Background Paper
The Fish and Fisheries of Stokes Inlet

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Introduction
Stokes Inlet is a valuable asset and a management plan is being developed to ensure that the recreational and environmental values are maintained into the future. A community survey on the values of Stokes Inlet revealed that fishing was the main recreational activity undertaken by visitors along with camping, bushwalking and general sightseeing. A clear message arising from the survey was that people wanted to preserve the Inlet in its current condition and were concerned about changes that might arise from various recreational and commercial activities undertaken in the area.

Background
As fishing is the main activity undertaken in the inlet, the diversity of fish species and the status of fish stocks are major issues that will need to be considered in the development of a management plan. The community survey raised several questions about the management of fishing and sought information on the compilation of fish populations and other factors that may influence the diversity and abundance of fish stocks in the inlet.
The papers and information set out below seeks to provide answers to those questions.

Stokes Inlet Fish & Fisheries

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Stokes Inlet Fish & Fisheries
Currently, the main sources of information on the fish stocks in Stokes Inlet are:

- Commercial catch and effort statistics since 1975 (submission of monthly summaries of catch and effort to DoF are compulsory for commercial fishers).
- DoF survey of recreational angling in 2002/3.
- DoF survey of recreational netting in 200?
- Fishery-independent sampling by Murdoch University from 2002 to 2004 (Hoeksema *et al.* 2006).

In future, the DoF recreational fisher logbook program may also provide data, but this program is yet to be extended to this estuary.

Fishery-independent sampling by Hoeksema *et al.* (2006) caught a total of only 12 fish species in Stokes Inlet. The 'shallow water community' was dominated by small-bodied species (mainly hardyheads (Atheriniidae) and gobies (Gobiidae)), but also included a significant quantity of black bream (*Acanthopagrus butcheri*) (21% of biomass). The 'deep water community' was dominated by black bream (96% of biomass).

Commercial and recreational fishery data is consistent with these findings and suggests that the fish community in Stokes Inlet is relatively depauperate (low abundance and diversity). The dominance of black bream is reflected in the composition of commercial and recreational fishery landings (bream are typically between 90-100% of annual landings).

Commercial fishery

Stokes Inlet has been commercially fished at a significant level since the mid-1970s. Since 1975, total annual commercial landings in Stokes Inlet have varied between 0 and 31,303 kg (Fig. 1). Zero landings were reported each year from 1991 to 1998. From 1999 to 2006, the total annual commercial catch varied from 1,264 to 18,433 kg.

Since 1975, a total of 19 finfish species and 2 invertebrate species (blue swimmer crabs and mussels) have been reported in commercial fishery landings from Stokes Inlet. However, the vast majority (usually 80-100%) of annual landings were black bream. Black bream is sold for human consumption. Most recently, from 1999 to 2006, the catch mainly comprised black bream (95%), with minor quantities of tarwhine (silver bream), sea mullet, yellow-eye mullet and 10 other finfish species (Table 1).

From 1999 to 2006, between 4 and 8 fishers have fished in the inlet each year. Collectively, these fishers spent between 190 and 433 fishing days per year in Stokes Inlet. NOTE: a 'fishing day' includes searching and other activities that are not actively fishing. Over this period, all commercial fishing occurred from May to November only (the estuary is closed to commercial fishing from December to April). In some years, fishing did not occur in all of these months – for example, in 2005 no fishing was reported in June or October. In Stokes Inlet, the annual commercial catch of black bream, the main target species, and the effort expended to catch it varies considerably.

The only commercial fishing method used in Stokes Inlet is gill netting. The nets used in the inlet in recent years have been a maximum of 1500m in length. The mesh size and methods of deployment make these nets highly selective for the target species. This also tends to exclude bycatch of undersized fish and non-target species.

The commercial catch rate (kg/day) provides an index of bream abundance. From 1999 to 2001, the catch rate increased, then declined gradually until 2005, then increased slightly in 2006 (Fig. 2). These trends probably reflect the abundance (or the catchability) of bream in the inlet. Overall, commercial catch data suggest that

black bream have been relatively abundant in the inlet in recent years, but that bream abundance has fluctuated considerably over the longer term.

Commercial landings of other species in Stokes Inlet are very low and are extremely variable. Apart from black bream, the commercially landed species are marine types that enter the inlet when the sand bar is open and occur most abundantly in landings during/immediately after openings. While the presence/absence of these fish does give some insight into water quality (salinity, oxygen, etc) in the inlet, the catch rates of these species in the inlet are of negligible use in assessing their stock status. Annual data collected elsewhere by the DoF is used to assess the widespread marine stocks of these species.

