

## **TO THE PROBLEM OF MANAGEMENT OF THE SOUTHERN SHARK FISHERY**

*(A paper prepared on the request of Australian southern shark fishermen)*

### **SUMMARY**

The Australian southern shark fishery (SSF) does not render itself well to management by TAC and individual quotas. School shark is a species, which requires management tailored to the peculiarities of its life history, as well as to those of the SSF (people, technology, operations, and environment). Additionally, and in spite of the great effort invested, the stock-assessment model developed cannot serve as a reliable scientific basis for management of this fishery, due to insufficient and ambiguous data and information. The new proposal of improving the assessment through use of a different methodology - the fixed-station surveys - may misfire, for it seems to be incompatible with what is known (and not known) of school shark migrations and behaviour.

Migrations here and back of both Australian and N.Z. sharks should be taken into account in the management of the Australian stock. The presently employed model suffers from inadequate data on such mobility, a problem, which can only be solved by a major tagging effort along with a study of environmental determinants of southern sharks movements & behaviour. Notwithstanding with the results of such studies, joint management of the NZ and the Australian stocks is politically and economically unrealistic, therefore, further disputing whether such management is justified appears to be waste of time.

I recommend to replace the present management strategy of mainly output (quota) management by a scheme to be worked out in co-operation with elected representatives of shark fishermen, based on input (effort) management. Such scheme would continue for about 5 years, during which period empirical studies into shark biology, ecology, migrations, food, stock composition, and preferred environmental conditions at various age stages would be effected. Then, on the basis of much improved data and information base, the management scheme would be reviewed, and if necessary, amended. Nursery area habitat revival

programme, as well as programmes aimed at reduction of coastal and upstream pollution, should be actively supported and assisted by appropriate legislation.

### ***1 - Some general remarks on science and fishery management***

Fisheries management is two-sided like a coin. One side is conservation of the stock. The other side of the coin is well-being of the fishing sector as a part of the economy at large and a supplier of protein food, and as a provider of income to fishing people. The management is about good functioning of the fishery and about the distribution of the benefits it derives from the resource. This, because *every management intervention influences the distribution of the benefits from the resource.*

Fisheries management is much more about people than it is about fish stocks. Although, we're after maintaining exploitation of stocks of fish at a sustainable level, but people are the only vector in the complexity of fishery ecosystems we're able to influence directly. We cannot manage fish – all we can manage are people. Thus, management's success or failure depends on people – those who prescribe the measures and those who have to comply with and are affected by them. If we apply management means to people without considering and addressing their livelihood needs, and their views, thoughts, feelings, habits, hopes, and aspirations, we may end either with a sure failure, or with exorbitant costs. Only too often we get both, and examples are aplenty.

Hence, management means must be acceptable to the fishing industry, enforceable, affordable, and based on maximum available information on the specific fishery ecosystem. Industry representatives should participate as members in all fishery assessment and management bodies. It is important that those representatives are elected or otherwise delegated and trusted by their peers, rather than nominated by authorities. It should be borne in mind that introduction of marketable quotas unavoidable lead to a gradual concentration of quota and fleet ownership, and to displacement of small-scale private owners with resulting social, economic, and political repercussions. When political and other objectives of the managing authority find themselves in conflict with the perceived interests of the fishing people and their industry, and/or ignore non-fishing deleterious factors in the ecosystem, there's a little chance that the applied means would be effective.

The best available science is not always sufficient to serve as a basis for fishery management. Using inadequate data and information to fill models' cells through highly speculative exercises causes, if used for making management decisions, more damage than benefit. With all the due respect to mathematical modelling, the use of models in forecasting ecological situations, and it is fishery ecology we deal with, is highly problematic. Simple models are more reliable, but they can hardly reflect the complexity of a fishery ecosystem. Complex models can theoretically reflect the inter-relations prevailing in a system, but would be unreliable for lack of hard data and being top-heavy with guesses, assumptions, and approximations (Priback et al. 2000). Responsible fishery scientists and managers should restrain placing reliance upon and use of models, especially where faced with rational criticism on the part of fishermen and independent scientists.

