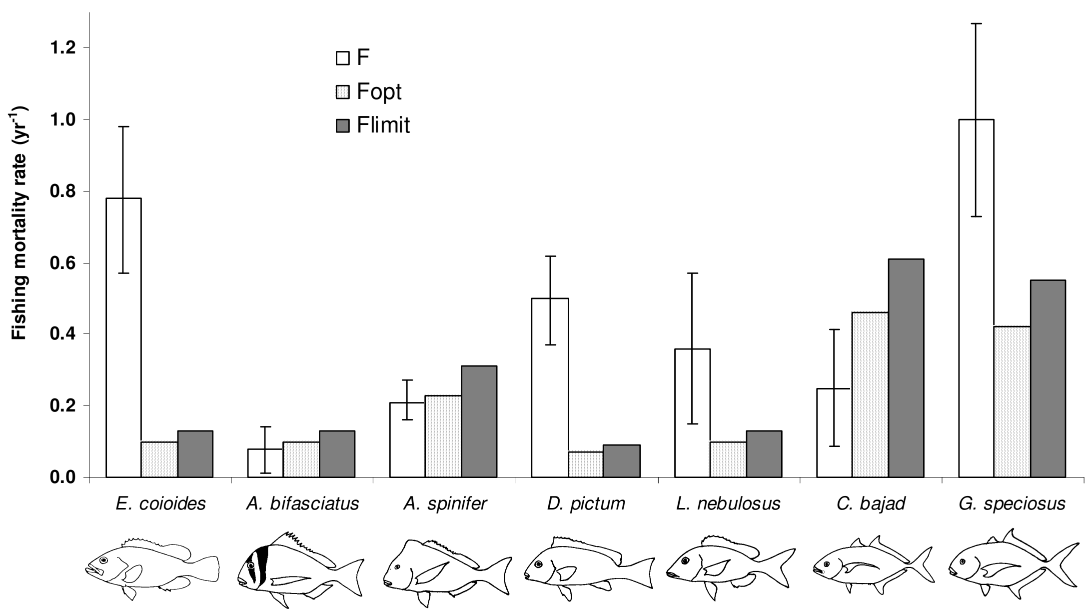

Figure (I) Resource status for the key species in the demersal fishery of Abu Dhabi Emirate. Bars show the annual instantaneous rate of fishing mortality (F) between 2001 and 2003 (±95CI) and the target (F_{opt}) and limit (F_{limit}) biological reference points.

Management options. Despite a reduction in the licensed number of dhows and traps to 125 traps and 345 vessels, fishing effort for *E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus* during 2004 was still in excess of the optimum levels. As such, a substantial reduction in fishing effort would be required to achieve management targets for these species (eg. Fig. II).

For the species that are currently exploited below optimum levels (*A. spinifer*, *A. bifasciatus* and *C. bajad*), the reduction in licensed effort in the dhow fishery to 125 traps and 345 vessels, has resulted in the effort for these species being reduced to levels which are considerably less than those associated with the target and limit biological reference points. As such, an increase in fishing effort would be required to achieve management targets for these species (eg. Fig. II).

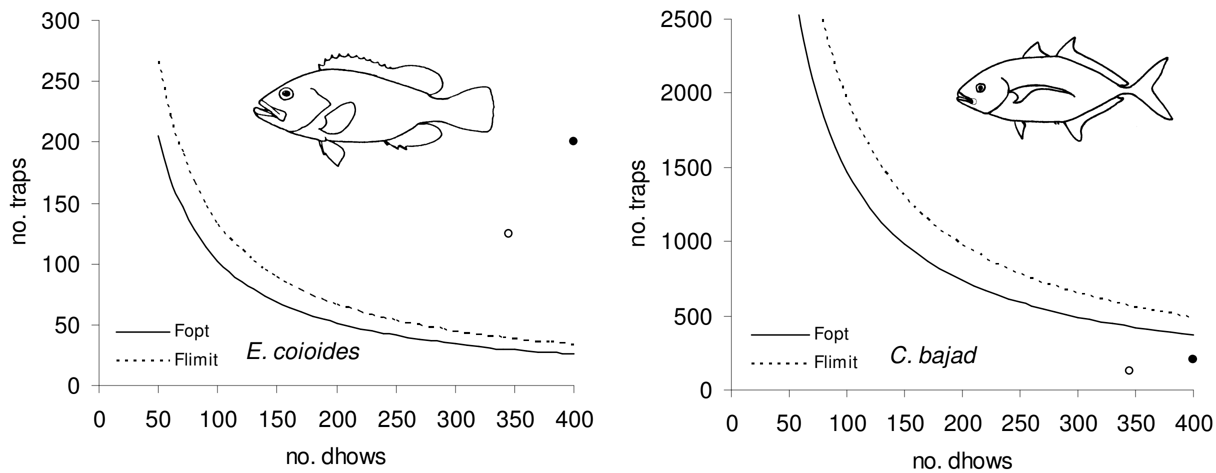

Figure II. The relationship between the number of vessels and trap numbers per vessel associated with target (F_{opt}) and limit (F_{limit}) biological reference points, showing the mean number of traps and vessels between 2001 and 2003 (•) and the current licensed fishing effort (○) for *E. coioides* (left) and *C. bajad* (right).

Catch and resource value. The mean annual catch of 6,506 tonnes of demersal species represented 85% of the total landings made in the Emirate of Abu Dhabi between 2001 and 2003, the remainder being composed of pelagics and other non fish categories such as crab. With a mean annual ex-vessel value of 43.5 million Dirhams, demersal species represented 83% of the total value for all species. The study species examined here were representative of families constituting 89% of the mean annual landed catch and 93% of the mean annual landed value of demersal species between 2001 and 2003.

Families and species that were exploited at levels less than the target reference points (*A. bifasciatus, A. spinifer* and Carangidae) only represented 20% of the mean annual total catch and 29% of the mean annual total value of demersal species between 2001 and 2003. Conversely, those species and families determined to be exploited above target reference points (Haemulidae, Lethrinidae and *E. coioides*) represented 69% of the mean annual total catch and 64% of the mean annual total value of demersal species between 2001 and 2003 (see Fig III).

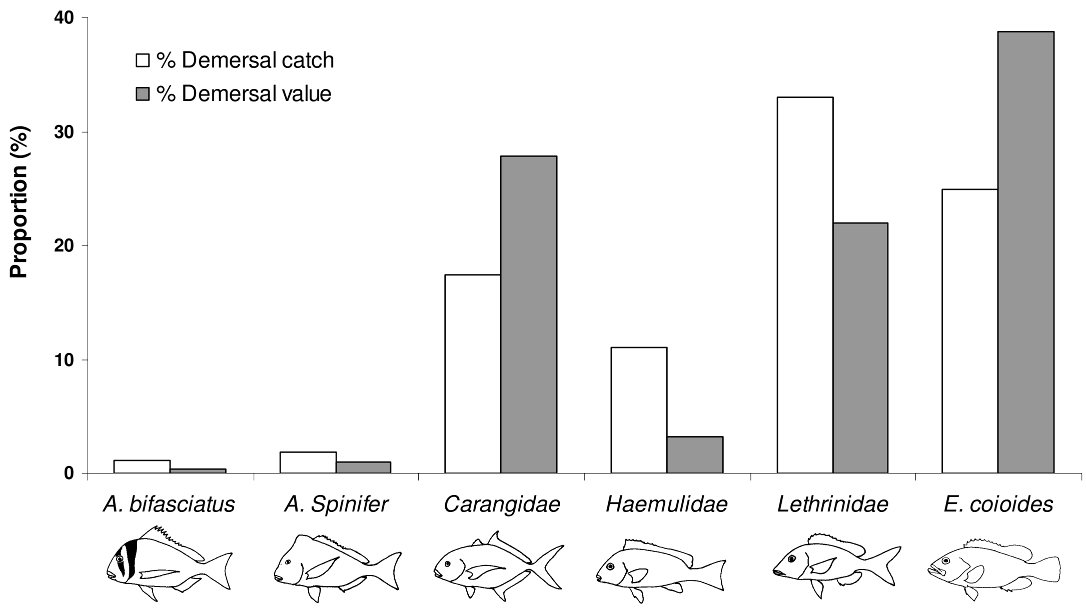

Figure (III) The proportion of the mean annual catch by weight and value (2001 to 2003) for key species and families in the demersal fishery of Abu Dhabi.

Conclusions and Resource Management Implications

This study has provided status assessments, biological reference points and management options for the key species in the demersal fisheries of Abu Dhabi which are required as a foundation for resource management and decision making. The critical findings are that the most important demersal fisheries resources are heavily over-exploited, that recent reductions in licensed fishing effort are inconsequential and a further and more substantial reduction of operational fishing capacity is required if management goals are to be achieved.

The most important species in the fishery (Hamour), which represented an average of 39% of the ex-vessel landed value of all demersal species, was the most heavily impacted by fishing. The fishing mortality rate was more than seven times the optimum level from 2001 to 2003. Despite a reduction in the number of trap and vessel licenses issued, the fishing effort during 2004 was still more than four times the optimum level for this species. Whilst the existing fishing effort is below optimum levels for Faskar, Kowfar and Jash, collectively these species only represented a comparatively small component of the demersal fishery in terms of the mean total catch (20%) and value (29%).

The study demonstrates the undesirable resource status that can occur in the absence of suitable fisheries assessment, management and regulation. As the key species in the demersal fishery are generally long-lived, stock recovery will only be fully realized after some 15 to 20 years following the removal of the appropriate amount of effective fishing capacity. The extended period required to achieve conservation and stock re-building objectives highlights the need for a long-term strategic approach to the monitoring, assessment, management and regulation of the demersal fisheries of the Emirate of Abu Dhabi.

