2009 Stock Assessment Report for Elephantfish (*Callorhinchus milii*)

Prepared by the Shark Resource Assessment Group (SharkRAG)

Stock Structure

The elephant fish is distributed from Esperance in Western Australia to Sydney in New South Wales, including Tasmania, at depths to at least 200 m. Elephant fish also occur in New Zealand, but are assumed to be separate genetic stocks from the population in southern Australia. Little is known about stock structure from an assessment and management perspective. Their biology suggests some potential for regional management of stocks. To date Westernport Bay is the only scientifically confirmed egg laying area of elephant fish, although industry accounts suggest egg laying probably also occurs in equivalent habitat around Tasmania.

Biological indicators

Biological productivity:	Medium
Trophic level:	2 (Scale: planktivorous whale shark 1, top predator white shark 5)
Associated species:	School shark, common sawshark, southern sawshark and elephant fish are byproduct
Percentage of gillnet catch targeted:	Negligible
Percentage of otter trawl catch targeted:	Negligible
Suggested environmental drivers:	Not examined

Recent catch history

	2002	2003	2004	2005	2006	2007	2008	2009
Agreed TAC (Global) (t)	83	100	130	130	130	94	94	94
Calculated RBC (t)						94	94	94
Actual Commonwealth TAC (t)								
Actual State TAC (t)								
GHATF catch (t)	40	47	35	36	36	36	45	52*
Trawl catch (SETF & GABTF) (t)	15	23	27	27	45	20	25	31*
Estimated GHATF discards (t)	na	na	na	na	na			7.28
Estimated trawl discards (t)	1	5	6	0	3			
% trawl discards	2	23	24	0	6			
State catch (t)	12	15	9	8	na	na		
Recreational (t)	na	na	na	na	na	na	48	29
Total catch (t)	68	91	77	71		52 +	118+	119+

* 2009 figures incomplete

Elephantfish are taken predominantly by gillnet in inshore and continental waters, although significant quantities are taken by demersal trawl and small quantities by longline. Several other holocephalan species occur on the continental slope and are taken only by trawling. The catches above are elephant fish from fisher logbooks only, whereas for the period 2004-2006 the agreed TACs covered all holocephalans. Since 2007 only elephantfish have been included in the TAC.

The productivity of Elephant Fish is similar to that for Gummy Shark but in contrast to Gummy Shark the adult age classes are selected by the gillnet gear used in the gummy shark fishery. The commercial catch from shark fishing is mostly landed in Victoria (64%) and Tasmania (35%), with some landed in South Australia (1%). Elephantfish have a shallower depth distribution than gummy shark and consequently

recieve substantial protection by the closure of 3 miles off Victoria, all Victorian bays and inlets, the west coast of Tasmania (proposed), Commonwealth Marine Protected Areas, and inshore shark nursery areas of Tasmania. Elephant fish is now an untargeted byproduct species as evidenced by its catch profile reflecting gummy shark fishing intensity rather than its the shallower depth profile, catch levels depend largely on gillnet effort targeted at gummy shark, which is declining towards levels last observed in the early 1970s.

Elephantfish discard rates have not yet been satisfactorily quantified for the GHATF but are likely to be relatively high in regions of the fishery that are more remote from markets, where fishers undertake longer trips. Over the past decade, there appears to have been a rapid increase in the recreational fishing catch of elephantfish from Westernport Bay and from Port Phillip Bay. Dr Terry Walker recently estimated this catch at around 48t per annum for 2007 but there is no information about how the size of recreational catches has changed over time. The recreational catch may decline for the estimated level, however, since the Victorian recreational bag-limit has been reduced from 10 to 3.

Recommended Tier Level

Elephantfish are assessed using the Tier 4 harvest control rule (HCR4) because standardized CPUE data are the primary data available for assessment, and the species is of low value.

2004 Assessment

In 2004 a quantitative synthesis stock assessment was developed with the intention of elephantfish being a Tier 2 species. The 2004 assessment was based on available catch, CPUE, and length-frequency data, and parameter estimates available from gillnet selectivity experiments and from biological studies to determine relationships of egg clutch size–length (linear), maturity–length (ogive), mass–length (allometric), and age–length (Von Bertalanffy). Given the generally low catches off Tasmania (south of latitude 41° South) and South Australia (west of the South Australia–Victoria border), the 2004 assessment was restricted to Bass Strait. The assessment used an age- and sex-based population dynamics model similar to that used for the 1996 assessment of school shark (Punt and Walker 1998). The estimates of stock status and productivity produced were imprecise because of a lack of data on length- and age-composition of the historical catches and insufficient tagging data to adequately estimate fishing and natural mortality rates. Reported catches are likely to be markedly less than the actual catches because some vessels discard elephant fish because of their low price, and reported catch rates have been influenced by occasional targeting and a change of log-book regime, which in the data is associated with a reversal in the probability of zero catches being recorded. The point estimates of current exploitable biomass depletion of elephant fish range 14–22%, with productivity measured by *MSYR* ranging 3–14%. Pup production at the start of 2004 was assessed as 20% (standard deviation ~6%) of its 1950 value.

SharkRAG considers the 2004 quantitative assessment of elephantfish as preliminary because of difficulties in interpreting the catch and effort time series. The selection criteria used to select the catch and effort time series for that assessment were the same as those developed for the gummy shark standardisation. The difficulties in interpreting the data are such that SharkRAG had no confidence that the initial standardization of CPUE in the 2004 assessment reflect actual abundance trends. Elephant fish assessment lacks the time-series of length-frequency and tag release-recapture data available for the gummy shark and school shark assessments and consequently the assessment outputs will reflect almost entirely the uncertain CPUE series. SharkRAG has had the view that an agreed standardization was needed for elephant fish CPUE.