Where the stock-assessment is insufficient for quota management and where quota management is unsuitable for a specific fishery, management by effort-control is indicated. Effort-control (input) management must be based on information specific to the fishery, species, environment, fishermen, and equipment involved. It requires understanding of problems involved with regulating multi-species fisheries, by-catch both, unnecessary and unavoidable, being only one of them. In contrary to such panacea measures as ITQs, input management means must be tailored to each fishery. Even the same species may need different meshsize regulation in different areas. Seasonally closed nursery areas must be locally selected, and even the same gear may have different impact in different areas. For example, some studies have indicated that it may not always be recommendable to fish selectively for the larger and let the smaller and younger ones go. Under certain environmental conditions and prey-predator relations, it may be advisable to fish out a share of the immature fish, and let a share of the large, more prolific ones to live and procreate. Effort-control management is more likely to react in true time to natural phenomena that influence fish distribution and mortality. Its success is as a rule stipulated by closed or limited access to the fishery.

## ***2 - Managing the SSF***

In my opinion, and in view of worldwide experience, the Australian southern shark fishery (SSF) along with other small-scale, multi-species fisheries is of the type that does not render itself well to management by TAC and individual quotas. Dr. Ray Beverton, in his "State of the Fishery Science" lecture on the 1<sup>st</sup> World Fishery Congress stated that, among other conditions, TAC management

may only be successful in a single area, single species fishery with low recruitment variability, and a few landing spots. This is not the case with the SSF in which more than one species is taken and which is landing catches at a multitude of outlets (Southern Shark Fishery Task Force, 1985). Also, school shark is highly mobile, even migratory, wide-ranging, and creates probably a single population (Prince, 1992) that spreads over southern Australia, Tasmania, New Zealand, and adjacent oceanic areas (Annala *et al*, 1998). This is a species, which requires management adapted to the peculiarities of its life history. Such are: different migrational behaviour of male and female concentrations, slow growth and late age of reproduction, the need for appropriate inshore "nursery" habitats where gravid females release their pups, schooling habits, major seasonal and other migrations, the need to shun from catching older, particularly male sharks with high mercury content, sensitivity to the ambient temperature, and more. There is also the rather cryptic factor of amateur fishing (Prince, *loc cit*). Such fishery cannot be rationally managed using simplistic, quantitative means. The SSF should be managed using, apart from general effort and capacity controls, and ways and means tailored to the above specifics of this fishery (*loc cit*), as a multi-species fishery, desirably in cooperation with, and participation of the shark fishermen. The latter, in view of the socio-economic effect of any management steps that may be undertaken.

The reviewer of my former comments asked for my "alternative ... to replace the existing assessment". I assume that this request stems from the FAG's terms of reference, making stock assessment as a basis for management the group's single, specific task. I have no alternative suggestions for the SharkFAG. I think that this group, and in particular Dr. Punt and his colleagues, have done a remarkable job and demonstrated considerable statistical-mathematical skills in building a fishery-specific model in their attempts to assess the southern sharks population (Priback *et al*. 2000; Punt *et al*. 2000). In my opinion, however, in spite of the incorporation of Dr.R.Deriso's of IATTC improvements (Deriso, undated), and of the great effort put into achieving meaningful results from insufficient and noisy data and information, this great effort is top heavy with assumptions, probability guesses, interpolations, and extrapolations (*loc cit*). Although, with appropriate qualifications, it satisfied peers' review, and a consensus among the FAG members, it remained in my view too problematic to serve as a sound, scientific basis for actual management steps. Even without the criticism on the part of the industry, it is sufficient to put together the various qualifications one can find in the various FAG reports and other papers to see the high probability of a major cumulative uncertainty in the results obtained. Therefore, the alternative I suggest in more detail below in this memo has

nothing to do with the methodologies of stock assessment. I suggest a general shift of the SSF management from quota system to effort-control (input) management, which can well do without quantitative stock assessment.