2. Introduction

Fisheries provide a source of income, employment and recreation at the same time as contributing to the cultural heritage of the inhabitants of the Emirate of Abu Dhabi. Recent statistics show that an estimated total of 9,042 metric tonnes of fish with an ex-vessel value of 74.4 million Dirhams was landed in the Emirate during 2003 (Grandcourt *et al*., 2004). The 'Fish Landings and Population Dynamics Project' was initiated in 2000 in order to establish and monitor the status of the principal fisheries resources of the Emirate of Abu Dhabi. The project is implemented by the Marine Environmental Research Center and responds directly to the Environmental Research and Wildlife Development Agency's goal of developing a fisheries management regime for the Emirate of Abu Dhabi.

The definition of status and monitoring of fisheries resources can be achieved using biological reference points which provide benchmarks for the assessment and management of the fishery. They are categorized into target reference points (TRP) and limit reference points (LRP). Target reference points reflect a desired management objective. A commonly used target reference point is the safe harvest rate ($F_{0.1}$) which is the level of fishing mortality at which the slope of the yield per recruit curve is one tenth of its value at the origin. Limit reference points relate to the level of fishing mortality associated with an undesirable resource status which management action should avoid. A widespread limit reference point is the maximum sustainable yield (MSY). Both target and limit reference points can be established on a precautionary basis given the uncertainty in stock assessments and other factors such as the perceived negative environmental impacts of fishing (Caddy and Mahon, 1995).

The safe harvest rate ($F_{0.1}$) and fishing mortality rate that would maximize yield per recruit (F_{max}) have been used as target and limit biological reference points respectively for the key species in the demersal fisheries of Abu Dhabi Emirate (Grandcourt *et al*., 2003). However, the yield per recruit method used assumes that there is no relationship between the size of the spawning stock biomass and recruitment. Furthermore, estimates of safe harvest rates may approximate and even exceed values of the annual instantaneous rate of natural mortality. Gulland (1970) suggested that in an optimally exploited stock, fishing mortality should be about equal to natural mortality, resulting in an exploitation rate of 0.5 yr^{-1}. However, exploitation rates should be very conservative for relatively long lived reef fish (Newman and Dunk, 2003), especially given that potential yields may be over estimated where $F = M$ (Beddington and Cooke, 1983).

Previous assessments may also have been confounded by the use of the relationship of Pauly (1980) to estimate natural mortality rates (*M*) as this has tended to overestimate *M*, especially for slow growing species (e.g. Ralston 1987; Russ *et al*. 1998). As a consequence, fishing mortality may have been underestimated, presenting an overly optimistic view of the resource status. An alternative equation (Hoenig, 1983) is considered to be more appropriate for estimating the natural mortality rate in relatively long lived reef fish (eg. Newman and Dunk, 2003). An improvement in estimates of the total mortality rate may also be possible using age-length keys to convert size frequency data into age frequency distributions.

There is a need to re-evaluate the status of the key demersal species using a precautionary approach for both the assessment process and the definition of biological reference points to be used for the management of the fishery. Furthermore, estimates of input controls (effort) are required for the fishery in order to provide authorities with management options that have an empirical basis. This is especially pertinent in light of existing management planning activities. In this context, specific objectives of this study were to:

- (i) Revise estimates of natural mortality rates for the key species in the demersal fishery.
- (ii) Develop age-length keys and revise estimates of total mortality rates using population age structures.
- (iii) Estimate fishing mortality rates for the key species.
- (iv) Establish precautionary target (F_{opt}) and limit (F_{limit}) biological reference points and associated fishing effort levels.
- (v) Provide assessments of the resource status for the key species in the demersal fishery between 2001 and 2004.
- (vi) Evaluate the existing input control (effort) regulations for the demersal trap fishery and provide management options in line with the objectives of resource conservation and stock rebuilding.

3. Materials & Methods

Data collection and sampling protocol

Size frequency data was collected from commercial catches made off the coast of the Emirate of Abu Dhabi in the United Arab Emirates (Fig. 1) between September 2000 and March 2003. Biological data was obtained from specimens purchased from commercial catches between June 2002 and May 2003. Size at age data was derived from validated growth increments in sagittal otoliths. A detailed description of the data collection and sampling procedure is given in Grandcourt *et al*., 2003. Study species are shown in Table 1 below.

Table 1. Key species in the demersal fishery of Abu Dhabi Emirate

Scientific name	Arabic name	English name
Acanthopagrus bifasciatus	Faskar	Two bar seabream
Argyrops spinifer	Kowfar	King soldier bream
Carangoides bajad	Jash	Orange spotted trevally
Gnathanodon speciosus	Zuraydi	Golden trevally
Epinephelus coioides	Hamour	Orange spotted grouper
Diagramma pictum	Farsh	Painted sweetlips
Lethrinus nebulosus	Sha'ari	Spangled emperor

Data Analyses

Natural mortality. The annual instantaneous rate of natural mortality (M) was estimated using the empirical equation derived by Hoenig (1983). As the Carangids (*Gnathanodon speciosus* and *Carangoides bajad*) could not be aged directly, ages of 4.7 and 5.1 yrs. were estimated from the inverse of the von Bertalanffy growth function.

Age-length keys and total mortality. Size at age data was used to construct age length keys following the method of Ricker (1975), these were used to convert aggregated length frequency data into age frequency distributions. The annual instantaneous rate of total mortality (Z) was subsequently determined using the age based catch curve method (Beverton and Holt, 1957). The natural logarithm of the number of fish in each age class was plotted against the corresponding age and Z (±95% CI) was estimated from the descending slope of the best fit line using least-squares linear regression. Initial ascending points representing fish that were not fully recruited to the fishery were excluded from the analysis.

The annual instantaneous rate of total mortality was also estimated using the length converted catch method of Pauly (1983). Pooled length frequency samples were converted into relative age frequency distributions using parameters of the von Bertalanffy growth function. The natural logarithm of the number of fish in each relative age group divided by the change in relative age was plotted against the relative age and Z (±95% CI) was estimated from the descending slope of the best fit line using least-squares linear regression. The estimates of Z from age based and length converted catch curves were compared using a modified *t*–test (Sokal and Rohlf, 1995). As the Carangids (*Gnathanodon speciosus* and *Carangoides bajad*) could not be aged successfully, (Z) was only obtained using length converted catch curves which were adapted to incorporate seasonal growth patterns (Gayanilo and Pauly, 1997).

Fishing mortality. The annual instantaneous rate of fishing mortality (F) was calculated by subtracting the natural mortality rate (M) from the total mortality rate (Z) ($F = Z–M$). The calculation was also made for the upper and lower 95% confidence intervals for estimates of Z in order to derive a range of fishing mortality rate estimates. The exploitation rate (E) was calculated as the proportion of the fishing mortality relative to total mortality ($E = F/Z$).

Biological reference points, resource status and management options. Precautionary target (F_{opt}) and limit (F_{limit}) biological reference points were calculated as $0.5.M$ and $2/3.M$ respectively. The proportion of the existing fishing mortality (F) to F_{opt} and F_{limit} were calculated for each species and used to describe resource status between 2001 and 2003, eg. the existing fishing mortality would be in excess of the reference point if the ratio is greater than 1 and vice versa. The optimum and limit fishing mortality rates were calculated as a proportion of the existing fishing mortality rates (F_{opt}/F and F_{limit}/F) in order to provide multipliers for values of fishing effort. The mean number of traps used per dhow, was calculated from survey data collected between 2001 and 2003 (Ministry of Agriculture and Fisheries, 2004 *unpublished data*) and raised by the number of vessels licensed in Abu Dhabi. This value was multiplied by the ratios (F_{opt}/F and F_{limit}/F) to give the total number of traps that would be representative of the fishing effort associated with the specified target and limit biological reference points for each species. The fundamental assumption being that the fishing mortality rate is directly proportional to fishing effort. The existing licensed fishing effort was calculated as a proportion of that required to achieve F_{opt} and F_{limit} for each species. Management options were presented in the form of a range of trap number and vessel number combinations for both F_{opt} and F_{limit}. This was achieved by dividing the total number of traps at these reference points by the number of dhows over a suitable range of values.