When elephantfish was introduced to the ITQ system in 2002 due to concern that reduced gummy shark TACs, and relaxation of net length restrictions, would encourage targeting SharkRAG recommended setting TACs slightly above the stable long term level of catch, so that discarding thought to be occurring could be landed and the actual level of catch determined. The TAC was initially set at 83t in 2002, but during 2003-2006 various accommodations with the trawl industry were made to recognize trawl catches which up until that time were less well known than gillnet catches. Those accommodations initially increased the TAC to 99.6t for 2003 and then to 130t in 2004 when several species of deeper slope trawl caught holocephalans were incorporated into the TAC. At the end of 2006 the deeper slope holocephalans were removed from the elephantfish TAC and SharkRAG computed an RBC for elephantfish in 2007 of

94t based on " the mean catch during the 4 year period 2002-05 of stable catches and weighted by 1.25% on the basis that only 80% of the quota of a byproduct species is likely to be filled."

During 2007 the revised Tier 4 rules of the time were applied and for the first time a recreational catch of 66t per annum was assumed, RBCs of 88-108t were estimated for 2008 contingent on the alpha value used. As those bracketed the existing TAC, no change was recommended to the TAC.

Assessment Update

During 2008 and 2009 Mrs Rodriguez of BRS has worked with SharkRAG members to develop an agreed CPUE standardization for the gillnet logbook data. Through this process industry members of the RAG have described how higher catch rates of sawshark and elephant fish are expected near but outside or on the edge of gummy shark fishing grounds. They have explained that when fishing effort on gummy shark is high and catch rates are low, catch rates of minor species such as elephantfish rise due to increased targeting of these minor species. Both congestion on gummy fishing grounds, and lower market prices for minor species influence these catch rates. Unfortunately the scale and subtlety of this fishing behaviour relative to the scale at which CPUE data has been historically reported prevent this effect being adequately accounted for in the standardization. Nevertheless, SharkRAG agreed protocols for data cleansing and sub-setting similar to those applied to Saw Shark:

- a number of regions were deleted as less than 5% of total observations of Elephant Fish occurred in those regions;
- a sub-set of data from the 'core fleet' was used. The core fleet being defined as those vessels with an elephantfish catch in a minimum of 10 % of shots;
- differences in fishing practices prior to 1980 were likely to introduce unnecessary noise therefore this data was not included in further analyses.

This data cleansing and sub-setting resulted in 138,018 observations (?%) for use in the CPUE standardisation.

A number of conclusions were drawn from the analysis of the different CPUE standardisations:

- The trend between the standardised and unstandardised CPUE series varied significantly for elephantfish.
- Splitting by region was found to have limited effect so the series which was inclusive of all regions was selected as the base case as it had the most data.
- The standardised CPUE series is highly variable but relatively stable. Overall there has been a decline in standardised CPUE of approximately 20% from 1980 to 2008.
- Vessel was the most important factor in the model.

SharkRAG noted the uncertainties in the assessment surrounding the level of discarding occurring in the fishery and a lack of data on catches and discards from the trawl sector in the earlier years of the series. Industry suggested that discarding practices may have changed in the last few years, with more boats landing the species due to the emergence of markets although these remain limited.

SharkRAG is also concerned that there is no information on changes in the size of recreational catches over time. The recent estimate indicated that recreation catch levels are significant, so that the lack of a time series complicates the application of current Tier 4 rules. If assumed to be a long term feature of the fishery the recreational catch is notionally added to the assessed biomass and subtracted again as the recreational share of the TAC, with little impact on the commercial TAC. If assumed to have commenced in the last couple of years it should be subtracted from the commercial TAC.

Application of the Tier 4 assessment protocol to elephantfish is also somewhat problematic because it is difficult to select a stable reference period for CPUE and catch. SharkRAG agreed that the most recent

reference period (1998-2004) appears most stable and represents the most reliable data. However, if the stock is already depleted below the target level, this would be an undesirable period to select.

The Tier 4 RBC formula was applied to the reference period 1998-2004, resulting in a target catch of 109.7t and an RBC of 122.81 tonnes which should give a TAC of close to 76.71 tonnes when discards, recreational and State catches are taken into account.

Industry members on SharkRAG and observers expressed their concern at the prospect of the elephantfish TAC being reduced. They say they are seeing this low value by-product species increase and that lowering TACs will inevitably drive an increase in discarding.

RBC for 2010/11

122.8t

2009 Stock Assessment Report for Gummy shark (*Mustelus antarcticus*)

Prepared by the Shark Resource Assessment Group (SharkRAG)

Stock Structure

Gummy shark is endemic to southern Australia and harvested by the SESSF from a single genetic stock extending from Bunbury in Western Australia to Jervis Bay in NSW. This single genetic stock is assessed as four separate sub-stocks within the four broad regions on the continental shelf of Bass Strait (BS), Tasmania (Tas), South Australia (SA), and Western Australia (WA). A second genetic stock is located off New South Wales in the region from Newcastle to Clarence River. A third genetic stock (potentially a separate species) is located off Queensland near Townsville (Gardner and Ward 1998; 2002).

For assessment purposes, Tas is defined as the broad region of waters south of latitude 41° South, which is just south of the north coast of Tasmania. BS is the broad region of waters south of the Victoria–NSW border, north of Tas, and east of the South Australia–Victoria border. SA is the broad region of waters between the Western Australia–South Australia border and South Australia–Victoria border. WA is the broad region of waters west of the Western Australia–South Australia border. SharkRAG assesses the BS, Tas and SA sub-stocks and the Western Australia fisheries agency assesses the WA sub-stock.