### **3 - Abundance assessment**

SharkFAG recognized concerns about the validity of catch rates as abundance index, and the sensitivity of their stock assessment to the selection of catch-rate series (Punt and Walker, 1998). This implies that the present stock assessment is inadequate for SSF management. Dr. Punt's reaction to fishermen's claim that catch rates before and after a change in management do not remain comparable, was that it is not so, "because the assessment is based on a population model, and the size of the population does not change" (letter to Ms. K.Dunn). But, one should take into consideration that a change in management arrangements may cause a change in a manner in which catch rates are reported in a compulsory reporting system. This may happen due to the attitude that may prevail throughout an industry, the members of which feel wronged by the management. Hence, if not the actual, these may be the reported catch rates, which become incomparable.

In view of its own and others' criticism of the validity of the catch rates data, Shark FAG recommended to use a different methodology - the fixed-station surveys. In the meantime, it is using the doubtful CPUE. It is doubtful in this case not only because of the rather shaky past data base and some doubts about the present one, but also because, as J.Gulland (1969) defined it in his *Manual: for the CPUE to be proportional to the stock density, and the number of operations proportional to the mortality caused, it must consist of a single unit operating on a uniform density of fish and taking in each haul a fixed proportion of fish present*. This is hardly the case of the school shark fishery. Beverton (1994) warned against applying his own and other models where they do not fit specific fisheries.

Unfortunately, also "fishery independent" fixed stations surveys may be a misfit. This methodology, normally applied in relative assessment of the state of stocks over trawling grounds where fish are assumed to be fairly spread about, may be incompatible with what is known (and not known) of school shark movements and spatial behaviour. There are also difficulties due to the vagaries of weather and tides, as well as longer-term variations in oceanic conditions in the area, and their effect on fishing operations and catches. Also, the little that is known of the hardly studied daily movements, seasonal and annual migrations and other

spatial behaviour of the highly mobile school sharks, indicates that they may not occur at times and in definite locations at a regularity that would make fixed stations a reliable abundance indicator.

Without adequate knowledge, information, and hard data for a reliable and socially responsible quantitative management of the SSF, the present stock assessment should not be considered as a basis for management (see also: Beverton 1994). Since management, which is suitable for the SSF, ought to be based on effort control, its scientific basis must comprise the biology and ecology of the sharks, and the specifics of fishing (technology, environment, and operations). Towards this end research, logistic, and human, hence also financial resources should go.

#### **4 – Some basic information on the school sharks of southern Australia**

School sharks are a cosmopolitan species and perform major migrations. While their pups tend to remain in protected, shallow areas, or in their vicinity at least till they are one year old and usually more, they may swim later on to distances of several hundreds to over 1,000 sea miles. School sharks tagged off west Scotland were recaptured over an area ranging from Algiers and Canary Islands to Iceland, or some 1,800 sea miles across (Little, undated). Females may perform greater migrations than males. Grown school sharks move invariably in rather dense schools, which is indicated in the manner of their capture. Gummy sharks do not school as densely, do not perform such long migrations, their behaviour is far more flexible, they aggregate to feed on pupping grounds, but at times appear widely dispersed, (Olsen 1954, 1984; Stevens and West, 1997). Both species are caught in small numbers occasionally, when some sharks come to feed on fish gilled in the nets. School sharks must be descending to and stay on the very bottom, because many of the gilled in the nets are found with mud stains on their belly (B.Daff, private communication). They feed mainly on fish both, demersal and pelagic (anchovy) and some cephalopods, while juveniles consume also large amounts of crustaceans and other lower invertebrates. (Olsen; Stevens and West, *loc cit*) School sharks venture hundreds of miles offshore, beyond the reach of the present fishery, to form bycatch by tuna longliners (Annala et al, 1998).