Recreational fishery

The most recent estimates of recreational fishery catch and effort levels in Stokes Inlet were obtained during a DoF creel survey of south coast estuaries, which ran from December 2002 to November 2003 (Smallwood and Sumner 2007*)*. Interviews with boat and shore-based fishers were conducted between 7am and 6:30pm (winter) or 8pm (summer). Hence, night-time landings were not assessed, but these are probably quite low regardless. Recreational netting catch and effort levels was not assessed in this survey because they were estimated recently by separate DoF survey. Netting catches were estimated to be negligible.

Overall, Stokes Inlet accounted for approximately 1% of the effort and 2% of the total south coast catch by recreational anglers across the 17 estuaries that were surveyed.

Of the 104 interviews conducted at Stokes Inlet in this survey, 72% were shore-based groups (all involved in recreational fishing). The majority of boat-based groups (93%) were involved in recreational fishing and the remaining 7% were participating in other activities. Camping is available at Stokes Inlet and 40 interviews were undertaken with groups who had been fishing and were staying for an extended period at this location. The majority of shore-based groups interviewed fishing at Stokes Inlet were from the local postcode area (40%), followed by interstate/overseas (32%). Boat-based groups were mainly from regional WA (57%).

The total effort for Stokes Inlet during this 12-month survey was estimated at 3,441 fisher hours (1,286 fisher days). The highest boat-based effort occurred in summer while the highest shore-based effort occurred in autumn. Total annual effort expended by boat-based fishers was higher than by shore-based fishers.

Both shore and boat-based recreational fishers in Stokes Inlet were primarily targeting black bream during the survey period. The only other species targeted were King George whiting and ‘unspecified bottom fish’ by shore-based groups, and blue swimmer crabs by boat-based groups.

Shore and boat-based recreational fishers caught three fish species (black bream, tarwhine, southern blue-spotted flathead) at Stokes Inlet during the survey period. Both groups mainly caught black bream (99% of catch). Boat-based fishers caught 75% of the total black bream catch. The total retained recreational catch of black bream in Stokes Inlet during the survey period was estimated to be 5,533 fish or 2,103 kg.

By comparison, the commercial catch of black bream in the inlet over the same period as the recreational survey was 17,714 kg, which comprised 99% of the total commercial catch. Commercial fishers also reported minor quantities of four other species (sea mullet, yellow-eye mullet, tarwhine, flathead) in this period.

During the 2002/3 survey, 62% of all black bream landed by boat-based fisher, and 65% by shore-based fishers, were released in Stokes Inlet. With the recent introduction of new bag and size limits for the South Coast region, it is possible that these proportions are now even higher.

Hoeksema *et al.* (2006) found that black bream in Stokes Inlet grew relatively slowly and attained a relatively small maximum size. In fact, a large proportion of the mature fish in this estuary appear to be below the legal minimum length (250 mm) and would need to be released if caught. This is consistent with the results of the creel survey in that most bream caught in the inlet were released. The survival rates of released black bream are probably relatively high but, nonetheless, the potential mortality of released fish must be considered when evaluating the impact of fishing in the inlet.

The 2002/3 creel survey indicated that most recreational fishers in south coast estuaries had a reasonable knowledge of the bag and size limits for the species they were targeting or the predominant species they had caught. Recreational shore-based and boat-based fishers correctly identified the bag limit during 60% and 78% of interviews, respectively. The size limits of species were correctly identified by 71% of shore-based and 90% of boat-based groups.

Summary

All available data suggests that the fish community in Stokes Inlet, which is infrequently open to the sea, is relatively depauperate (i.e. low number of species and low abundance) compared to other south coast estuaries that are annually or permanently open. The data also suggest that fish abundance and community composition in the inlet varies annually, as a result of variable environmental conditions.

Black bream comprises a discrete, self-recruiting stock in Stokes Inlet and is the primary fishery target species in this estuary. Fishing pressure in the inlet has the potential to directly affect the size and structure of this stock, although environmental factors are likely to be at least as significant as fishing. Available evidence suggests that salinity (which is a function of river flow, rainfall and sand bar openings) may be a particularly important factor controlling recruitment success and stock size of black bream.

The abundances of fishery target species other than black bream are generally very low in the inlet. The abundances of these species are almost entirely determined by environmental factors inside and outside the inlet, rather than fishing.