Biological indicators

Biological productivity:	Medium
Trophic level:	3 (Scale: planktivorous whale shark 1, top predator white shark 5)
Associated species:	School shark, common sawshark, southern sawshark and elephant fish are byproduct
Percentage of gillnet catch targeted:	Most
Percentage of otter trawl catch targeted:	Negligible
Suggested environmental drivers:	Not examined, moon phase & water temperature affect targeting

Recent catch history

	2002	2003	2004	2005	2006	2007	2008	2009
Agreed TAC (Global) (t)	1700	1800	1800	1800	1800	1800	1800	1800
Calculated RBC (t)						1682	1682	
Actual Commonwealth TAC (t)	1606	1700	1698	1717	1708	1701		1717
Actual State TAC (t)	94	100	102	83	83	82		
GHATF catch (t)	1501	1526	1495	1455	1358	1557	1762	*1515
Trawl catch (SETF & GABTF) (t)	67	90	100	171	163	123	132	*127
Estimated GHATF discards (t)	0	0	0	0	0			
Estimated trawl discards (t)	1	13	4	3	10			
% trawl discards	2	15	4	2	6			
State catch (t)	91	87	124	130		?		
Total catch (t)	1659	1716	1723	1759	1531	1680	1892	*1642+

* 2009 figures still incomplete

The above catches are those reported on fisher logbooks. Additional catch was taken off Western Australia outside the SESSF; these were 239, 278, 338, and 337 t during 2002, 2003, 2004, and 2005, respectively.

Historic GHATF discard rates have not been monitored, but are considered to be negligible. Current discard rates are being determined.

From the mid-1920s to the early 1970s gummy shark were mainly taken by the southern shark fishery of southern Australia as a by-product of targeting school shark (*Galeorhinus galeus*) with baited hooks set on demersal longlines. Monofilament gillnets, which are more effective than hooks at catching gummy sharks, were first introduced in 1964, but it was not until the early 1970s that gillnets replaced longlines as the preferred fishing method, and then starting with Bass Strait (BS) gummy shark became the target species. In South Australia (SA) the targeted gummy shark fishery did not develop until the 1980s. Of the total catch of gummy shark from southern Australia, by all fishing methods, during 2002–04, 77% was taken by GHATF, 3% by SETF, 2% by GABTF, 3% by State-licensed vessels in South Australia, Victoria, Tasmania, and New South Wales, and 15% by State-licensed vessels in Western Australia. For management purposes, gummy shark is now the only species of shark recognised as a target species in the GHATF.

The targeted gillnet fishery for gummy shark has two important distinctive features, which strongly influence assessment and management. The first notable feature of the fishery is that the catch is comprised principally of just 4 year classes of sub-adult animals and the adult biomass remains relatively unfished. Secondly, catches remain remarkably stable over wide ranges of effort, in BS since 1973 when the fishery can be considered to have been fully developed effort has ranged from 15 - 54 thousand km.lifts while annual catch has remained between 732 - 1488t per annum, while in SA since 1981 when the gummy shark developed in that region effort has ranged 11 – 45 thousand km.lifts while annual catch has remained between 223 - 680t (Walker & Gason 2009). By way of reference in 2008 the catch and effort reported from BS was 18 thousand km.lifts and 1063t and from SA 17 thousand km.lifts and 498t. This feature of the fishery's dynamic produces a negative relationship between catch rates and effort so that catch rates decline as effort increases and *vice a versa* and during the 1980s when a large portion of the fleet might switch between scallop and shark fishing large inter-annual variations in catch rate were normal. With successive management interventions; net length reductions (1980s), mesh size regulation (1990s) and ITQ management and buy-out (2000s), effort levels in this sector have returned to levels recorded in the 1970s. As a consequence catch rates are returning to levels of that period.

These features of the fishery's dynamics mean that there is no index of adult abundance, and commercial catch rate data provide a poor index of sub-adult abundance for the quantitative stock assessments developed for the fishery (SharkRAG 2000). In contrast the stability of the catch of 4-7 year old sub-adults through a thirty year period of fishing and a four-fold range in effort levels, means that the wide variety of assessment models applied by SharkRAG over the years since its inception in 1994 all estimate that recruitment to the fishery has remained stable at its original level. Consequently SharkRAG members are confident of the current stability of recruitment to this fishery and far less confident of estimates of adult biomass or of pup production derived from the estimates of adult biomass.

Recommended Tier Level

Under the harvest strategy framework for providing advice on the recommended biological catch (RBC) in the SESSF, gummy shark was initially assessed against the Tier 1 harvest control rule (HCR1) because it had previously developed and accepted a quantitative assessment while under the chairmanship of Dr Andre Punt. Prior to the adoption of the harvest strategy framework, objectives for gummy shark have been variously stated by AFMA as stabilising stocks at the 1994 level, stabilising breeding biomass above 40% of initial levels, and stabilising pup production above 40% of initial levels. The new Commonwealth harvest strategy policy is that B_{TARG} should be a proxy of B_{48} to incorporate a 1.2 multiplier effect on B_{MSY} as an economic efficiency factor. SharkRAG has considered estimates of pup production to be the best index of shark abundance and derived estimates of pup production from the modelled estimates of adult biomass and its imputed size composition..

However, this is now being reviewed, as SharkRAG is increasingly conscious that estimates of pup production and the estimates of adult biomass they are derived from are poorly constrained by data. During 2010 and 2011 SharkRAG will be developing a new assessment framework for this fishery.

2006 Assessment

The last quantitative assessment of this fishery was conducted in 2006 assessment using the computer software developed in the ADMB package. The 2006 assessment differed from the 2004 assessment in that an additional 2 years of monitoring data (2004–05) were included. The data included in the 2006 assessment were catches by gear-type (1927–05), catch-rates (1976–05), length-frequency data (1970–04), age-composition data (1986–87, 1990–93) and tagging data (1943–05).

In the 2000, 2004 and 2006 assessments, the values for some parameters (density dependence, natural mortality, and availability) were assumed to be the same for BS and SA whereas other parameters (initial biomass, catchability, and annual recruitment residuals) were estimated separately for each of BS and SA. The 2000 assessment estimated MSYR for BS and then applied that value to SA; in the 2006 assessment MSYR was estimated for each of BS, SA and Tas separately. Unlike previous stock assessments of gummy shark, the 2006 stock assessment explicitly considers the population in Tas (under the assumption that productivity and availability of gummy shark in Tas are the same as those in BS and SA). The results of this assessment were used to apply the Tier 1 rules. Base case trajectories indicated that the 2005 pup production is well above 48% of the 1927 level in Tas, between 40% and 48% for BS, and below 40% for SA. The recommended biological catch (RBC) calculations for 2006 in each zone are summarised as follows.