Punt et al (2000) mentioned the possible effect of the seasonal oscillations of the convergence off southern Australia on the marine food chain, and hence on the movements of school sharks, but I don't feel that such potential relationships have been seriously investigated, if at al. Also, the model serving for stock

assessment inferred from reported data 2 separate stocks, one of them dispersed. There seems to be no concrete empiric evidence, however, supporting such deduction.

On the average, school shark perform greater migration than gummy sharks (Stevens and West, 1997). Gummy shark support an actively promoted large recreational fishery in Victoria. It seems to be poorly recorded, but by rather conservative estimates hundreds of tonnes must be caught annually. It is likely that more gummy shark are caught by sport than by commercial fishermen (R.McDonald, private communication). This is inconsistent with the number of tags returned by recreational fishermen as compared with the commercial ones. This, however, may reflect human attitudes and not necessarily the actual catch proportion.

It seems that since Olsen (1954), relatively little new has been published on the southern sharks ecology, food and feeding, migrations and vertical movements, behaviour and its relation to external conditions, etc. The assessment reports seem to scarcely mention these fishes' biology, including measured age composition (cohorts) in the stock, and other empirical data. Also, apparently, only lip service was done to possible influence of changes of environmental conditions. For example, the drastic fluctuations in shark catches off Tasmania between 1973 and early 1990s (Prince 1992) were probably influenced by factors other than fishing effort.

## ***5 - The fishery***

SSF is a small-scale, multi-species fishery with 2 main catch components: gummy and schools sharks, and some 15% composed of mainly elephant fish and 2 spp of saw sharks. The early settlers had fished them, but the offshore fishery started off Victoria in the early 1920s (Campbell et al, 1991), although according to some fishermen it actually took off only in the late 1930's.

School sharks had been plentiful up until 30 years ago in Port Phillip Bay. Their habit of biting off hooked snapper gave them the local name "snapper shark". Commercial longline catches of school sharks in the Bay decreased in the last twenty years. In the last decades, and co-incidentally with the widespread introduction of gillnets, fishery for school shark has become of what had been originally a winter off-season supplement to crayfish fishery – a seasonal summer fishery (R.McDonald, private communication).

Beginning with 1964, during late 1960s – early 1970s most longlines were replaced by gillnets, and in 1990 the latter took 90% of the total catch (Campbell et al, *loc cit*). It is practiced in Victoria, Tasmania, and S.Australia.

A map in the "Fishery surveys report 1993" entitled: D-value of catches in the southern shark fishery, 1991-92, shows the value of catch per unit area. This should indicate the relative productivity of the southern shark fishery on various fishing grounds. For example the area of Portland, half way between Adelaide and the Melbourne-Lake Entrance area, appeared to be distinctly of low production. Assuming that the data is correct, one should ask the question whether was it poor of sharks, or simply much less fished, and the mapped "area productivity" reflects also distance from landings spots and other logistic (including weather) and market factors.

Another difficulty with the area productivity data, stems from misreporting, under-reporting or over-reporting by the fishermen. According to my sources, some fishermen perceived that for certain zones they need a good "catch history". Also, according to Punt et al (undated – (b)), historical catches of school shark might have been underestimated during the 10-years "mercury ban" period, as well as under-reported on one hand, and affected by "paper-fish" reporting, on the other. There is also the problem of confidentiality of data, aggravated by AFMA's publishing shot data in an indiscreet way, which enabled deducing the catches of individual fishermen. Hence the reported catch and catch distribution data should be considered unreliable in the extreme. Distrusting fishermen keep to themselves the records of the real data.

The mercury ban on large school shark was lifted in 1985, which saw some longlines used again in Bass Strait and school shark targeted again when they were around. This was the period of a considerable bloom in catches. It came to an end at about 1990 and after, apparently due to both, stock lessening and management steps. Gradually, gummy became more important in landings. In mid 1990s, school sharks represented 36% (\$5.6M) of total SSF value (\$15.6M), (Walker, 1995). Most of the catch is sold as flake for human consumption. In the late 1990s, 70 (20-m) boats, over a dozen were "set-up" to catch school shark, the rest targeted gummy shark. One reason for the shift to a more dedicated gummy shark fishing was reduction in the allowable meshsize, which resulted in diminished capture of school sharks. (R.McDonald, private communication).