The relative impacts of commercial and recreational fishing on the bream stock are difficult to gauge. In the period of the 2002/3 creel survey, the recreational catch was about 12% of the total. However, in other years, it is possible that the recreational

catch share is significantly higher than this. Additionally, as mentioned above, recreational fishers release large numbers of bream in the estuary and post-release mortality (currently unknown) needs to be factored into the recreational fishing impact.

There seems to be a public perception that the quality of recreational fishing would improve if commercial fishers were excluded from the estuary. Perceived improvements include higher catch rates and the availability of larger fish for recreational fishers. However, the slow growth rate and small maximum size of bream in this estuary suggests that removal of commercial fishing not would not lead to a significant increase in the availability of large fish. Indeed, it could even lead to further reductions in growth rate and average size, due to density-dependent effects.

Options for ongoing monitoring

Fishery-independent surveys, such as that by Hoeksema *et al.* (2006), provide comprehensive data on the composition and status of fish communities. It is desirable to undertake such surveys occasionally. However, the high cost of these surveys (relative to fishery-dependent data) means that it is not feasible for the Government to undertake them annually. Nor are such surveys necessarily required on an annual basis.

Commercial and recreational fisheries provide annual data about a component of the total fish community (i.e. captured species) and the fishery catch levels can provide a reasonable index of abundance for these species. Fishery catch data does not directly inform about the status of non-captured species. However, the catch composition (species diversity and abundance) does provide an annual index by which the condition or 'health' of the environment can be monitored, and from this the status of the broader fish community can be inferred. The similarity of fishery data to recent fishery-independent data in Stokes Inlet (i.e. both indicate a very depauperate fish community and an overwhelming dominance of black bream) demonstrates the validity of fishery-based monitoring.

Cost-effective long-term monitoring would be best performed with the following suite of tools :

- occasional fishery-independent surveys,
- commercial catch and effort monthly returns,
- daily recreational fisher logbooks (these offer detailed data because fishers record both the retained and discarded catch),
- occasional creel surveys.

References

C.B. Smallwood & N.R. Sumner. 2007. *A 12-month survey of recreational estuarine fishing in the South Coast bioregion of Western Australia during 2002/03*, Fisheries Research Report No. 159, Department of Fisheries, Western Australia, 56p.

Hoeksema SD, Chuwen BM, Hesp SA, Hall NG, & Potter IC. 2006. *The impact of environmental changes on the fish faunas of Western Australian south-coast estuaries.* FRDC Project No 2002/0-017. Final Report.

Table 1. Proportions of all species in commercial fishery landings in Stokes Inlet from 1999 to 2006.

Common name	Species	%
Black bream	*Acanthopagrus butcheri*	95.44
Tarwhine	*Rhabdosargus sarba*	1.66
Sea mullet	*Mugil cephalus*	1.65
Yellow-eye mullet	*Aldrichetta forsteri*	0.60
Flathead	Platycephalus spp.	0.20
Western australian salmon	*Arripis truttaceus??*	0.13
Blue swimmer crab		0.12
Tailor	*Pomatomus saltatrix*	0.10
Other fish		0.04
Cobbler	*Cnidoglanis macrocephalus*	0.03
Groper, wrasse	Labridae	0.01
Trevally	*Pseudocaranx* spp.	0.01
Australian herring	*Arripis georgianus*	0.00
Flounder, sole		0.00
Mulloway	Argyro???	0.00
Grand Total		100

Figure 1. Annual landings of black bream and other species by commercial fishers in Stokes Inlet, 1977 to 2006.