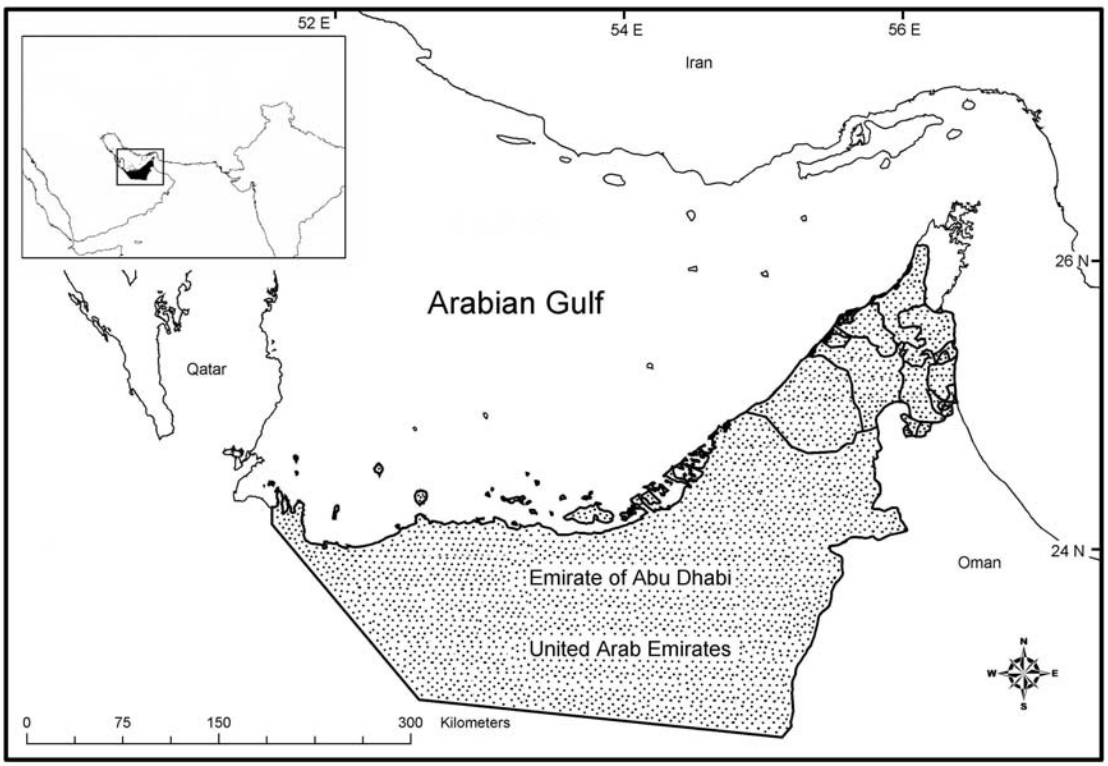

Figure 1. Position of the Emirate of Abu Dhabi in the Southern Arabian Gulf

Selected catch and economic data collected through the Fish Landings and Population Dynamics project was presented in order to provide a perspective on the relative importance of the study species or family as appropriate within the demersal fishery.

4. Results

Biological reference points, mortality and age-length keys

Total mortality rates ranged widely, from 0.28 yr^{-1} for *A. bifasciatus* to 1.83 yr^{-1} for *G. speciosus*. Rates of natural mortality ranged from 0.13 yr^{-1} for *D. pictum* to 0.91 yr^{-1} for *C. bajad*. The annual instantaneous rate of fishing mortality ranged from 0.08 yr^{-1} for *A. bifasciatus* to 1.0 yr^{-1} for *G. speciosus*. The fishing mortality rate represented 22% of the total mortality for *C. bajad*, and 80% of the total mortality for *E. coioides*. Table 2 below presents a summary of the mortality rate estimates and values of biological reference points and exploitation rates.

Table 2. Values of total (*Z*), natural (*M*), fishing (*F*) mortality rates, target (F_{opt}) and limit (F_{limit}) biological reference points and exploitation rates (*E*), for the key species in the demersal fisheries of the Emirate of Abu Dhabi.

	E. coioides	*A. bifasciatus*	*A. spinifer*	*D. pictum*	*L. nebulosus*	*C. bajad*	*G. speciosus*
$Z\ yr^{-1}$ (95% CI)	0.97 (0.8-1.2)	0.28 (0.2-0.3)	0.67 (0.6-0.7)	0.63 (0.5-0.8)	0.56 (0.4-0.8)	1.16 (1.0 -1.3)	1.83 (1.7-2.1)
$M\ yr^{-1}$	0.19	0.20	0.46	0.13	0.20	0.91	0.83
$F\ yr^{-1}$ (95% CI)	0.78 (0.6-1.0)	0.08 (.01-.14)	0.21 (0.2-0.3)	0.50 (0.4-0.6)	0.36 (0.2-0.6)	0.25 (0.1-0.4)	1.00 (0.9-1.2)
$F_{opt}\ yr^{-1}$	0.10	0.10	0.23	0.07	0.10	0.46	0.42
$F_{limit}\ yr^{-1}$	0.13	0.13	0.31	0.09	0.13	0.61	0.55
E	0.80	0.26	0.28	0.79	0.64	0.22	0.45

Age length keys showing the proportion of fish in each size and age category are given in Annexes 1 to 5 for the species which were successfully aged with sagittal otoliths (*E. coioides, A. bifasciatus, A. spinifer, D. pictum and L. nebulosus*). The age frequency distributions by size class that were derived by converting length frequency data using age-length keys are shown in Annexes 6 to 10.

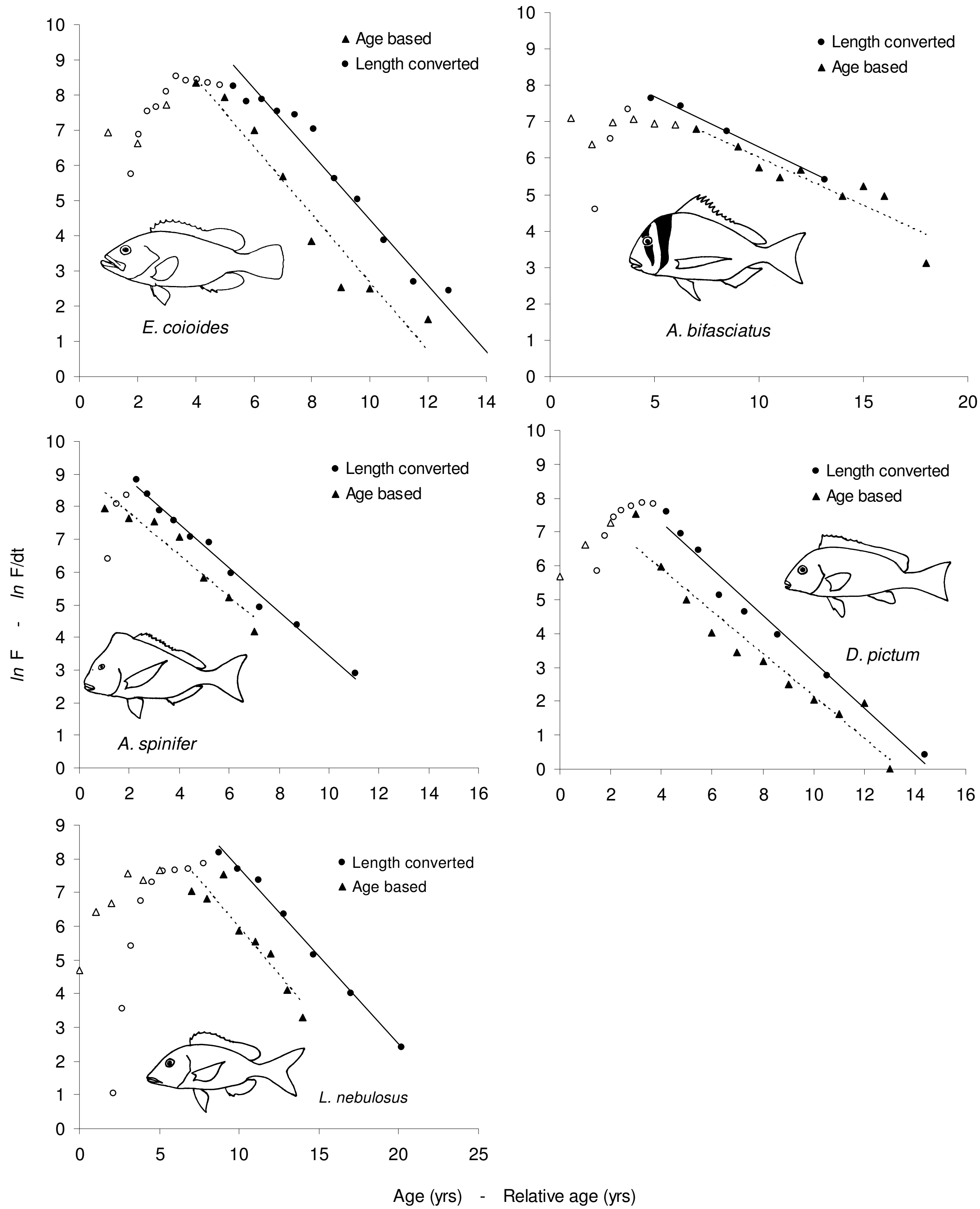

Figure 2. **Length converted (*ln* F/dt against Relative age) and age based catch curves (*ln* F against Age) used for estimating total mortality rates (*Z*).**