## **6 - Pupping habitats**

It has been well established that school sharks give birth to pups in coastal, often protected waters between December and March, and that the pups feed and grow in certain inshore and coastal habitats. For example, during the 1960s inshore areas were reclaimed in Corner Inlet, where the last mass catch of school shark pups occurred in 1967-68. Also, the reclamation of nursery areas must have influenced the strength of the cohorts fished 15 to 30 years later. Afterwards, school shark adults and pups have been never caught in dense aggregations in the Inlet. A review of all the pupping areas surveyed by Olsen in the 1940's and 1950's (Olsen, 1954) caught no pups using his methods, although a few were caught. One conclusion of that study was that the pups found on those grounds were too few to support the present, however depleted school-shark population, and that must exist presently unknown other pupping areas, some of them perhaps off open coastline.

The shrinking and other deterioration of the previously rich pupping grounds during the 1960s-70s, might have affected the shark population, while improved management of those areas would most probably promote stock recovery (Prince, 1992; Stevens and West, 1997). The SharkFAG, however, did not take the degradation of pupping grounds into consideration, for lack of "quantitative understanding". Such approach seems unacceptable. Lack of quantification cannot "delete" from reality the consequences of the process of the degradation of nursery areas. All the more that, according to Stevens and West (*loc cit*), "Information suggests that *both* fishing and habitat degradation have dramatically reduced the numbers of new-born and juvenile school sharks". Neglecting an existing and, most probably, very important, although inadequately researched abundance-affecting phenomenon not only perverts essential understanding of the fishery, but also ridicules the however shaky scientific basis for its management.

The works of Prince (1996) and Stevens and West (1997) indicate the direction of the desired research of conditions under which takes place reproduction of sharks. Prince (*loc cit*) described a workshop, which was in my opinion, an example of how fishery, its research and management should be discussed, before the authorities take management steps. It appears that these are the fishermen who can provide so far the best information on pupping seasons and areas. One can learn from the workshop discussions what biological studies are needed to understand the ins and outs of the sharks' life history, especially if also climatic/oceanographic factors are not ignored.

Regulating fishing alone may be quite useless where fishes' habitat is destroyed by reclaiming inshore sea areas, changes in the amount and quality of river flow, pollution from upstream industrial, agricultural, and municipal effluents flowing into the sea, and other anthropogenic factors. Taking care of the many ecosystem functions should become first and highest fishery management priority. Nonetheless, many NGOs and authorities in charge still tend to ignore deterioration and even destruction of habitat in their approach to depletion of fishery resources, and only too often select fishing and fishermen as the only or, at best, the main derelict.

### ***7 - To the question of joint or separate stocks between the Australian and the New Zealand's school shark fisheries.***

The present knowledge indicates that the mixing between the New Zealand's and S.Australian-Tasmanian school sharks populations is sufficient to make them genetically similar, although geographic distribution may lead to certain slight differences. There appears to be a significant mobility between them. The level and character of this mobility, and especially the degree to which it may affect the respective fisheries and their management need further research. While the recovery rate of sharks tagged in New Zealand indicates considerable immigration to Australian waters (Hale, 1999); reverse migration to New Zealand has yet to be assessed. According to Prince (1992) they form a single stock.

Migrations and exchange between the populations should be taken into account in the management of the Australian stock. It seems that the presently employed model, whether it takes into consideration only the school shark immigration to S.Australia, or also the vice-versa, would not be much of use, for inadequate data (Punt, undated). This question remains open, and as long as there is no well funded and well executed research including major tagging effort, and a study of environmental determinants of southern sharks movements & behaviour, the jury would stay out.