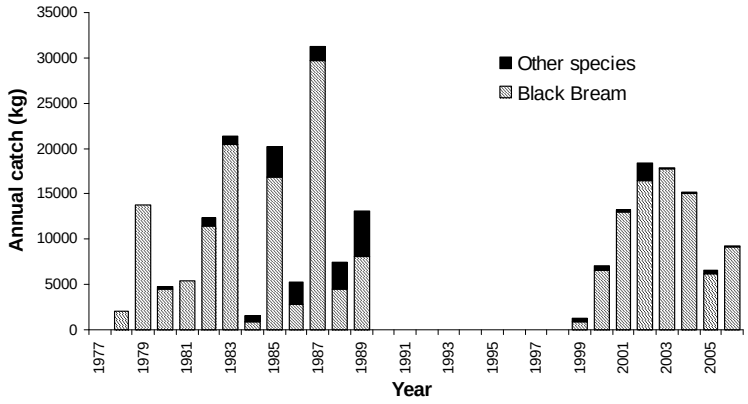
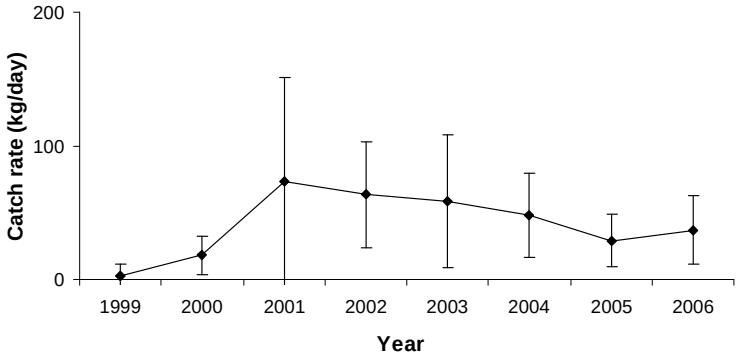


Figure 2. Mean annual catch rate (± s.d.) of black bream by commercial fishers in Stokes Inlet, 1999 to 2006.



Fisheries Management

Commercial Fishery

Stokes Inlet is part of the South Coast Estuarine Managed Fishery (SCEF). This fishery includes all estuaries, rivers, streams and tributaries on the south coast between Cape Beaufort and the SA border. Licensees in the SCEF are permitted to fish in thirteen of these estuaries (including Stokes). Commercial fishing is strictly regulated and the *South Coast Estuarine Managed Fishery Management Plan* (The Plan) is the management framework for this fishery. In addition to The Plan there are also restrictions such as minimum size limits and fishing prohibitions that are set out in *Fish Resources Management Act* (FRMA) and subsidiary legislation to which authorisation holders must adhere. A summary of management arrangements in place relating to commercial fishing in Stokes Inlet are;

- There are 25 units licensed to fish in the fishery. All or any of the licensees can fish in Stokes Inlet but historically only 4 licensees have regularly fished there.
- Generally commercial fishers camp in the camping ground when fishing the inlet.
- There is no zoning in the fishery and authorised fishing units can operate in any of the thirteen estuaries except the Beaufort Inlet which is restricted to three fishing units per year.
- Licensees can net in Stokes Inlet between the 1st of May and the 1st of December each year.
- Netting is permitted only at night (ie 1½ hours before sunset to 2 hours after sunrise) in all waters of the inlet excluding waters of the Young and Lort rivers upstream from the bridges that cross those rivers at the South Coast Highway.
- Nets can be either a set net, ring net, haul net or seine net.
- Up to 6 set nets totalling a maximum of 1500 metres may be set.
- Haul, ring and seine nets can not exceed 500 metres in length.
- Commercial fishing (including netting) is closed on weekends and public holidays in the SCEF
- Licensees can fish in Stokes Inlet using fishing methods other than nets all year round but this is rarely if ever done as the target species is Black Bream using set nets.
- There is no “quota’ for fish in this fishery however licensees must adhere to size limits and have larger size limits than recreational fishers for some species.
- The majority of the fish caught commercially in Stokes Inlet (95%+) is consigned to the Metropolitan Fish Markets for sale by auction. A small proportion is sold to local retail outlets.

Recreational Fishing

Black Bream is the main species caught by recreational fishers in Stokes Inlet. Black Bream have a minimum legal size of 250mm and recreational fishers have a daily bag limit of 8 per person. The daily bag limit of 8 forms part of the category two mixed daily bag limit of 16. This means that a person can only have a total of 16 category 2

listed fish. For example if a person already had 8 flathead and 4 salmon then they would only be allowed 4 Black Bream to remain within the category 2 limit of 16. This is rarely an issue in Stokes Inlet as Black Bream is the main species caught.

Recreational fishers can use set nets in Stokes Inlet between 4pm and 9 pm on Friday and Saturday nights only from the 1st of May to the 31st of October each year. Recreational netters must attend their nets and the nets have to checked and cleaned at least once every hour. Set nets can be no longer than 60 metres, can have a "drop" of no more than 25 meshes and the mesh must not measure less than 63 mm or more than 87mm.

Recreational fishers cannot use a haul or seine net in Stokes Inlet.

There is no formal allocation process for the sharing of finfish between user groups at present, however this is planned with the development of Integrated Fisheries Management (IFM). An allocation process through IFM is still a way off for this fishery and in the interim allocation is controlled by seasonal closures, bag limits and size limits.