2006 RBC Calculations

HCR1, as prescribed in 2006, required a quantitative assessment that provides estimates of various levels of biomass (B) and fishing mortality (F) as they relate to the biomass level before fishing began (B_0) and the current biomass (B_{CUR}). For setting the RBC, where $B_{CUR}>B_{40}$ then $F_{TARG} = F_{40}$, where $B_{40}>B_{CUR}>B_{20}$ then $F_{TARG} = F_{40}*(B_{CUR}/B_{20}-1)$, or where $B_{CUR}<B_{20}$ then $F_{TARG} = 0$. Target biomass (B_{40}) is 40% of B_0 and the limit biomass (B_{20}) is 20% of B_0; the RBC should be set at zero if B_{CUR} falls below B_{20}.

Stock targets	BS	SA	Tas	Total
20-48-48	760 t	210 t	234 t	1194 t
20-40-48	870 t	291 t	234 t	1395 t
20-40-40	1016 t	343 t	273 t	1632 t

These RBC estimates did not include 33 t of gummy shark for the GABTF operating off WA and 13 t of gummy shark for the SETF off NSW.

In providing its RBC from the 2006 assessment, SharkRAG used B_{40} referenced against B_{1927} as the primary biological reference point, but adopted pup production as a substitute for biomass. On this basis SharkRAG recommended a global RBC of 1632 t, which is the sum of 1016 t for BS, 343 t for South Australia, and 273 t for Tasmania based on separate assessments for these three regions (Punt et al. 2006). SharkRAG concluded that the RBC calculations from the 2006 assessment were not inconsistent with the 2003–05 TAC of 1800 t and because of the long term positive qualitative indicators being observed recommended continued stability in the TAC at 1800t.

Stock Assessment Update

No new Tier 1 assessments have been developed for this fishery since the 2006 assessment as there have been insufficient resources available to SharkRAG to update the school shark assessment and redevelop a gummy shark assessment concurrently. SharkRAG has begun reviewing the existing gummy shark assessment model and discussing whether an emperically based Harvest Strategy might provide a more cost effective and robust basis for setting TACs in this fishery. A TRF was initiated in December 2009 with the aim of developing a proposed empirical method, and proposing future MSE modelling to support SharkRAG's process.

However, based on Walker & Gason (2009) the long term qualitative stock indicators (effort, catch rates, catch and average carcase weight) have either returned, are trending back to levels last observed when the

fishery first developed in each region, and the gillnet sector's economic indicators are similarly robust (Galleano 2008). In 2008, the last year for which C&E figures are complete, effort was reported at the lower bounds observed since the fishery fully developed in each region; BS 2008: 18 compared to 15 - 54 thousand km.lifts; SA 2008: 17 compared to 11 – 45 thousand km.lifts. Catches were around the average catch observed over the same periods; BS 2008: 1063t, Av. 1973-2008: 1054t; SA 2008: 498t, Av. 1981-2008: 438t. Consequently in 2008 reported catch rates from BS and SA were around the highest levels observed for each region; 57.8 kg/km.lift and 29.2 kg/km.lift respectively, compared to historic average levels of 38.9 kg/km.lift and 19.4 kg/km.lift respectively. While trends in average body weight in SA are complicated by the gradual transition from 8" to 6" mesh which has occurred over these time periods, in BS the fishery where 6" mesh has primarily been used since 1973 and the trends are clearer. Since 1973 to 2006 (the last year for which there is data) male and female body weights have ranged from 5.6 – 3.6 kg, Av.=4.1kg and 7.25 – 3.8 kg, Av= 4.7kg respectively. In 2006 the average body weight was measured at 4.8 and 5.1 kg for males and females respectively.

Without the benefit of a revised Tier 1 assessment SharkRAG is maintaining the position it developed on the basis of the 2006 assessment and its general understanding of this fishery and recommending no change to the current 1800t TAC.

RBC for 20010/11

1800t

2009 Stock Assessment Report for Sawshark (*Pristiophorus spp*)

Prepared by the Shark Resource Assessment Group (SharkRAG)

Stock Structure

Three endemic species of sawshark occur off southern Australia, but their distributions have not been described precisely. Common sawshark (*Pristiophorus cirratus*) is reported to range from Jurien Bay in WA to Eden in NSW, including Tasmania, to depths of 310 m. Southern sawshark (*P. nudipinnis*) is reported to range from the western region of the Great Australian Bight to eastern Gippsland in Victoria, including Tasmania, to depths of 70 m. Eastern sawshark (*Pristiophorus* sp. A) is reported to range from approximately Lakes Entrance in Victoria to Coffs Harbour in NSW at depths of 100–630 m (Last and Stevens 1994). Nothing is known about stock structure of any of these species, although the suspicion is that they do not move long distances so that management and assessment would ideally recognize some degree of regional stock structure.

For assessment purposes, all sawsharks south of the Victoria–NSW border are assumed to be common sawshark and southern sawshark, whereas those north of this border are assumed to be eastern sawshark. Whereas there are sufficient data to undertake stock assessment of common sawshark and southern sawshark combined (Walker and Hudson 2005), there are insufficient data to undertake stock assessment of eastern sawshark.