Notwithstanding with the results of such studies, joint management of the NZ and the Australian stocks, even if they form, at least in part, one fishery stock (Ward and Gardner, 1997), is politically and economically unrealistic. Therefore, further disputing whether such management is justified appears to be waste of time.

Movement/mixing of school sharks between NZ and Australia are not necessarily either "feeding visits", or "joining the population", as mentioned in one report. Their migrations may be much more complex and need to be studied. For example, scientists in New Zealand believe that cross-Tasmanian migration may be influenced strongly by oceanic conditions, including the ElNino cycle, and availability of prey like squid in the Tasman (M.Francis, private communication). Hence, there may be major inter-annual quantitative and qualitative differences in the movements and distribution of the school shark populations. For better understanding of the whole picture, quantitative/statistical analysis of tag returns is insufficient. The analysis of tags returns must be approached from the points of view of the fish life history, ecology, and the dynamics of their interaction with environment. One must ask questions as to whether the fish spread in the area where the tagging was performed and beyond at random, or either tags are recovered, perhaps seasonally, along defined migration paths, whether some recoveries result from intercepting schooling fish on their way to more distant areas, and what is the effect of local fishing effort on the recoveries (Walker *et al*, 1997). Thus, where and when tags are recovered, as well as how many of them, must be correlated with quite a few other factors.

In the meantime, it seems that tagging of sharks in Australia has been forfeited for being inefficient for stock assessment. From the point of view of people charged with stock-assessment only, it may be so. Nevertheless, tagging, including the use of "hi-tec" tags, remains about the best instrument for studying sharks' migrations and other behavioural traits in space and time.

## **8 - Conclusions and recommendations**

The management strategy of TAC and ITQs is not appropriate for a small-scale fishery based on coastal communities and small fishing harbours that is catching more than a single species distributed over large areas. All the more, when such species is migratory and assumed to belong to a stock shared with other countries with their own management systems. Moreover, the present management of the SSF is based on stock assessment modelling, is not grounded on sufficient evidence, and hence, on adequate science. The TAC/ITQ strategy would most certainly backfire where perceived harmful by the fisherfolk affected.

In view of the obvious need for management of this fishery, however, with the apparent lessening of total catches and for the sake of precaution, management steps must be taken. Such steps should address: (1) the breeders; (2) pups and

juveniles; and (3) breeding and nursery habitats. They may incorporate a rule, agreed on with the fishermen, to release (if practicable) large (over 20 years in age) females that seem to be able to survive if returned to the sea. Additionally, in accordance with the existing knowledge, regions and seasons should be selected where and when no fishing will be performed as to not interfere with breeding, pupping and juvenile sharks grow-out. Any such regulation should be enforced also among sport fishermen.

The managing authorities would be well advised to formulate such input-based management scheme in co-operation with authentic (democratically elected) fishermen representatives, and enact it as a working and realistic alternative to the output management methodology. Initially, the fishery may be required not to exceed the present fishing effort levels. A strategy, supported by the fishing people, would require little enforcement costs, owing to a creation of a social norm among the fishermen to abide by the agreed on rules. One result would be improved reliability of reported data. Such scheme should continue for, say, 5-6 years, during which time research efforts are increased, especially empirical studies (see below), and the fishery is properly monitored. During this period access to this fishery should be closed and enabled only on the basis of one out - one in.

This stage should be accompanied by a research program aimed at determination of areas in which management steps, such as, for example, closed seasons/zones could be applied. Studies may comprise: (1) detailed study of the preferred habitats, food, and physical environmental conditions at successive life stages; (2) direct sampling and underwater observation in inshore habitats; (3) sampling and examination of fish on board commercial fishing boats with special attention to catch composition by species, cohorts, and age/size relation, stomach contents etc., also as related to environmental data collected during fishing; (4) massive tagging using diverse, including hi-tec methods. Such tagging effort must be executed in co-operation with NZ and be large enough to secure massive returns at both ends. The problem of motivation and incentives for tag returning should be investigated by an expert (socio-anthropologist, or the like) and appropriate reward scheme worked out with shark fishermen, as well as with other fishermen whose catches include school sharks often enough. All this, without detracting from Dr.Deriso's (*loc cit*) recommendations 1-5.