Aboriginal Fishing Strategy
The Draft Aboriginal Fishing Strategy was developed, and released for public comment in May 2003. The draft strategy's recommendations were developed by the Aboriginal Fishing Strategy Working Group, chaired by Hon E.M. Franklyn QC. Following an extended period of public consultation, the final strategy is before the Minister for Fisheries for his consideration.

The Aboriginal Fishing Strategy is looking at how Aboriginal and Torres Strait Islander people can:

- Be involved in making rules about fishing for food and cultural reasons, and
- Be involved in commercial fishing, aquaculture and fishing eco-tourism whilst making sure there will be fish for the future.

The Aboriginal Fishing Strategy is about fishing – ensuring that all interests commercial, recreational and Aboriginal are included within a sustainable fisheries management framework.

When finalised, the finer details of recommendations in the strategy, will apply to Stokes Inlet. Indigenous and cultural fishing activities and rights will also be considered in future management arrangements relating to fishing in Stokes Inlet.

Compliance
To maintain the integrity of the Management arrangements in place for fishing in Stokes Inlet compliance is carried out by Fisheries and Marine Officers (FMO's) based in the Southern region. There are two full time FMO's based in Esperance and three full time FMO's based in Albany. These officers conduct regular compliance and education patrols to monitor fishing activity and enforce the legislation where necessary. This patrol activity is infrequently complimented with mobile patrols by a DoF mobile patrol unit based in Busselton.

Options for increasing compliance includes the placement of extra FMO's in the region and the cross authorisation of other compliance staff under the FRMA. Both of these options have funding implications.

Options for closing or restricting fishing in Stokes Inlet

Under Section 43 the FRMA the Minister for Fisheries has the power to prohibit the take of fish (this can include individual species of fish) or a particular fishing activity. This prohibition can be applied to either commercial or recreational fishers (or both) and can be at all times or for a specified period.

The process for implementing a closure involves an extensive consultation process involving all stakeholders and authorities. The Minister will take into consideration the outcomes of the consultation process, research and relevant information as well as any other information available on the need for and impact of any closure or restriction.

The Fish Fauna of Stokes Inlet – Background Paper

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Fish community

The fish fauna of Stokes Inlet is highly depauperate due to a combination of this estuary being normally-closed to the ocean, which restricts the entry of marine species, and the naturally low diversity of the fish faunas of the estuaries in this region (Hoeksema *et al.*, 2006*a*). Extensive seine netting of nearshore, shallow waters and gill netting of offshore, deeper waters of the basin and lower reaches of the main tributary of this estuary yielded only 12 species (Hoeksema *et al.*, 2006*a*). This point is further emphasised by the fact that 38 species of fish were recorded in the nearshore, shallow and offshore, deeper waters of the large and seasonally-closed Wilson Inlet, which is further to the west on the south coast of Western Australia (Potter *et al.*, 1993).

The most abundant of the species in Stokes Inlet, by far, were two small and short lived species, an atherinid (*Atherinosoma elongata*) and a goby (*Pseudogobius olorum*), and the far larger and commercially and recreationally important Black Bream, *Acanthopagrus butcheri*, each of which completes its life cycle within estuaries. The fauna of Stokes Inlet also contained Estuary Cobbler, *Cnidoglanis macrocephalus* and Southern Blue-spotted Flathead, *Platycephalus speculator*, the individuals of which can complete their life cycles in estuaries. However, these species, which are also fished recreationally and commercially, were far less abundant and are represented by discrete marine populations.

Nearshore, shallow waters were dominated by a small hardyhead (*A. elongata*), which contributed *ca* 80% to the total catch of fish in these waters (Hoeksema *et al.*, 2006*a*). A small goby (*P. olorum*) was also relatively abundant in these catches (*ca* 16%), as were juveniles of the Black Bream (5%). The only marine species in the catches from nearshore waters was the Yelloweye Mullet, *Aldrichetta forsteri*, which was represented by very low numbers of juveniles and had probably been swept over the bars at the mouth of this estuary during high swells.