Biological indicators

Biological productivity:	Medium
Trophic level:	3 (Scale: planktivorous whale shark 1, top predator white shark 5)
Associated species:	School shark, common sawshark, southern sawshark and elephant fish are byproduct
Percentage of gillnet catch targeted:	Negligible
Percentage of otter trawl catch targeted:	Negligible
Suggested environmental drivers:	Not examined

Recent catch history

	2002	2003	2004	2005	2006	2007	2008	2009
Agreed TAC (Global) (t)	362	434	434	434	434	312	312	312
Calculated RBC (t)						312	312	312
Actual Commonwealth TAC (t)								
Actual State TAC (t)								
GHATF catch (t)	167	191	187	173	158	115	130	99*
Trawl catch (SETF & GABTF) (t)	96	126	118	162	172	122	122	127*
Estimated GHATF discards (t)	na	na	na	na	na			
Estimated trawl discards (t)	1	5	3	2	20			
% trawl discards	1	4	3	1	7			
State catch (t)	18	24	29	15				
Total catch (t)	282	436	337	352		237 +	252+	226+

* 2009 figures incomplete

The above catches were reported on fisher logbooks. Sawshark discards from the GHATF are considered

negligible although not sufficiently documented. Additional catch was taken off Western Australia outside the SESSF; these were 4 and 5 t during 2005 and 2006, respectively.

Common and southern sawshark are taken predominantly by gillnet, with significant quantities taken by demersal trawl and small quantities by longline. They are a species of moderate value but gillnet fishermen prefer not to target them because they tangle badly in the net and at high catch rates are laborious to disentangle. Males during the breeding season can spoil more valuable catches in the holds. Of the trawl catch, most is taken by Danish seine off eastern Victoria out of Lakes Entrance on the inner shelf. Eastern sawshark is taken mostly by otter trawl off NSW south of Sydney on the outer shelf. The catch of sawshark from Bass Strait is ~90% of the total catch from southern Australia. The catch grew slowly during 1950–69 and then rapidly during the early-1970s with the rapid phase-in of gillnets of 6-inch mesh-size in Bass Strait. Landings have since fluctuated mainly in the range 200–300 t (carcass mass), but peaked at >400 t in 1995.

Recommended Tier Level

Sawshark have been assessed against the Tier 4 harvest control rule (HCR4) because CPUE data will be the primary data available for assessment and the species are of relatively low value for the fishery.

2004 Assessment

A preliminary quantitative assessment was undertaken 2004 for common sawshark and southern sawshark in waters south of the Victoria–NSW border. Common sawshark and southern sawshark were assessed jointly because reported catches do not distinguish between species (Punt *et al*. 2004). Insufficient data are available for an assessment of eastern sawshark off NSW. The 2004 assessment was based on available catch, CPUE, and length-frequency data and parameter estimates available from gillnet selectivity experiments and from biological studies that determined the relationships between litter size–length (linear), maturity–length (ogive), maternity–length (ogive), mass–length (allometric), and age–length (von Bertalanffy). The 2004 assessment was restricted to Bass Strait, defined as the waters south of the Victoria–NSW border, north of Tasmania, and east of the South Australia–Victoria border. The assessment used an age- and sex-structured population dynamics model similar to that adopted for the 1996 assessment of school shark (Punt and Walker 1998). Estimates of stock status and productivity were imprecise because of a lack of data on length- and age-composition of the historical catches, insufficient tagging data to adequately estimate natural and fishing mortality rates, and lack of species breakdown of the catch. Natural mortality was specified at 0.2 yr^{-1} for fish aged 2+ years and was calculated as part of the assumed density dependent mechanism for the younger fish. The coefficient of variation of the catch rate data was assumed to be 0.3. Point estimates of current depletion of sawshark biomass ranged from 17–39%, with productivity, measured as *MSYR*, ranging 3–23%. Pup production in 2004 was assessed at 32% (using common sawshark parameters) or 26% (using southern sawshark parameters) of the 1950 value.

SharkRAG considers the quantitative 2004 assessment for both common sawshark and southern sawshark as preliminary. Besides combining two dissimilar species, the sawshark assessments lack the time-series of length-frequency and tag release-recapture data available for the gummy shark and school shark assessments. Consequently the sawshark assessment outputs are determined entirely by interpreted trends in CPUE and at the time of the 2004 assessment there was no agreed catch rate trend for the fishery. The 2004 assessment simply used the CPUE trend of the vessels selected for use in the gummy shark assessment. A long running cause for uncertainty regarding sawshark has been that SharkRAG has not had an agreed catch and effort data series for sawshark fishing. Interpretation of the time series is complicated by changes in logbooks and by episodes of opportunistic targeting that occurred in some areas when gummy shark catch rates were low. A crucial apparent decline in raw geometric CPUE occurs abruptly in the mid to late 1990s, and is preceeded by a short-lived doubling in catch rates which clearly cannot be indicative of population abundance. Interpreting this break point in the data is confounded by a change of logbook which is accompanied by a reversal of the probability of zero catches being recorded in the data.

During 2008 and 2009 Mrs Veronica Rodriguez of BRS worked with SharkRAG to develop agreed standardizations for both sawshark and elephant fish. Through discussion with industry it was decided that in addition to the logbook transition some anticipation of catch histories being used to allocate ITQs also

made the data during the period 1992-1996 unreliable and the RAG's decision was to cull these years (1992-1996) of data from the data-set.

When sawshark were introduced to the ITQ system in 2002 due to concern that reduced gummy shark TACs, and relaxation of net length restrictions, would encourage targeting, SharkRAG recommended setting TACs slightly above the stable long term level of catch, so that any discarding that might be occurring could be landed and the actual level of catch determined. The TAC was initially set at 362t in 2002, but in 2003 an accommodation was made with the trawl industry to account for extra trawl catches which up until that time were less well known than gillnet catches and the TAC was set at 434t through until 2006. At the end of 2006 SharkRAG computed an RBC for sawshark for 2007 of 390t based on "the mean catch during the 4 year period 2002-05 of stable catches and weighted by 1.25% on the basis that only 80% of the quota of a byproduct species is likely to be filled." The TAC for 2007 was subsequently set at 312t.

During 2007 the revised Tier 4 rules of the time were applied, RBCs of 282-319t were estimated contingent on the selection of a value for the constant alpha. As these estimates bracketed the existing TAC no change was recommended, therefore that TAC has continued through to 2009/10 while SharkRAG has been developing an agreed CPUE standardization and applying the current Tier 4 rule.