Toward the end of such management cum research period, with better data and information base, the continuation or amendment of this strategy could be discussed and decided on.

September, 2002

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## REFERENCES

Annala et al. 1998. Report from the fishery assessment plenary, May 1998: stock assessments and yield estimates. Ministry of Fisheries, Wellington.

Beverton, R.H.J. 1994. The state of fishery science. In: C.W.Voigtlander (Ed.) The State of the World's Fishery Resources- Plenary Sessions. Proc.Wrld Fish.Congr. (Athens, 1992). (Oxford & IBH Publishing Co.Pvt., New Delhi).

Campbell et al. 1991 Management options for the Southern Shark Fishery – an economic analysis. Austral. Bur. Of Agric. and Resource Economics Discussion Pap. 91.12. 43 p.

Deriso, R., undated. A review of the 1966 assessment of school shark in the southern shark fishery. MS

Gulland, J. 1969. Manual of Methods for Fish Stock Assessment: Part 1. Fish Population Analysis. FAO Man.Fish.Sci. (4):154 p., FAO, Rome.

Hale, P.T. 1999. Stock structure of school sharks (*Galeorhinus galeus*) between Australia and New Zealand. (A consultancy report for the Southern Shark and Gillnet Fishermen's Association-SSGFA). 11 pp.

Little, B. , undated. Tope & common skate tagging off the West of Scotland – an update. A press release.

Olsen, A.M. 1954. The biology, migration, and growth rate of the school shark, *Galeorhinus australis* (Macleay) (Carcharhanidae) in southeastern Australian waters. *Res.*, 5:353-410.

Olsen, A.M. 1984. Synopsis of the biological data on the school shark *Galeorhinus australis* (Macleay 1881). *FAO Fish.Synop.*, (139):42 p.

Priback et al. 2000. Shark population modelling simplified. Shark FAG/00/07.

Prince, J.D. 1992. Stock assessment and fisheries management in the southern Australian shark fishery: an independent perspective. SharkFAG Document. 23 p. (Austral.Fish.Managm.Authority, Canberra).

Prince, J.D. 1996 Report on the Southern Shark Fishery Pupping Workshop, August 1994. (Biospherics Pty Ltd.). 54 pp.

Punt, A.E. and T.Walker. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. *Mar. Freshwater Res.*, 1998 (49):719-31.

Punt, A.E. et al. 2000. Stock assessment of school shark, *Galeorhinus galeus*, based on a spatially explicit population dynamics model. *Mar. Freshwater Res.*, 2000 (51):1-16.

Punt, A.E., undated. Some thoughts related to including New Zealand stocks of school shark into the spatially-structure stock assessment. SharkFAG/98/D17.

Punt et al., undated – (a). Data and biological parameter specifications for a spatially-structured stock assessment of school shark. SharkFAG/98/D20-Rev.

SharkFAG. 1999. School shark stock assessment – July 1999. Report to the Southern Shark Fishery Management Advisory Committee.

Southern Shark Fishery Task Force. 1985. Report on future management. (Submitted to the Standing Committee on Fisheries and the Australian Fisheries Council.

Stevens, J.D. and G.J.West. 1997. Investigation of school and gummy shark nursery areas in south eastern Australia. FRDC Project 93/061. (CSIRO & FRDC).

Walker, T.I. 1995. Stock assessment report 1995: school shark. Australian Fisheries Management Authority, Canberra.

Walker T.I. et al. 1997. Southern shark tagging project: Final report to Fisheries Research and Development Corporation. Marine and Freshwater Resources Institute, Queenscliff, Victoria.

Ward, R. and M. Gardner, 1997. Stock structure and species identification of school and gummy sharks in Australasian waters. CSIRO Marine Research, Canberra.