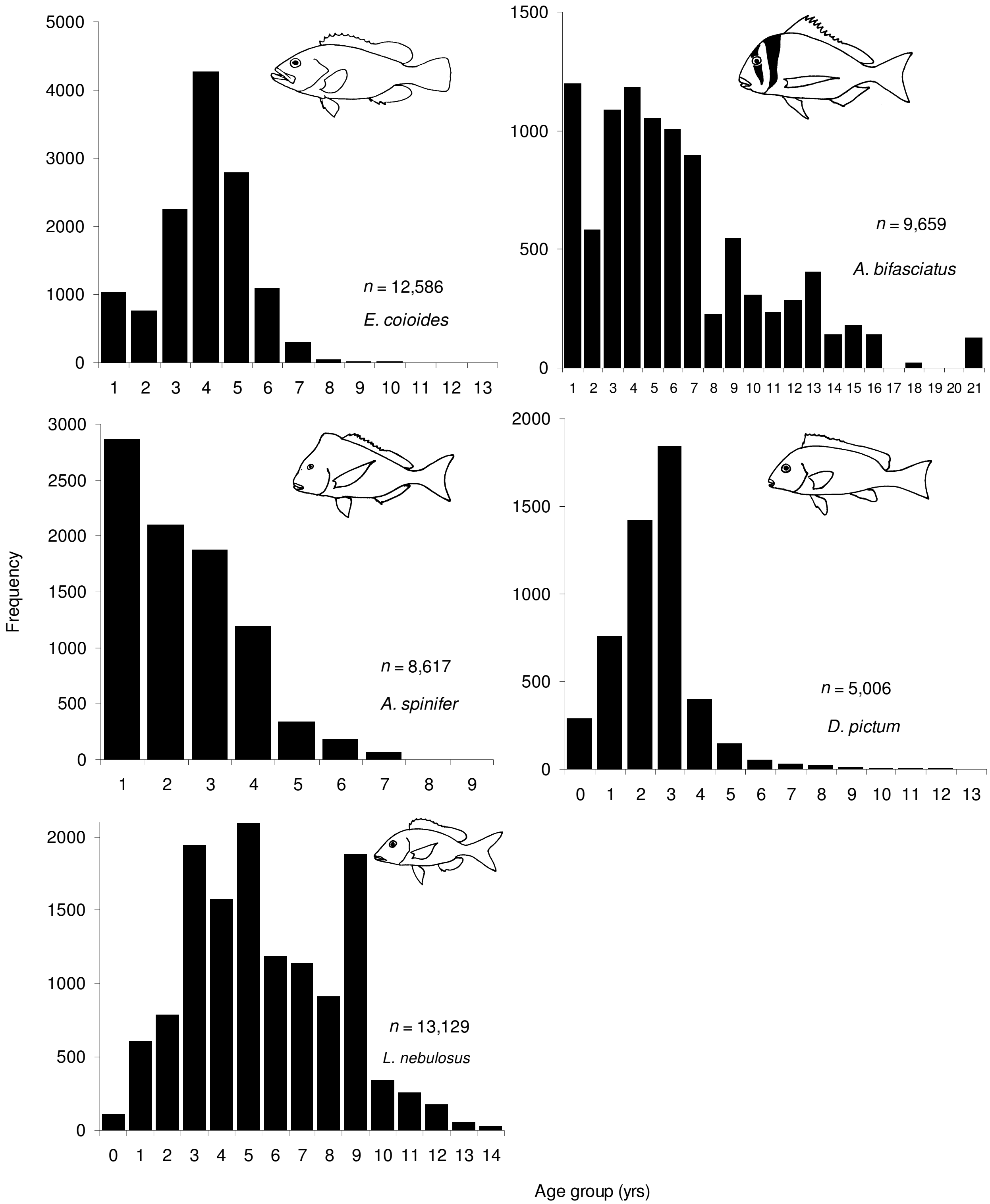

Figure 3. **Age structures derived from size frequency data converted using age-length keys, showing the frequency distribution by age class.**

The comparisons between length converted and age based catch curves (Figure 2) showed that there were no significant differences in the total mortality (Z) estimates derived from the two methods for all species (Table 3). Age structures revealed that older age classes were depleted for *E. coioides*, *D. pictum* and *A. spinifer* (Figure 3).

Table 3. Results of comparisons of total mortality estimates obtained using length converted and age based catch curves.

	t	*df*	*P*
E. coioides	0.42	17	0.68
A. bifasciatus	0.18	9	0.86
A. spinifer	0.49	14	0.64
D. pictum	0.81	15	0.43
L. nebulosus	0.03	11	0.98

Resource status

Resource status indicators showed that *E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus* were all exploited at rates in excess of the target and limit biological reference points (Figure 4). The fishing mortality rates were particularly high for *E. coioides* and *D. pictum*, being more than seven times the optimum levels for these species during 2001-2003. Conversely, for *A. spinifer*, *A. bifasciatus* and *C.bajad* fishing mortality was less than optimum levels over the same period (Table 4). However, the optimum fishing mortality rate was within the 95% confidence interval limits for *A. spinifer* and *A. bifasciatus*.

Despite a reduction in the licensed number of dhows and traps, fishing effort for *E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus* during 2004 was still in excess of the optimum levels. Although for *G. speciosus*, the fishing effort approximated that which was representative of the limit reference point (F_{limit}). For *A. spinifer*, *A. bifasciatus* and *C.bajad* fishing mortality was less than half of that at the target reference point (F_{opt}) over the same period (Table 4).

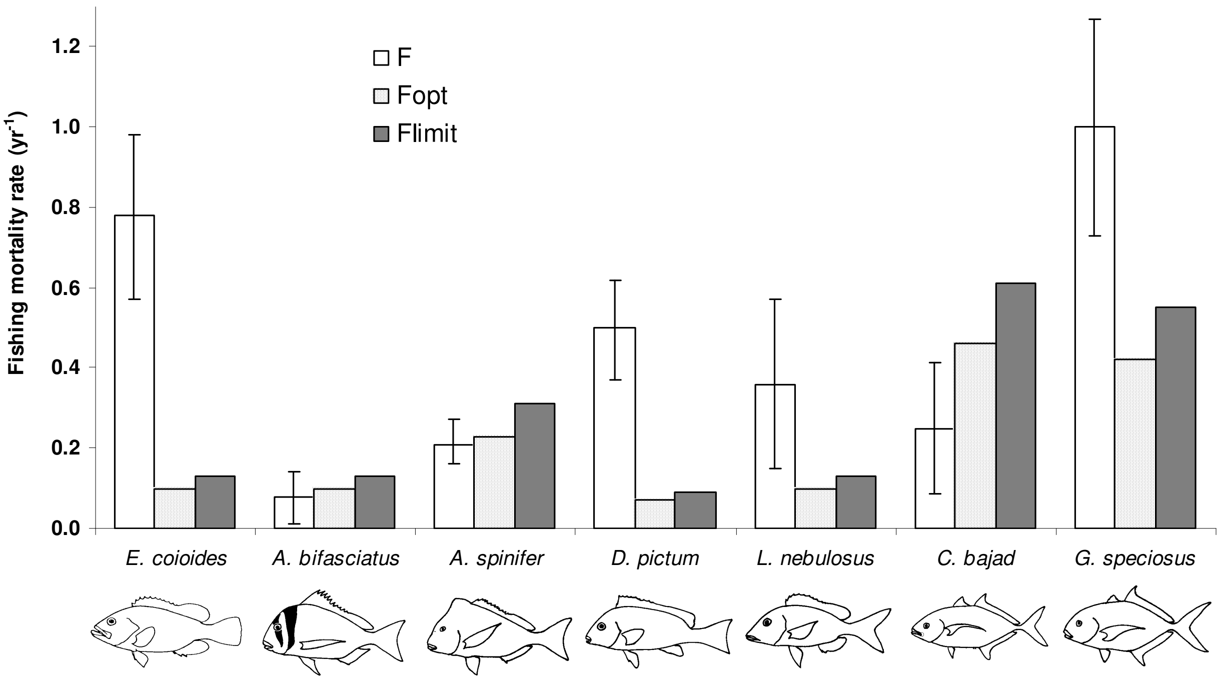

Figure 4. **Resource status for the key species in the demersal fishery of Abu Dhabi Emirate. Bars show the annual instantaneous rate of fishing mortality (F) between 2001 and 2003 (±95CI) and the target (F_{opt}) and limit (F_{limit}) biological reference points.**

The mean number of traps utilized by dhows between 2001 and 2003 was 200. Values of the total number of traps equivalent to the target and limit biological reference points are; *E. coioides*, F_{opt} = 10,256 and F_{limit} = 13,333, *D. pictum*, F_{opt} = 11,200 and F_{limit} = 14,400, *L. nebulosus*, F_{opt} = 22,222 and F_{limit} = 28,889, *G. speciosus*, F_{opt} = 33,600 and F_{limit} = 44,000, *A. spinifer*, F_{opt} = 87,619 and F_{limit} = 118,095, *A. bifasciatus* F_{opt} = 100,000 and F_{limit} = 130,000 and *C. bajad*, F_{opt} = 147,200 and F_{limit} = 195,200.

The optimum total fishing effort ranged from 10,256 traps for *E. coioides* to 147,200 for *C. bajad* and the total limit fishing effort ranged from 13,333 traps for *E. coioides* to 195,200 for *C. bajad*.

Table 4. **Resource status indicators (F/F_{opt} and F/F_{limit}) for the key species in the demersal fisheries of the Emirate of Abu Dhabi (2001-2003), biological reference points expressed as a proportion of fishing mortality (F_{opt}/F and F_{limit}/F) (2001-2003) and the existing fishing effort (E_t) as a proportion of that corresponding to the optimum and limit levels (2004).**

	2001 - 2003				2004	
	F/F_{opt}	F/F_{limit}	F_{opt}/F	F_{limit}/F	E_t/E_{opt}	E_t/E_{limit}
E. coioides	7.8	6.0	0.13	0.17	4.21	3.23
D. pictum	7.1	5.6	0.14	0.18	3.85	2.99
L. nebulosus	3.6	2.8	0.28	0.36	1.94	1.49
G. speciosus	2.4	1.8	0.42	0.55	1.28	0.98
A. spinifer	0.9	0.7	1.10	1.48	0.49	0.37
A. bifasciatus	0.8	0.6	1.25	1.63	0.43	0.33
C.bajad	0.5	0.4	1.84	2.44	0.29	0.22

Management options

Estimates of the existing licensed fishing effort for dhows, and that between 2001 and 2003 have been plotted to show the status of the fishery in relation to the fishing effort associated with target and limit biological reference points (Figures 5 and 6). For the species that are currently exploited above optimum levels (*E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus*) it can be seen that whilst there has been a reduction in licensed effort in the dhow fishery to 125 traps and 345 vessels, fishing effort is still considerably greater than that associated with the target and limit biological reference points, in particular for *E. coioides*, *D. pictum* and *L. nebulosus* (Figure 5). As such, a substantial reduction in fishing effort would be required to achieve management targets for these species.