The Black Bream dominated the fish fauna of offshore, deeper waters, contributing, in terms of numbers, 98% to the gill net catches in this estuary (Hoeksema *et al.*, 2006*a*). Only five marine species were recorded, namely Yelloweye Mullet, Sea Mullet (*Mugil cephalus*), Australian Herring (*Arripis georgiana*) and Tarwhine (*Rhabdosargus sarba*). Although Yelloweye Mullet was the most abundant of these species and ranked second overall by abundance, each of these species contributed less than 1% to the total number of fish caught in offshore waters. The minimum length of the marine species found in the deeper waters of these estuaries was far greater than that of Black Bream, which spawn and grow within the estuary. It is thus concluded that these marine species had been landlocked in Stokes Inlet for a protracted period and almost certainly entered these systems when the estuary bar at the mouth was breached in 2000.

Black Bream

Black Bream spawn in late winter and spring in the normally-closed Stokes Inlet, which is earlier than in permanently-open and seasonally-open estuaries further to the west, and allows this species to produce offspring before salinities become high during the typically dry summer months (Hoeksema *et al.*, 2006*a*). An examination of annual growth rings in otoliths (ear bones) demonstrated that the population of Black Bream in Stokes Inlet bred successfully in all but one of the years between 1992 and 2003. During the spring of 2002, this species was captured in spawning condition when salinities in the basin had reached over 45, however, recruitment was not successful in that year with no juveniles of that year class being captured in two subsequent years of sampling. The recruitment of juveniles was also extremely variable in the years when recruitment was successful, and was greatest in years of moderate freshwater flow in the months preceding and during the spawning period.

The fact that the strengths of different year classes in Stokes Inlet vary markedly has important implications for the management of this fishery. The fact that *A. butcheri* do not recruit into the fishery until they have reached 250 mm and *ca* seven years of age means that, for example in 2004, the fishery in this estuary was largely dependent on a single year class, *i.e.* the 1993 year class. Although the strong year class of 1998 were recruited into the fishery by 2005, the dependence of this fishery on one or two strong year classes highlights its vulnerability to recruitment over-fishing, if several years of poor juvenile recruitment occur in a row.

In Stokes Inlet, Black Bream typically reach maturity at the end of their second year of life when they are about 150 mm in length. This species is slow growing in Stokes Inlet, with the average age at the Minimum Legal Length (MLL) for capture being seven years (Hoeksema *et al.*, 2006*a*). Black Bream are therefore able to spawn approximately five times before being recruited into the commercial and recreational fisheries.

Black Bream ingested a diverse range of plant material, polychaete worms, molluscs, crustaceans, insects and fish in Stokes Inlet, emphasising that Black Bream is an omnivore and feeds opportunistically (Chuwen *et al.*, 2006). The diversity of the diet of this species in Stokes Inlet presumably reflects a large diversity of prey in that estuary. The slow growth of this species in Stokes Inlet could not be obviously related to the composition of food consumed, but appears to be due to the high density of this species in this system. Other factors that may influence the growth of Black Bream include water temperature (Sarre and Potter 2000) and other environmental factors such as salinity, or genetic divergence (Morison *et al.* 1998), although Partridge *et al.* (2003) demonstrated that environmental influences rather than genetic divergence were responsible for the differences in growth of two populations of Black Bream in Western Australian estuaries.

The mean seasonal salinities in the main body of Stokes Inlet increased during 2002-2004. However, while average salinities never rose above about 60 ppt in Stokes Inlet, they exceeded 140 ppt in the Hamersley Inlet and 290 ppt in the Culham Inlet during the same time period. Mass mortalities of Black Bream and other species were recorded in those two estuaries when salinities had reached approximately 85 ppt (Hoeksema *et al.*, 2006*b*). Thus, while salinities were relatively stable in Stokes Inlet and fish remained relatively abundant in that estuary, salinities did increase to near critical levels for the survival of Black Bream (Hoeksema *et al.*, 2006*b*). This conclusion was substantiated by the observation of numerous Black Bream with salt sores on their bodies during the period when salinities had reached *ca* 60 ppt in Stokes Inlet. It is thus important that the level of salinity in Stokes Inlet is maintained below 60 ppt to sustain the population of Black Bream in this estuary.

References

Chuwen, B.M., Platell, M.E. and Potter, I.C. (2006). Dietary compositions of the sparid *Acanthopagrus butcheri* in three normally-closed and variably hypersaline estuaries differ markedly. *Environmental Biology of Fishes* (in press).

Hoeksema, S.D., Chuwen, B.M. and Potter, I.C. (2006*b*). Massive mortalities of black bream, *Acanthopagrus butcheri* (Sparidae) in two normally-closed estuaries, following extreme increases in salinity. *Journal of the Marine Biological Association of the United Kingdom* **86**, 893-897.