Assessment Update

During 2008 and 2009 SharkRAG worked with Mrs Veronica Rodriguez of BRS to develop an agreed standardization of the sawshark CPUE. Protocols for data cleansing and sub-setting similar to those applied to elephant fish were agreed for sawshark:

- a number of regions were deleted as less than 5% of total observations of sawshark occurred in those regions;
- a sub-set of data from the 'core fleet' was used; the core fleet being defined as those vessels reporting a sawshark catch in a minimum of 10 % of shots;
- differences in fishing practices prior to 1980 were likely to introduce unnecessary noise and so this data was not included in further analysis.

SharkRAG also took the view that the strange hump in the time series data from 1992-1996 should be regarded as an artifact because it is impossible for a stock of this type to double and then halve again within four years, so the temporary variation from the longer term trend cannot be assumed indicative of stock abundance. Consequently data from the years 1992-1996 were excluded from the analysis. This data cleansing and sub-setting resulted in 174,149 observations (?%) for use in the CPUE standardisation. The year 2002 was selected as the reference year for the standardization, rather than 1975 as it was a more stable period of data from the modern GNO1 logbook and therefore more reliable. The trend between the standardised and unstandardised CPUE series did not vary significantly but the standardised CPUE series seemed to be somewhat smoother. The standardised CPUE series for the 2002-2008 reference period seems relatively stable but a slight downward trend is discernable which will require ongoing monitoring. Overall there has been a decline in standardised CPUE of approximately 50% from 1980 to 2008.

A new Tier 4 assessment framework was developed and with the standardized CPUE time series used to compute the RBC for sawshark. The period 2002-2008 was selected as the reference period in the Tier 4 assessment. SharkRAG considered this reference period a stable equilibrium in terms of CPUE, catches and the status of the resource. The choice of this reference period results in a catch target of 391.4t. The RBC calculated using the 2002-2008 reference period is 369.6 tonnes.

RBC for 20010/11

369.6 t

2009 Stock Assessment Report for School shark (*Galeorhinus galeus*)

Prepared by the Shark Resource Assessment Group (SharkRAG)

Stock Structure

School shark is distributed around southern Australia mainly on the continental shelf and upper slope where they have been recorded from Moreton Bay (southern Queensland) to Perth (Western Australia), including Tasmania. They have been taken from the near shore zone to 550 m depth, mainly near the bottom, but at times occur in the pelagic zone and well offshore. Genetic studies suggest there are six genetically isolated populations of school shark around the world. Tag studies provide evidence of some mixing between southern Australia and New Zealand, but genetic studies suggest these populations are not inter-breeding. The behaviour of SharkRAG's assessment models supports the existence of some regional stock structure SharkRAG's agreed assessment model assumes two stocks because insufficient data exist to support more complex stock structures.

Biological indicators

Biological productivity:	Low
Trophic level:	4 (Scale: planktivorous whale shark 1, top predator white shark 5)
Associated species:	School shark is taken as a byproduct when targeting gummy shark with gillnets, and of trawling and longline fishing.
Percentage of gillnet catch targeted:	Low
Percentage of otter trawl catch targeted:	Negligible
Suggested environmental drivers:	Not examined. Moon phase & water temp. affect catch rates.

Recent catch history

	2002	2003	2004	2005	2006	2007	2008	2009
Agreed TAC (Global) (t)	327.0	309.6	292.2	274.8	257.4	240	240	240
Calculated RBC (t)						0	0	0
Actual Commonwealth TAC (t)	289.4	273	327	243	228	213	240	240
Actual State TAC (t)	37.6	35.6	na	na	29.4	27.7		
GHATF catch (t)	195	193	174	199	209	196	234	*238
Trawl catch (SETF & GABTF) (t)	16	13	14	10	27	12	13	*18
Estimated GHATF discards (t)	na	na	na	na	na			
Estimated trawl discards (t)	0	0	0	1	2			
% trawl discards	0	1	1	17	4			
State catch (t)	21	14	13	15	na	?		
Total catch (t)	211	206	188	211	238	208 +	247+	*256+

* 2009 figures still incomplete

The above catches are those reported on fisher logbooks. Additional catch was taken off Western Australia outside the SESSF; these were 11, 18, 17, 15, 4, 9 and 13 t during 2002-2008, respectively. GHATF discard rates have not been monitored, but are considered to be low for the gillnet sector.

In contrast to the gummy shark, if fisheries management were to permit, school sharks can be targeted throughout their life-cycle with hooks and gillnets. From the mid-1920s to the early 1970s, school shark was targeted by demersal longline in southern Australia, and gummy shark (*Mustelus antarcticus*) was

taken mostly as byproduct. Catches from the SESSF are thought to have peaked around 2500t per annum during the 1960s before declining and then rising to another peak of around 2000t per annum in the late 1980s. Monofilament gillnets, which are more effective than the shark longlines at catching gummy sharks, were introduced first in 1964, but it was not until the early 1970s that gillnets replaced longlines as the preferred fishing method. This change was in part caused by a ban on the sale of large school shark during 1972–85 in Victoria because the mercury content of the meat exceeded the former health standard (subsequently revised upwards). With the adoption of gillnets the core of the GHATF through Bass Strait effectively became a small mesh (6-6.5 inch) fishery for gummy shark which only opportunistically targeted school shark. At the margins of the GHATF in western SA and southwestern Tasmania where local stocks were less depleted the targeting of school shark persisted with larger mesh sizes (7-8 inch) until smaller mesh sizes (6-6.5 inch) were regulated throughout the fishery in 1997, and the ITQ system was implement in 2001 with a 350t TAC.