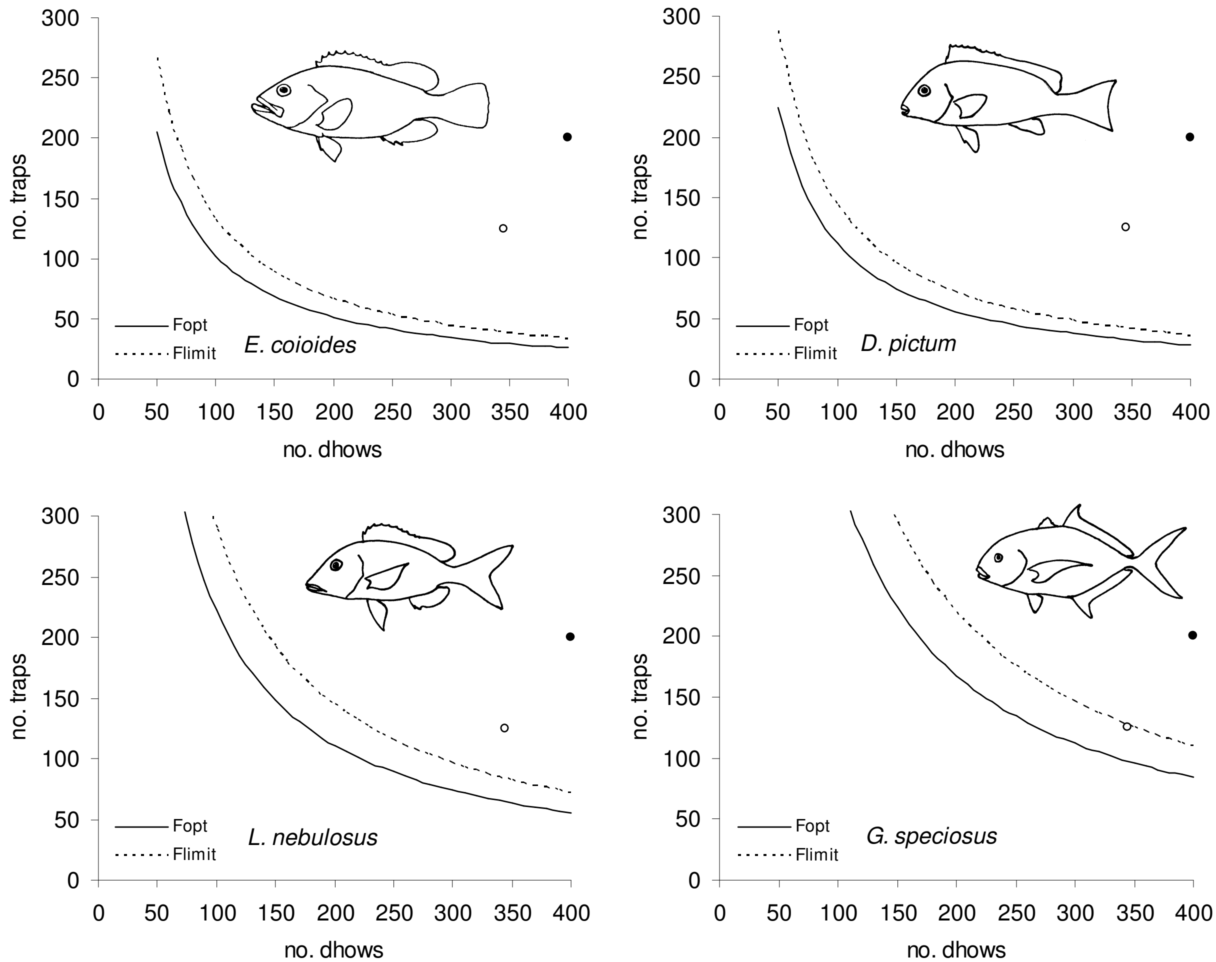

Figure 5. **The relationship between the number of vessels and trap numbers per vessel associated with target (F_{opt}) and limit (F_{limit}) biological reference points, showing the mean number of traps and vessels between 2001 and 2003 (•) and the current licensed fishing effort (○).**

Combinations of the number of vessels and traps required to achieve target and limit reference points for each of the study species are given in increments of 50 vessels for each species in Table 5.

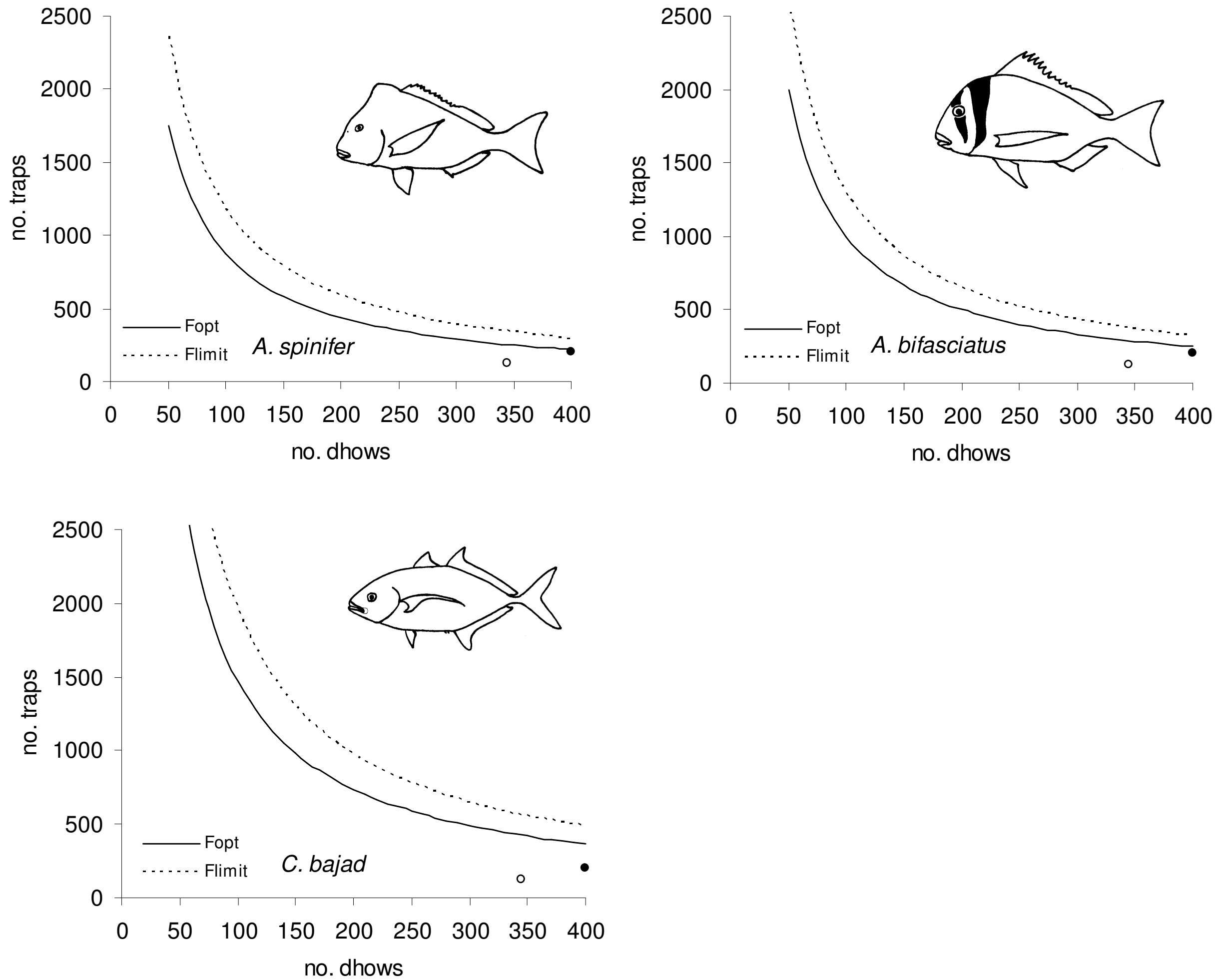

Figure 6. The relationship between the number of vessels and trap numbers per vessel associated with target (F_{opt}) and limit (F_{limit}) biological reference points, showing the mean number of traps and vessels between 2001 and 2003 (•) and the current licensed fishing effort (○).

For the species that are currently exploited below optimum levels (*A. spinifer*, *A. bifasciatus* and *C. bajad*), the reduction in licensed effort in the dhow fishery to 125 traps and 345 vessels, has resulted in the effort for these species being reduced to levels which are considerably less than those associated with the target and limit biological reference points (Figure 6). As such, an increase in fishing effort would be required to achieve management targets for these species.

Table 5. Management options for the demersal trap fishery of Abu Dhabi showing combinations of vessel (lanch) and trap numbers associated with the optimum (F_{opt}) and limit (F_{limit}) fishing mortality rates for the key species in the demersal fishery.

	No. Dhows	50	100	150	200	250	300	350	400
E. coioides	F_{opt}	205	103	68	51	41	34	29	26
	F_{limit}	267	133	89	67	53	44	38	33
D. pictum	F_{opt}	224	112	75	56	45	37	32	28
	F_{limit}	288	144	96	72	58	48	41	36
L. nebulosus	F_{opt}	444	222	148	111	89	74	63	56
	F_{limit}	578	289	193	144	116	96	83	72
G. speciosus	F_{opt}	672	336	224	168	134	112	96	84
	F_{limit}	880	440	293	220	176	147	126	110
A. spinifer	F_{opt}	1752	876	584	438	350	292	250	219
	F_{limit}	2362	1181	787	590	472	394	337	295
A. bifasciatus	F_{opt}	2000	1000	667	500	400	333	286	250
	F_{limit}	2600	1300	867	650	520	433	371	325
C. bajad	F_{opt}	2944	1472	981	736	589	491	421	368
	F_{limit}	3904	1952	1301	976	781	651	558	488

Catch and economic data

The mean annual catch of 6,506 tonnes of demersal species represented 85% of the total landings made in the Emirate of Abu Dhabi between 2001 and 2003, the remainder being composed of pelagics and other non fish categories such as crab. With a mean annual ex-vessel value of 43.5 million Dirhams, demersal species represented 83% of the total value for all species. The study species examined here were representative of families constituting 89% of the mean annual landed catch and 93% of the mean annual landed value of demersal species between 2001 and 2003.