Hoeksema, S.D., Chuwen, B.M. Hesp, S.A., Hall, N.G. and Potter, I.C. (2006*a*). The impact of environmental changes on the fish faunas of Western Australian south-coast estuaries (Fisheries Research and Development Corporation, Final Report 2002/017).

Morrison, A.K., Coutin, P.C. and Robertson, S.G. (1998). Age determination of black bream, *Acanthopagrus butcheri* (Sparidae), from the Gippsland Lakes of south-eastern Australia indicates slow growth and episodic recruitment. *Marine and Freshwater Research* **49,** 491-498.

Partridge, G.J., Sarre, G.A., Hall, N.G., Jenkins, G.I., Chaplin, J. and Potter, I.C. (2003). Comparisons between the growth of *Acanthopagrus butcheri* cultured from broodstock from two estuarine populations that are reproductively isolated and differ markedly in growth rate. *Aquaculture* **231,** 51-58.

Potter, I.C., Hyndes, G.A. and Baronie, F.M. (1993). The fish fauna of a seasonally closed Australian estuary. Is the prevalence of estuarine-spawning species high? *Marine Biology* **116**, 19-30.

Sarre, G.A. and Potter, I.C. (2000). Variation in age composition and growth rates of *Acanthopagrus butcheri* (Sparidae) among estuaries: some possible contributing factors. *Fishery Bulletin* **98**, 785-799.

Additional Notes provided by Mieke Bourne
(only some of this information was provided by DoF)

Q: If the commercial fishery at Stokes is closed what impact will this have on other estuarine fisheries on the south coast?
A: It is possible that the licensees would translate the effort that they put in to Stokes into other estuaries, and it would reduce the fishery from 13 estuaries to 12. It is also possible that the licensees would not translate their effort to another fishery.

Q: What is the cause of fish kills in the Inlet?
A: Fish kills may be due to one factor, eg low oxygen, or they could result from multiple factors, eg low pH and elevated aluminium concentrations. In other instances many fish kills are associated with normal seasonal weather changes producing extremely cold or warm conditions. Fish and most other aquatic organisms lack the means of regulating their body temperature and consequently die. Human causes such as discharge or spillage of potentially toxic chemicals have been associated with fish deaths. However, a common but subtler phenomenon is the degradation of a natural waterway by interference in the natural flow and the build-up of excessive nutrients. This results in the development of stagnant conditions and excessive growth of aquatic plants and/or algae. Fish become stressed due to reduced oxygen concentrations during overcast weather, when the rate of oxygen production by plants is reduced, or at night when photosynthesis ceases but algal and plant respiration continues. Where excessive algal and plant growth occurs, their respiration at night can deplete the available dissolved oxygen sufficiently to result in a fish kill. Also fish under stress as a result of human activities may be more susceptible to harm from natural disturbances such as temperature change and disease (Department of Environment and Heritage, 1998; O'Sullivan, 1996).

Q: Are the fish caught safe to eat? What are the fisheries and health department's policy requirements relating to testing commercially caught fish?
A: It is recommended that people don't eat fish killed in a fish kill. As for the other fish caught in the estuary it depends on the cause of the fish kill. Fish are not usually tested unless there has been a fish kill. It is assumed that if they are healthy and alive then they are safe to eat as long as they do not make up all of a persons diet. There has been no known analysis of the fish caught at Stokes Inlet to look at toxins/bacteria or pesticides.

Q: What is the response to fish kills at the Inlet?
A: There is a standard fish kill response. For inland waters the Department of Water takes the lead and works with the Department of Fisheries and other stakeholders. Generally once a report has been received the site is inspected and a sample taken if necessary.

Q: The presence of potentially icthyotoxic species indicates the probability of fish kill events in this estuary. What levels of each would result in this occurring?
A: *Karlodinium micrum*- there is no set density. As with all fish kills it is usually a combination of many factors. We have had kills with *Karlodinium* present at about 10,000 to 15,000 cells/mL and also had it in the upper Swan over 100,000 cells/mL and no fish kill. There have been several incidences where rain has preceded a kill with *Karlodinium* present- burst cells, toxins into the water? Unfortunately with high densities the fish are usually stressed anyway. Oxygen demand is usually high and an additional stress. It depends on the depth too. An integrated density from the Swan in May 2007 had *Karlodinium* at just over 16,000 cells/mL while a 0.5m discreet sample from the same site- density was nearly 90,000 cells/mL. (Field crew observed high DO and flurometer readings at 0.5m).
As a guide only- we usually start being more alert when densities rise very quickly from one week/ sample to the next. We use a guideline of about 10,000 to 20,000 cells/mL. For a fish kill- usually rain (run off, nutrient input) and then sun alternating can be a problem and overcast still days- when the oxygen recharge is not the best. And of course- the DO is usually the main factor to monitor, particular early morning. (as with any bloom!).