SharkRAG's assessments have consistently estimated that the school shark population is below 20% of pristine levels, and given the low productivity of the species is likely to remain below the threshold reference point for some years so the RBC for this species will remain zero for many years. The species is however unavoidably taken by the other sectors of the SESSF. SharkRAG's recommendation in 2001 was to step the initial 350t TAC down to the level estimated to be the unavoidable incidental catch of the gummy shark fishery (240t) over 5 years. The management measures implemented by AFMA since the mid-1990s has aimed to stop all targeting of school shark and has reduced school shark catches from around 800t per annum in the mid-1990s to the current level of around 200t, within a 240t TAC. School shark is now mostly taken as byproduct when targeting gummy shark. Extensive closures to gillnetting have also been implemented since 2000 closing areas in Spencer Gulf, St Vincents Gulf, the head of the Great Australian Bight and west coast of Tasmania which were historically used to target adult school sharks. Those areas complemented pre-existing closures to shark fishing within 3 miles off Victoria and inside all Victorian bays and inlets, and the inshore nursery areas of Tasmania which have been in place since the 1980s. Further closures were implemented in 2007 outside 183 m to shark gillnets and shark longlines and inside 183 m to auto-longliners were also aimed at reducing the bycatch of long lived mature age classes of school shark. Further closures of 4nm around around 150+ SA islands aimed primarily at reducing interactions with Australian sea-lions will also close >100 sq. nm of shallow water where adult school sharks were formerly targeted seasonally, while the recent closure of the small mesh scalefish fishery in Corner Inlet in Victoria will also provide further protection to a formerly important school shark pupping area.

Recommended Tier Level

School shark is assessed against the Tier 1 harvest control rule (HCR1).

Previous Assessments

There is a long history to school shark stock assessment in southeastern Australia. In the 1950s Olsen used life history (Olsen 1954) and catch and effort data (Olsene 1959) to describe the collapse of the fishery in Bass Strait and off eastern Tasmania. During the 1960s and 1970s, assessment models were based on yield per recruit models (Kesteven 1966, Walker 1970, Grant et al. 1979) the Holden model (Harrison 1970), and the Schaefer model during the 1980s (Walker 1986). These provided less certain results probably because the fishery was assumed to be comprised of a single stock and catches and catch rates were increasing during that period with the introduction of mono-filament gillnets and the expansion of fishing grounds in remote GAB and south western Tasmanian waters. A succession of eight scientific workshops on school shark stock assessment held during 1983–91 drew progressively more pessimistic conclusions. The third workshop in 1986 recommended that fishing effort be reduced to the 1982 level and, in 1991, it was recommended that the catch be reduced to 550t. Sex- and age-based models that integrated catch and effort data with demographic and gear selectivity parameters emerged during the early 1990s, these treated the school shark resource off southern Australia as a single stock (Sluczanowski 1991; Prince 1992) or eight spatially separate stocks (Prince 1992). SharkRAG produced its first assessments for school shark in 1995. Those assessments were based on Schaefer (Xiao 1995a) and delay-difference models (Walker 1995); both models used standardised CPUE (Xiao 1995b) and were applied in a risk framework. The 1996 assessment used an age- and sex based model that incorporated the peculiarities of shark biology and shark fisheries,

including the pupping process and the selectivity characteristics of the gear. The model considered sharks aged 0–60 years, allowed for age-specific natural mortality, and density-dependent natural mortality for those aged 0 years (neonates or pups). Estimates were determined using a Bayesian approach with prior distributions for virgin biomass, MSYR (productivity), and annual pup survival (Punt and Walker 1998). Dr Richard Deriso of the Inter-American Tropical Tuna Commission reviewed this assessment and while agreeing with its results made a number of recommendations which incorporated into the 1999 assessment.

In 1998 SharkRAG called for fishery independent surveys for the shark fishery on the basis that ITQ management and low TACs would debase targeted commercial catch rates as an index of abundance. In its 1999 assessment SharkRAG incorporated Deriso's comments and extended the model used for the 1996 assessment to produce a spatially structured model which assumes two separate stocks. This assessment made use of tag release-recapture data, primarily to estimate rates of movement among regions (Punt et al. 2000a). The 1999 assessment estimated that pup production at the start of 1999, expressed as the number of births in 1999 as a percentage of the number of births in 1927 when the fishery began, was in the range of 9–14% of the pristine level. In 2001 the 1999 school shark assessment was updated with current data and a range of other assumptions modified to reflect new data, including assuming a level of tagging mortality occurred during the tagging studies. While estimates of the relative level of depletion remained similar these later analyses reduced estimates of the species intrinsic productivity from 7-9% down to 3-9% and so produced more pessimistic estimates of the stock's ability to recover, even with the cessation of all fishing. SharkRAG's analysis of the 2001 assessment revealed that since 1998 when small mesh sizes were implemented by management to prevent targeting, catch rates had fallen below levels the model expectation for targeted fishing. This cause the 2001 assessment to estimate the intrinsic productivity of school shark (reproductive capacity) to be lower than the level expected on the basis of school shark biology. In 2004-05 the 1999 assessment was updated with catch data but only fitted to catch rates up until 1997 the 2004-05 assessment's estimates remained similar to those of the 2001 assessment.

In response to the 2005 Ministerial directive SharkRAG developed and implemented Fishery Independent Surveys for school shark stocks during 2007/2008, and developed a Draft School Shark Rebuilding Strategy. The recovery plan agreed during 2008 for school shark requires AFMA to use SharkRAG's 2009 school shark assessment to plan a recovery trajectory and develop a graduated response in case management fails to achieve the planned recovery trajectory.

Stock Assessment Update

During 2008 Dr Robin Thomson (CSIRO, Hobart) joined SharkRAG and revised the 1999 assessment framework, incorporating updated data and overhauling the data analysis software, migrating this to the R programming language and identifying some errors. During 2008 and 2009 SharkRAG has worked with Dr Thomson to finalize an updated school shark assessment. The most significant advances to previous assessments have been that the analysed data from the Fishery Independent Survey became available during 2009 and have been incorporated, and a standardization of CPUE data collected between 1998 and 2008 has been developed by Dr Malcolm Haddon (CSIRO) and incorporated. The previous assessments used a standardization of CPUE data based on vessels selected because they targeted school shark, this standardization procedure has been invalid since 1998 when management regulations were implemented to prevent targeting. In the 2009 assessment the original CPUE standardization is retained up until 1997 as a time series indexing targeted catch rates, and the new standardization is incorporated as a separate time series beginning in 1998 of standardized untargeted catch rates. However, given the small amounts of catch being made under recent low TACs and high levels of variation present in the data there are no real trends in the 1998-2008 standardizations from SharkRAG's regions of Central and Eastern South Australia and from Eastern South Australia. In Western South Australia and Western Bass Strait there was the appearance of some increases in catch rates in more recent years. However, in the context of the longer time series and the long lived nature of school shark these increases remain minor.