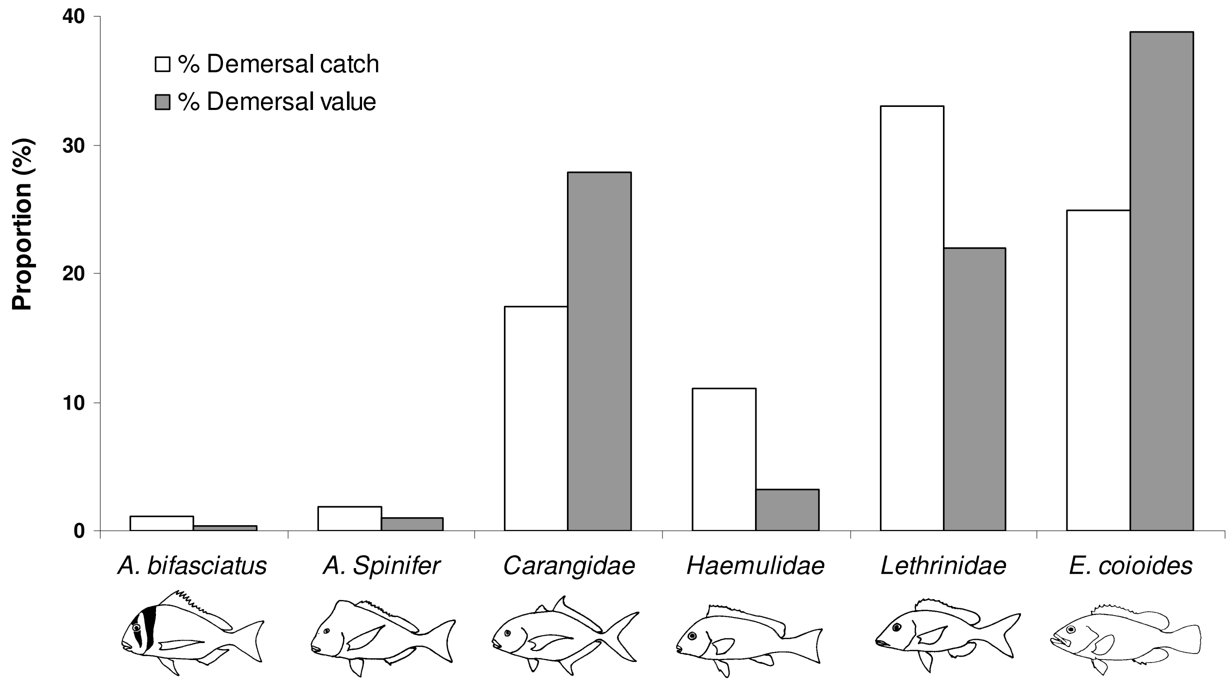

Figure 7. The proportion of the mean annual catch by weight and value (2001 to 2003) for key species and families in the demersal fishery of Abu Dhabi.

Families and species that were exploited at levels less than the target reference point (*A. bifasciatus, A. spinifer* and Carangidae) only represented 20% of the mean annual total catch and 29% of the mean annual total value of demersal species between 2001 and 2003. Conversely, those species and families determined to be exploited above the target reference point (Haemulidae, Lethrinidae and *E. coioides*) represented 69% of the mean annual total catch and 64% of the mean annual total value of demersal species between 2001 and 2003 (see Figure 7).

5. Discussion and Conclusions

This study has provided status assessments, biological reference points and management options for the key species in the demersal fisheries of Abu Dhabi which are required as a foundation for resource management and decision making. The critical findings are that the most important demersal fisheries resources are heavily over-exploited, that recent reductions in licensed fishing effort are inconsequential and a further and more substantial reduction of operational fishing capacity is required if the management goals of resource conservation and stock re-building are to be achieved.

The most important species in the fishery (Hamour) which represented an average of 39% of the ex-vessel landed value of all demersal species between 2001 and 2003 was the most heavily impacted by fishing. The fishing mortality rate over this period was more than seven times the optimum level. Despite a reduction in the number of trap and vessel licenses issued, the fishing effort during 2004 was still more than four times the optimum level for this species. Similarly, the current fishing effort for Farsh was estimated to be more than three times the optimum level and for Sha'ari it was about double the optimum level. Whilst the existing fishing effort is below optimum levels for some species (Faskar, Kowfar and Jash), collectively these only represented a comparatively small component of the demersal fishery in terms of the mean total catch (20%) and value (29%) between 2001 and 2003.

The study clearly demonstrates the highly undesirable resource status that can develop in the absence of suitable fisheries assessment, management and regulation. As the key species in the demersal fishery are generally long-lived, stock recovery will only be fully realized after some 15 to 20 years following the removal of the appropriate amount of effective fishing capacity. The extended period required to achieve conservation objectives highlights the need for a long term strategic approach to the monitoring, assessment, management and regulation of the demersal fisheries of the Emirate of Abu Dhabi.

Previous assessments of the species investigated here (Grandcourt *et al.*, 2003) have provided more optimistic outlooks on resource status due to differences in methodologies. The current assessment is considered more realistic primarily owing to the use of an alternative method of estimating natural mortality rates (Hoenig, 1983) and the use of precautionary biological reference points based on natural mortality (0.5.*M* and 2/3.*M*). Until very recently, harvest strategies where $F = F_{0.1}$ were thought to be conservative. However, these usually resulted in values of *F* approximating the natural mortality rate (*M*) when in fact, optimal fishing mortality rates are substantially lower than natural mortality rates for most species and stocks Walters (in press). Furthermore, fishing mortality rates above 2/3 *M* are often associated with stock declines, whereas fishing mortality rates below this level have resulted in stock recovery (Patterson, 1992).

The development of age-length keys and conversion of length-frequency data to age frequencies for use in estimating the total mortality rate (*Z*) had little impact on the assessment by comparison with the use of length converted catch curves as there were no significant differences between estimates of *Z* derived from the two methods. Nevertheless, the use of age frequencies was of utility as it helped to elucidate the impact of fishing on the age-structures for the populations examined.

The impacts of exploitation were particularly pronounced for *E. coioides*, *D. pictum* and *A. spinifer* with older age classes being depleted for these species. In the case of *E. coioides* and *D. pictum* the high level of fishing mortality resulted in few old fish surviving beyond the age at which they became fully vulnerable to the fishing gear. With longevities in the order of 20 years, these species will require particularly long periods of recovery in the context of a stock re-building management strategy. Increasing the biomass of older and larger fish is important to develop the spawning stock biomass and is particularly important for protogynous species where males are usually found in the older and consequently larger age classes. With such a heavily female biased sex ratio of 1 male to 48 females (Grandcourt *et al.*, 2003), the reproductive capacity of *E. coioides* in particular may be jeopardized by the excessive fishing effort especially as there were very few fish above the age (8 years) at which females change sex.

Whilst the point estimate of fishing mortality was less than the optimum rates for *A. bifasciatus* and *A. spinifer*, the upper 95% confidence interval limit for *F* was in excess of the limit reference point for *A. bifasciatus* and the target reference point for *A. spinifer*. Interpretation of the resource status between 2001 and 2003 may therefore be different if the upper limit of the 95% CI is used. As the upper 95% confidence interval limit of *C. bajad* was below the target reference point there is no ambiguity in relation to the exploitation status of this species. For *E. coioides*, *D. pictum*, *L. nebulosus* and *G. speciosus*, the lower 95% CI limits were above the limit reference point, clearly demonstrating that the fishing mortality rates were in excess of maximum limits for these species. The overall disparity in resource status can be attributed to differences in demographic characteristics and hence resilience to fishing among species. Furthermore, whilst some species had similar population parameters such as *C. bajad* and *G. speciosus*, the latter was impacted to a greater extent as it is much less abundant (Grandcourt *et al*., 2003).

A fundamental assumption of the analyses presented here is that fishing mortality rates are directly proportional to fishing effort eg. a 20% reduction in fishing effort would result in a 20% reduction in the fishing mortality rate. This assumption is reasonable and has practical application where the operational fishing capacity is well defined. However, it has been shown from survey data that the dhow fleet of Abu Dhabi operates at a level below the maximum capacity and some vessels have been engaged in other activities such as cargo transport. Furthermore, it is unclear how many of the licensed vessels that are actively engaged in fishing are using traps. As a result, there are important considerations associated with the interpretation of the management options and absolute values of fishing effort that correspond to the optimum (F_{opt}) and limit (F_{limit}) biological reference points. The most important of these being that the optimum and limit fishing effort values may have been over estimated in the absence of detailed information on the effective fishing capacity as opposed to the licensed fishing effort.

Furthermore, the reduction in the number of fishing vessels from 400 (2001 to 2003) to 345 in 2004 relates to a portion of the fleet that was redundant, and while holding fishing licenses they were not actively engaged in fishing. There was an associated reduction in licensed fishing effort, though the effective fishing capacity may well have remained constant with no real reduction in fishing mortality rates.

When implementing input (effort) regulations in line with the results presented here, it must be emphatically clear that in order to achieve stated management target reference points, a relative reduction in active, operational fishing effort is required and not simply holders of fishing licenses. For this reason, whilst the management options in terms of the number of traps and vessels may seem restrictive in terms of the existing fleet capacity, in fact they may have been overestimated given the absence of detailed data on the active component of the fleet using traps. The upgrading of the existing catch and effort data recording system will resolve this issue and provide necessary data inputs into such analyses in the future.