Heterosigma akashiwo- this species has been found 'toxic to caged fish' - there are no known cases of wild fish kills. Very high densities have been recorded with no fish kills, they can

usually move away from the vicinity. As a precaution we usually notify Fisheries when densities are getting up around 10,000 cells/mL. Obviously in an enclosed inlet prior to a bar opening, this may be a problem.

Heterocapsa spp- this species blooms in the Serpentine River and while it doesn't directly kill fish when the bloom collapses it can. In 2003 as a bloom of *Heterocapsa* (over 100,000 cells/mL) collapsed it resulted in about 250,000 fish dying (decapods- the lot), no oxygen. Again - the increasing density and very low DO were the concern (shallow waterway too). Technically a *Scrippsiella* bloom could probably do the same. *Scrippsiella* and other moderate sized cells *(Prorocentrum cordatum)* blooms resulted in sudden anoxia and fish deaths when collapsed in the Yunderup canals.

Suggested discussion points:

- Catchment revegetation works to reduce salinity input from the rivers to the estuary to avoid future fish kills
- Bream resource sharing between recreational and commercial fishers
- Future research

Recommendations arising from the third (31/5/07) steering group meeting

The following recommendations and information was provided by the steering group during discussion at the steering group meeting 31/05/2007.

Black Bream are the main fish discussed in this paper as they are they make up the majority of the commercial and recreational catch.

It was suggested that salinity is the biggest environmental threat to fish in the Inlet. Salinity should not rise above 60ppt and the optimal level is around 45ppt. Salt input from the catchment, evaporation and bar openings all impact upon salinity levels in the Inlet. We are unable to control evaporation and the group felt that artificially controlling the bar was not a good option. Bar interference at other estuaries along the South Coast has not been very successful and often if a bar is broken before sufficient water levels are achieved to naturally break it then the water exchange is severely limited and the bar is closed by wave action quickly. Reduction in salt input from the catchment is thus considered the best option.

Recommendation: work is undertaken in the catchment to minimise salinity input to the Inlet.

Recommendation: the bar is not interfered with in the future.

It has been shown that the Black Bream fishery at the Inlet is sustainable. However, the sharing of this resource is an issue that has been raised by the community as they feel they should have a greater share. Historically only 3-4 commercial fishermen have fished the Inlet. It was discussed that to ensure the commercial fishing effort does not increase in the future the group could put forward the idea of limiting the number of commercial fishermen who can fish it in the future. This suggestion would be made to the Minister for Fisheries and may include the suggestion that only historical fishers of the Inlet are awarded licences. Another suggestion relating to resource sharing was that the boundaries of the area commercially fished be reduced, to exclude the estuarine reaches of the rivers. This was suggested as the rivers are popular for recreational fishing.

Recommendation: alter the boundaries of the commercial fishery at Stokes Inlet to exclude the estuarine reaches of the rivers.

Recommendation: reduce the number of commercial fishermen licensed to fish the Inlet to those that have fished it consistently in the past.

It was felt that the community did not have the best information available on the fishery at the Inlet. It was considered important that the community was educated about the Black Bream fishery, about its sustainability and management. This could be done through media releases, as an explanatory note in the management plan and by making this background paper available to the community.

Recommendation: community education about the existing management of the commercial fishery and its sustainability.

Fisheries identified that they plan to look at allocation of fish resources for the Inlet through the development of Integrated Fisheries Management (IFM). They suggested that this process was still a long way off for the estuarine fishery. The group highlighted the need for such an approach at Stokes Inlet and recommended that the Inlet be set as a priority.

Recommendation: Stokes Inlet is suggested as a priority for Integrated Fisheries Management.

The group also identified the need for ongoing research and monitoring of the Black Bream population size and health. It was also suggested that it would be interesting to determine the survival rates of released Bream after being caught. These is of particular interest at Stokes Inlet as the Bream growth rates and thus size are smaller at Stokes then other systems and so it is likely that more bream are released.

Recommendation: ongoing monitoring of the Black Breams population size and health takes place.

Recommendation: Promote research into the survival rates of released Black Bream at Stokes Inlet.