The results of the 2009 assessment are consistent with SharkRAG's previous assessments. The current biomass is estimated to be between 8-17% of pristine levels, well below the threshold reference point of 20%. However for the first time the assessment clearly suggests that adult biomass levels have been stabilized by the management measures implemented since the 1990s. Most sensitivity tests suggested that the school shark resource is recovering at present catch levels, but some indicated that it is still in decline.

However, given the long-lived nature of the species and the low levels of data now being gathered it is not yet possible to determine whether a rebuild has commenced.

The 2009 assessment's estimate of the stock's intrinsic productivity (MSYR) remains highly uncertain and very low, around 2%. Based on school shark biology SharkRAG's expectation is that it should be around 6-10%, compared to gummy shark which is estimated at around 17%. Within the context of the Draft School Shark Rebuilding Strategy this low and uncertain estimate of productivity has major implications. The default rate of rebuild suggested in the Commonwealth Harvest Strategy Policy is that the rebuild back to the threshold reference point (20% of pristine), and from the threshold reference point to the default target reference point (40%), should each occur within one generation and 10 years, which SharkRAG computes to be 32 years for school shark. If south eastern Australian stocks of school shark really are as unproductive as currently estimated the MSY for these stocks will be produced from the stock at 49% of pristine levels and is only 525t per annum. In this case, in order to rebuild the stock back to 20% or pristine pup production within 32 years catches of 26t or less are required, and the stock cannot be rebuilt from 20 to 40% of pristine within 32 years even if catches could be reduced to zero.

In order to formulate its advice on catch levels SharkRAG requested advice from Drs Neil Klaer and Malcolm Haddon of CSIRO on the distribution of catches across the fishery with the aim of determining the extent to which targeting might still be occurring and so the potential for reducing fishing mortality further with TAC reductions. In 2008 Dr Klaer presented an analysis to SESSRAG of all SESSF species, which on the basis of the species composition reported in shot data across multiple years estimated that 35% of the school shark catch might be targeted. This finding however needs to be understood within the context of Dr Haddon's more recent and detailed analysis of recent logbook data. Dr Haddon's analysis showed that across the last five years the six fishers who caught the most school shark in each year accounted for an average of 45% of all school shark taken in the GHAT fishery. An examination of the relative catches of school shark and gummy shark by individual fishers indicates that some fishers, especially the top six in each year, are often taking either more school shark than gummy shark or else almost as much school shark as gummy (i.e. a mean ratio $\geq$1.0). On the other hand up to 90% of fishers are only taking relatively small amounts of school shark each year, with an average of 41% taking less than one tonne in the last five years and an average of 70% taking less than three tonnes; it would be very difficult to reduce their catch any further. These relatively low catching fishers have a skewed ratio of school shark to gummy shark with a median ratio of 0.175, and a mean ratio of about 0.4. Given a need to reduce the catch/ kill of school shark it needs to be recognized that a simple reduction in the TAC is unlikely to reduce fishing mortality. Those few operators with access to large enough quota parcels to continue fishing in areas at times likely to make large catches will be cut back to some extent but are likely to still retain enough quota to continue current fishing practices, while the majority of operators with small quota packages who are already successfully avoiding school shark are likely to be forced to start discarding. On balance SharkRAG considers further TAC reductions alone are likely to start driving discarding, which while giving the appearance of a successful outcome in terms of landed catch will not do enough to reduce fishing mortality.

SharkRAG is strongly of the view that alternative mechanisms should be examined that would encourage the GHAT fishers to avoid catching their available quota. If those fishers who catch a relatively high proportion of the school shark catch can be identified and encouraged to avoid taking school sharks the desired cut in fishing mortality (and catch) might be achieved without driving discarding and withput disadvantaging those fishers who are currently successfully working with low levels of quota and avoiding school shark. A set of criteria that could be used to identify those fishers who are less successful at avoiding school shark could be an annual catch of more than five tonnes of school shark and a ratio of school shark catches to gummy shark catches of more than 0.5.

SharkRAG members discussed a range of management measures that could be investigated and developed by SEMAC, AFMA and the new Shark Fishers Association, Sustainable Shark Fishing Incorporated:

Gear Modification:

- Regulate for 6"mesh and 30 micron ply. This should reduce the potential for adult school shark being meshed and make it easier for them to break free should they contact a net.

- Reduce slinging ratios to reduce the entanglement of large school sharks.

Management:

- No allowance for undercatch on school shark TAC so that unfilled quota cannot be carried across years.
- Provide a rebate on levies for unfilled school shark quota so that unfilled quota attract no levy fees
- Develop a mechanism which allows quota holders to permanently convert school shark quota they are holding into gummy shark quota.
- Flexible limitations on school shark landings over some period of time (monthly/seasonal) based on the ratio of school shark to gummy shark.

Industry:

- Develop industry association and begin communicating with, and educating members about the way continued large catches of school shark by a few operators is placing the more valuable gummy shark TAC in jeopardy.
- Develop a code of conduct with 'Move on' clauses to prevent shooting back when a high school shark catch rate has been observed, slinging ratios to reduce the entanglement of large school sharks, and low target ratios of SS:GS in the catch.
- Work with SharkRAG to develop a research plan targeted at key information gaps.

RBC for 2009/10

The stock remains well below the Limit Reference Point of 20% so the RBC is zero.

SharkRAG recommends reducing the catch of school shark further through a range of non-TAC measures that target the few operators recording a ratio of school shark to gummy shark catch of more than 0.5.