Nevertheless, the resource status indicators are independent of such bias and the heavy over-exploitation of the principal demersal species identified here is a critical management issue. Reductions in effective fishing effort are required if management objectives are to be achieved for all species and the extent of depletion in combination with their longevity suggests that long term strategies are required to rebuild stocks and conserve these resources.

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Annex 1. Age-length key (proportion by size and age) for *E. coioides*

Length (L_T cm)	Age group 1	2	3	4	5	6	7	8	9	10	11	12
21	1.00											
22												
23	1.00											
24	0.33	0.67										
25	0.33	0.67										
26	0.50	0.50										
27	0.86	0.14										
28	0.78	0.22										
29	0.36	0.45	0.18									
30	0.73	0.18	0.09									
31	0.57	0.14	0.29									
32	0.40	0.40	0.20									
33	0.50	0.20	0.10	0.20								
34	0.27	0.45	0.18	0.09								
35	0.75	0.25										
36	0.45	0.27	0.09	0.18								
37	0.50			0.50								
38			0.33	0.00	0.67							
39		0.50		0.50								
40	0.33	0.33		0.33								
41			0.50	0.50								
42	0.33		0.33	0.33								
43			0.25	0.75								
44			0.75		0.25							
45			0.20	0.40	0.40							
46		0.20	0.20	0.40	0.20							
47				0.67	0.33							
48			0.20	0.40	0.40							
49			0.36	0.55	0.09							
50			0.40	0.30	0.30							
51			0.38	0.63								
52			0.18	0.45	0.36							
53			0.33	0.42	0.25							
54				0.67		0.33						
55				0.25	0.50	0.25						
56			0.33	0.17	0.33		0.17					
57			0.10	0.40	0.50							
58				0.25	0.63			0.13				
59			0.33	0.33		0.33						
60					1.00							
61					0.33	0.67						
62			0.25	0.25		0.25	0.25					
63				1.00		0.00	0.00					
64					0.50	0.25	0.25					
65					0.50	0.50						
66				0.50	0.50							
67			0.20	0.20	0.60							
68				0.50	0.25	0.25						
69			0.20	0.20	0.20	0.40						

Cont …

Annex 1. Age-length key (proportion by size and age) for *E. coioides*

Cont…

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9	10	11	12
70				0.33	0.33	0.33						
71				0.14	0.29	0.14	0.14	0.14		0.14		
72				0.20	0.20	0.20	0.40					
73				0.20	0.40	0.20	0.20					
74				0.33	0.17	0.33						0.17
75				0.33	0.33		0.33					
76				0.20	0.00		0.60		0.20			
77				0.18	0.18	0.36	0.27					
78						0.43	0.57					
79						0.33	0.67					
80					0.17		0.50	0.33				
81					0.17	0.17	0.50	0.17				
82						0.75			0.25			
83							1.00					
84					0.20		0.40	0.40				
85						0.20	0.80					
86						0.50		0.50				
87						0.50				0.50		
88							1.00					
89								0.50	0.50			
90												
91							0.50	0.50				
92							0.50		0.50			
93						1.00						
94												
95									1.00			
96												
97									1.00			
n	55	32	44	80	61	36	37	10	6	2	0	1
Mean length (L_T cm)	31.3	32.2	46.4	54.7	60.5	72.5	78.6	80.7	89.0	79.1	-	74.2
SD (cm)	4.1	4.9	10.3	11.3	11.0	10.2	7.3	9.6	8.1	11.2	-	

Annex 2. Age-length key (proportion by size and age) for *A. bifasciatus*

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9	10
14	1.00									
15	1.00									
16	0.77	0.23								
17	0.69	0.25	0.06							
18	0.83	0.17								
19	0.45	0.45	0.05		0.05					
20	0.47	0.21	0.21	0.05	0.05					
21	0.19	0.13	0.50	0.13	0.06					
22	0.26	0.22	0.22	0.13		0.13	0.04			
23	0.04		0.38	0.29	0.13	0.13	0.04			
24			0.30	0.17	0.26	0.13	0.09		0.04	
25			0.17	0.46	0.21	0.13	0.04			
26	0.07			0.29	0.14	0.29	0.07			0.14
27		0.05	0.10	0.19	0.33	0.24			0.05	
28			0.04	0.18	0.11	0.18	0.32			0.04
29					0.17	0.17	0.39		0.11	
30				0.08	0.15	0.08	0.15		0.23	
31				0.12	0.12	0.16	0.08	0.04	0.08	0.12
32				0.04	0.11	0.11	0.18	0.14	0.04	
33							0.25	0.17		0.17
34									0.33	
35										0.33
36									0.25	
37										
38								1.00		
n	65	30	42	46	40	37	34	8	12	9
Mean	18.7	19.9	23.1	25.8	26.9	27.4	29.2	33.0	30.7	30.8
SD	2.3	2.4	2.1	2.8	3.3	3.0	2.8	2.1	3.0	3.0

Annex 2. Age-length key (proportion by size and age) for *A. bifasciatus* Cont…

Length (L_F cm)	Age group 11	12	13	14	15	16	17	18	19	20	21
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27	0.05										
28	0.07				0.04	0.04					
29			0.06	0.11							
30	0.08		0.23								
31	0.16		0.04		0.04			0.04			
32	0.04	0.18	0.11	0.04		0.04					
33	0.08	0.25			0.08						
34			0.33								0.33
35			0.33	0.33							
36		0.25			0.25	0.25					
37											
38											
n	10	9	10	4	4	3	0	1	0	0	1
Mean	30.5	33.0	31.9	31.5	32.4	32.3	25.2	31.5	-	-	34.2
SD	1.9	1.3	2.0	2.6	3.3	4.2	-	-	-	-	-

Annex 3. Age-length key (proportion by size and age) for *A. spinifer*

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9
13	1.00								
14	0.85	0.08	0.08						
15	0.79	0.08	0.13						
16	0.94		0.06						
17	0.85	0.15							
18	0.71	0.29							
19	1.00								
20	0.47	0.40	0.07	0.07					
21	0.32	0.53	0.11	0.05					
22	0.50	0.30	0.20						
23	0.27	0.33	0.20	0.20					
24	0.24	0.41	0.29		0.06				
25	0.14	0.23	0.41	0.18		0.05			
26		0.39	0.44	0.11	0.06				
27		0.56	0.19	0.19	0.06				
28		0.50	0.38	0.13					
29		0.36	0.36	0.18	0.09				
30		0.09	0.27	0.45	0.18				
31		0.17	0.50	0.33					
32			1.00						
33		0.18	0.55		0.27				
34			0.50	0.50					
35				0.67	0.33				
36				0.75		0.25			
37		0.14	0.43	0.43					
38			0.25	0.50		0.25			
39			0.50		0.50				
40			0.67	0.33					
41				0.50	0.50				
42									
43				0.33	0.67				
44							1.00		
45				0.50		0.50			
46						1.00			
47				0.33	0.33	0.33			
48						0.33	0.67		
49						1.00			
50							1.00		
51							1.00		
52							1.00		
53					1.00				
54									
55						1.00			
56									
57									
58									
59									1.00
n	118	78	73	41	17	9	6	0	1
Mean	18.3	24.2	28	31.8	36.8	43.6	49.1	-	59
SD	3.0	4.3	5.9	6.7	9.1	8.9	2.8	-	-

Annex 4. Age-length key (proportion by size and age) for *D. pictum*

Length (L_F cm)	Age group													
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
20	1.00													
21	0.25	0.75												
22	0.50	0.50												
23	0.57	0.43												
24	0.37	0.58	0.05											
25	0.45	0.50	0.05											
26	0.25	0.67		0.08										
27		0.50	0.50											
28		0.50	0.50											
29		0.25	0.75											
30			0.71	0.29										
31	0.17	0.08	0.75											
32		0.40	0.60											
33		0.30	0.60	0.10										
34		0.17	0.33	0.50										
35			0.67		0.33									
36				1.00										
37			0.50	0.50										
38			0.33	0.67										
39				0.80	0.20									
40			0.22	0.67		0.11								
41			0.33	0.33	0.17	0.17								
42			0.17	0.83										
43			0.14	0.43	0.36	0.07								
44				0.45	0.55									
45				0.33	0.33	0.22	0.11							
46				0.80	0.20									
47				0.43	0.43	0.14								
48				0.29	0.14	0.14	0.29	0.14						
49				0.22	0.22	0.33	0.11	0.11						
50						0.25	0.50	0.25						
51				0.18	0.36	0.27	0.09	0.09						
52					0.33	0.22	0.11	0.11	0.11		0.11			
53				0.17	0.17	0.08	0.33	0.08	0.08		0.08			
54					0.29	0.29	0.14		0.14	0.14				
55						0.43	0.14		0.29			0.14		
56					0.11	0.11	0.11	0.33	0.22	0.11				
57									0.50				0.50	
58										1.00				
59							0.33	0.67						
60									1.00					
61											1.00			
62												1.00		
63														1.00
n	46	58	48	69	37	23	16	11	9	3	2	1	1	1
Mean	24	25.6	33.8	41.7	47.1	50.2	52.2	53.9	55.7	56.4	52.5	55.4	57.5	63
SD	2.3	3.2	4.6	5.3	4.9	4.6	3.5	3.9	2.3	1.9	0.4	-	-	-

Annex 5. Age-length key (proportion by size and age) for *L. nebulosus*

	Age group														
Length (L_F cm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
17	1.00														
18	1.00														
19	0.82	0.18													
20	0.58	0.37	0.05												
21	0.50	0.44	0.06												
22	0.21	0.21	0.57												
23		0.43	0.57												
24	0.07	0.53	0.33	0.07											
25	0.10	0.45	0.15	0.30											
26		0.20	0.30	0.50											
27		0.56	0.33	0.11											
28		0.17	0.50	0.33											
29		0.22	0.22	0.11	0.11	0.33									
30			0.14	0.71	0.14										
31			0.07	0.64	0.14	0.14									
32		0.08	0.08	0.31	0.23	0.15	0.08	0.08							
33				0.42	0.33	0.17		0.08							
34			0.25	0.25	0.38			0.13							
35				0.50				0.50							
36				0.25	0.25	0.50									
37				0.50	0.17	0.33									
38				0.14	0.57	0.14	0.14								
39				0.20	0.40	0.40									
40						0.50	0.25			0.25					
41					0.25	0.13	0.38		0.13		0.13				
42						0.25		0.50	0.25						
43										1.00					
44						0.33	0.17	0.33	0.17						
45						0.14	0.14	0.21	0.36		0.14				
46							0.25			0.50		0.25			
47							0.25	0.25	0.08	0.25	0.08		0.08		
48							0.08	0.17	0.25	0.25	0.17		0.08		
49								0.13	0.38	0.38			0.13		
50								0.13	0.25	0.13		0.13	0.13	0.13	0.13
51								0.08	0.42	0.25	0.08		0.17		
52								0.08	0.08	0.23	0.38	0.15	0.08		
53									0.25	0.25	0.25		0.25		
54												0.50		0.50	
55										1.00					
56										1.00					
n	36	50	38	48	24	24	14	20	24	23	13	5	8	2	1
Mean	20.8	24.1	25.8	31	35.1	37.2	43.4	44.3	48.3	49.5	49.5	51.1	50.5	52.4	50.4
SD	1.7	2.9	3.7	3.9	3.4	5.2	4.4	6.1	3.3	3.5	3.7	2.9	2.1	2.3	-

Annex 6. Age frequency distributions by size for *E. coioides*

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9	10	11	12
21	6											
22												
23	11											
24	6	11										
25	3	6										
26	16	16										
27	34	6										
28	51	14										
29	30	37	15									
30	69	17	9									
31	75	19	37									
32	59	59	30									
33	69	27	14	27								
34	43	71	29	14								
35	110	37		0								
36	110	66	22	44								
37	118		0	118								
38			76		153							
39		164		164								
40	117	117		117								
41			246	246								
42	111		111	111								
43			89	266								
44			297		99							
45			64	128	128							
46		96	96	192	96							
47			0	248	124							
48			72	144	144							
49			162	243	40							
50			133	100	100							
51			189	315								
52			55	138	110							
53			112	140	84							
54				301		150						
55				93	186	93						
56			116	58	116		58					
57			24	96	120							
58				51	128			26				
59			119	119	0	119						
60					274							
61					138	277						
62			57	57		57	57					
63				272								
64					135	68	68					
65					82	82						
66				164	164							
67			50	50	149							
68				66	33	33						
69			36	36	36	72						

Cont …

Annex 6. Age frequency distributions by size for *E. coioides*

Cont…

Length (L_T cm)	Age group 1	2	3	4	5	6	7	8	9	10	11	12
70				84	84	84						
71				12	24	12	12	12		12		
72				13	13	13	26					
73				9	18	9	9					
74				10	5	10						5
75				11	11		11					
76				10			30		10			
77				1	1	1	1					
78						4	6					
79						3	6					
80					2		6	4				
81					1	1	2	1				
82						3			1			
83							3					
84					1		1	1				
85							2	0				
86						3		3				
87												
88							1					
89												
90												
91												
92							1		1			
93						1						
94												
95												
96												
97									1			
n	1037	764	2258	4265	2796	1093	298	46	13	12	0	5
Mean	31.3	32.2	46.4	54.7	60.5	72.5	78.6	80.7	89.0	79.1	-	74.2
SD	4.1	4.9	10.3	11.3	11.0	10.2	7.3	9.6	8.1	11.2	-	-

Annex 7. Age frequency distributions by size for *A. bifasciatus*

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9	10
14	33									
15	79									
16	86	26								
17	112	41	10							
18	198	40								
19	156	156	17		17					
20	181	81	81	20	20					
21	108	72	287	72	36					
22	177	147	147	88		88	29			
23	20		177	138	59	59	20			
24			222	127	190	95	63		32	
25			83	228	104	62	21			
26	52			208	104	208	52			104
27		24	48	96	168	120			24	
28			17	86	51	86	154			17
29					109	109	254		73	
30				40	80	40	80		120	
31				68	68	91	45	23	45	68
32				16	48	48	79	64	16	
33							100	66		66
34									128	
35										53
36									111	
37										
38								77		
n	1201	586	1090	1186	1054	1005	898	230	548	308
Mean	18.7	19.9	23.1	25.8	26.9	27.4	29.2	33.0	30.7	30.8
SD	2.3	2.4	2.1	2.8	3.3	3.0	2.8	2.1	3.0	3.0

Annex 7. Age frequency distributions by size for *A. bifasciatus*

Cont…

Length (L_F cm)	Age group 11	12	13	14	15	16	17	18	19	20	21
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27	24										
28	34				17	17					
29			36	73							
30	40		120								
31	91		23		23			23			
32	16	79	48	16	0	16					
33	33	100			33						
34			128								128
35			53	53							
36		111			111	111					
37											
38											
n	238	289	407	142	183	144	0	23	0	0	128
Mean	30.5	33.0	31.9	31.5	32.4	32.3	25.2	31.5	-	-	34.2
SD	1.9	1.3	2.0	2.6	3.3	4.2	-	-	-	-	-

Annex 8. Age frequency distributions by size for *A. spinifer*

Length (L_F cm)	Age group 1	2	3	4	5	6	7	8	9
13	96								
14	208	19	19						
15	210	22	33						
16	246		14						
17	208	38							
18	250	104							
19	510								
20	262	225	37	37					
21	218	363	73	36					
22	350	210	140						
23	134	168	101	101					
24	130	227	162		32				
25	43	72	130	58		14			
26		190	217	54	27				
27		141	47	47	16				
28		98	73	24					
29		104	104	52	26				
30		20	61	102	41				
31		45	135	90					
32			140						
33		32	96		48				
34			112	112					
35				66	33				
36				236		79			
37		20	59	59		0			
38			17	33		17			
39			57		57				
40			55	27					
41				23	23				
42									
43				11	21				
44				0			33		
45				15		15			
46						33			
47				6	6	6			
48						3			
49						9			
50							13		
51							6		
52							8		
53					7				
54									
55						6			
56									
57									
58									
59									1
n	2865	2097	1881	1189	337	182	66	0	1
Mean	18.32	24.21	27.96	31.85	36.81	43.62	49.13	-	59
SD	3.0	4.3	5.9	6.7	9.1	8.9	2.8	-	-

Annex 9. Age frequency distributions by size for *D. pictum*

Length	Age group													
(L_F cm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
20	25													
21	16	47												
22	42	42												
23	29	23												
24	33	52	5											
25	57	63	6											
26	40	107		13										
27		70	70											
28		80	80											
29		49	146											
30			110	44										
31	51	25	229											
32		59	89											
33		91	182	30										
34		51	102	153										
35			95		48									
36				475										
37			95	95										
38			50	100										
39				242	61									
40			46	137		23								
41			75	75	38	38								
42			27	137										
43			17	51	42	8								
44				67	81									
45				18	18	12	6							
46				147	37									
47				30	30	10								
48				13	6	6	13	6						
49				7	7	11	4	4						
50						6	12	6						
51				7	15	11	4	4						
52					5	3	2	2	2		2			
53				4	4	2	8	2	2		2			
54					6	6	3		3	3				
55						9	3		6			3		
56					1	1	1	4	3	1				
57									7				7	
58										8				
59							2	3						
60									1					
61											4			
62												2		
63														1
n	292	757	1422	1845	398	147	57	31	24	12	8	5	7	1
Mean	24	25.6	33.8	41.7	47.1	50.2	52.2	53.9	55.7	56.4	52.5	55.4	57.5	63
SD	2.3	3.2	4.6	5.3	4.9	4.6	3.5	3.9	2.3	1.9	0.4	-	-	-

Annex 10.   Age frequency distributions by size for *L. nebulosus*

Length (L_F cm)	Age group 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
17	2														
18	9														
19	13	3													
20	17	11	2												
21	22	19	3												
22	18	18	47												
23		44	59												
24	12	93	58	12											
25	17	75	25	50											
26		45	68	114											
27		149	90	30											
28		52	157	104											
29		73	73	37	37	110									
30			51	254	51										
31			29	258	57	57									
32		28	28	111	83	55	28	28							
33				150	120	60		30							
34			102	102	153			51							
35				136				136							
36				155	155	311									
37				212	71	141									
38				66	263	66	66								
39				159	318	318									
40						405	203			203					
41					271	135	406		135		135				
42						180		359	180						
43										836					
44						205	103	205	103						
45						53	53	79	132		53				
46							179			358		179			
47							122	122	41	122	41		41		
48							26	52	78	78	52		26		
49								35	106	106			35		
50								27	54	27		27	27	27	27
51								12	60	36	12		24		
52								8	8	23	39	16	8		
53									18	18	18		18		
54												34		34	
55										50					
56										34					
n	109	610	790	1948	1578	2095	1184	1143	912	1890	349	255	178	60	27
Mean	20.8	24.1	25.8	31	35.1	37.2	43.4	44.3	48.3	49.5	49.5	51.1	50.5	52.4	50.4
SD	1.7	2.9	3.7	3.9	3.4	5.2	4.4	6.1	3.3	3.5	3.7	2.9	2.1	2.3	-