Harvest Strategy for the Bass Strait Central Zone Scallop Fishery (BSCZSF)

Overview of the fishery

Scallop fishing in Bass Strait commenced in early 1970s. Fishing is managed under three jurisdictions: AFMA manages the Central Zone fishery and, Victoria and Tasmania manage zones generally out to 20 nm off their respective coastlines. The main target species is the southern scallop, *Pecten fumatus*. SFRs are also issued for doughboy scallops, but these are generally not fished. Scallops may be taken by dredging or trawling (trawling is an historical concession).

The CZSF is overfished and is currently inactive and closed to commercial fishing under the 2005 Ministerial Direction. Scallops are patchily distributed in beds ~3-4km long and ~1-2km wide. Once opened, a bed tends to be fished to economic depletion. Between 1990 and 2003, known scallop beds have been closed several times to allow stocks to rebuild. Abundance is currently (as at 2005 – no surveys have taken place subsequently) unknown, with only one known aggregation (east of Flinders Island) (McLoughlin 2006). Bass Strait has a history of boom and bust: the discovery of beds has been followed by an influx of effort that fished the beds to depletion (McLoughlin 2006). There are currently no known beds in the western zone of the CZSF, and recruitment has always been episodic in Bass Strait (successful recruitment events are strong but occasional). The highest GVP in the period from 1997 to 2005 was in 1997/98 at $7 million. Subsequently the GVP declined drastically, to $191 000 in 2005/06 (Moore and Patterson 2007).

Access to the fishery is by limited entry, with entry limited to the number of permits held on 1 March, 2001. From January 1, 2005 there were 103 Statutory Fishing Right (SFR) holders, with each holder allocated one boat SFR and 3500 quota SFRs commercial scallops and 3500 quota SFRs for doughboy scallops for every permit held on the snapshot date. Boat SFRs ceased to exist on February 1, 2007. Prior to the 2007 buy back, there were 89 SFR holders and 152 concessions pre buy back.

Review of current management of the fishery

The fishery is managed under a Management Plan. The current Central Zone (CZ) management regime is such that most of the area is open, with specific beds closed. The boundaries of these closed areas are flexible every year. Pre-season surveys must be undertaken to determine size distributions and areas of beds. At least one bed in the east and one in the west must remain closed.

In the absence of fishery-independent stock assessments, the Management Plan stated that AFMA would determine annual TACs of 1000 tonnes (maximum) for commercial scallops and 100 tonnes (maximum) for doughboy scallops. AFMA was able to further increase the TAC if subsequent assessments of beds were favourable.

A minimum size for commercial scallops is set at 90mm (≈ 3 years old), allowing for two years of spawning prior to harvesting. There is a "discard rate" of 20%, meaning that the undersize scallop discard rate should not exceed 20%. If greater than 20% of the catch (as determined at the start of season from surveys) is less than 90mm, then the area will be closed to fishing to protect small-size scallops to allow them to spawn and grow to contribute to the future yield of the bed.

The default fishing season is 1 May – 20 December but there is the option to vary these dates. For a bed to be opened, surveys must meet the 90mm minimum size and less than (or equal to) 20% "discarding" rules in at least 1 fishable area (bed). Otherwise fishing is allowed across the majority of the fishery where there are no closures in place.

The fishery is currently (as at 2007) information-poor. Logbook data exists, but does not extend back to the early years of the fishery (i.e. mid 1980s). There have been various recruitment and abundance surveys, but apart from surveys to review area closures, there has been little Bass Strait scallop research since the fishery was closed in 2005.

The management arrangements as at 2007 are effectively a harvest strategy. However, these are not considered consistent with the intent of the Policy, given the following:

- whole fishery open with one bed closed. There is a risk that this may protect less than the limit reference point of B_{20}.
- need to demonstrate a more defensible overall level of protection in terms of the limit reference point
- The harvest strategy should apply in all circumstances and stock conditions, e.g. different responses for monitoring etc. depending on stock status.

It must be emphasized that this fishery does not conform well to the biological assumptions underlying the Policy reference points. It has naturally sporadic and fluctuating availability and intermittent recruitment, such that the concept of B_0 is meaningless. The scallops aggregate in sub-populations (scallop beds) which come and go and have historically resulted in a boom-and-bust fishery, so that the notion of maintaining the fishery at a nominated Btarg level is inconsistent with the nature of the species. Moreover, the ability of fishers to effectively clear out a scallop bed once opened to fishing implies that the overall stock level can rapidly decrease from B_{TARG} to B_{LIM}. Even defining a B_{LIM} is difficult as stocks have recovered from collapse from what must be assumed to be very low levels. Combined with the intermittent nature of this fishery, this strongly suggests that the Bass St Central Zone scallop fishery should not be relied upon as a continuous source of product, and hence income.

Proxies against the Harvest Strategy Policy Reference Points

Under the proposed spatial management system, there is no absolute or direct target reference point proxy. This is because the concept of B_0 (unfished biomass) has little meaning in this fishery, due to the patchy distribution of the stock, and the fact that recruitment events are episodic and irregular.

That the percentage of viable areas remaining closed to fishing must be greater than or equal to 40% at all times, was intended to be indirectly consistent with the $B_{MSY} \approx 0.4B_0$ target reference point of the late-2006 version of the draft Policy. In terms of the target reference point optimizing economic yield, as per B_{MEY}, this would perhaps indirectly equate to an adequate number of areas being opened to enable continuous harvesting by all SFR holders during the fishing season.

A proxy B_{LIM} is defined for this fishery, as a combination of spatial and biomass criteria, whereby the fishery is or remains closed if both of these are not fulfilled. This is discussed in detail below. The spatial criteria are that there must be > 1 "viable" area in terms of scallop density, size and discard rate (area = unit sized blocks of approximately 5 nm x 5 nm); the percentage of viable areas remaining closed to fishing must be ≥ 40% at all times, and areas will be opened on a rotational or staged basis (if multiple viable areas are available.) Biomass criteria are that the surveyed biomass must be ≥ B_{LIM} set at 500t based on scaling of historical high catches and levels of biomass from which the stock has been known to recover. If the number of viable areas available = 2 , the smaller of the two areas should generally be opened, and at the closed area must have a biomass estimate greater than 500t.

General description of the harvest strategy

Fishery Issues; justification for approach

- The fishery has shown a declining "boom and bust" cycle. There was only one commercially viable area known in 2007 (east of Flinders Island).

- The fishery was closed by Ministerial Direction for at least three years (2006-2008). Surveys will need to provide evidence that stocks are capable of sustaining fishing in order to reopen the fishery.

- The fishery is overcapitalised as at 2007.

- The fishery requires spatial management (due to its patchy distribution and irregular, episodic recruitment). Opening the entire fishery, with no accompanying regulations (e.g. season length, size limits), or with a large area open and small areas closed, has in the past been both biologically and economically unsustainable (Moore and Patterson 2007). However, detailed spatial management has a high information requirement.

- The benefits of closed area spatial management strategies for scallops have been detailed in the literature and include increased protection from fishing and consequent increased abundance, mean age and size, and enhanced local reproductive potential and hence improved probability of larval export to surrounding areas (Ward *et al.* 2001; Gell and Roberts 2003; Halpern 2003; Beukers-Stewart *et al.* 2005). Closed area spatial management of commercial scallop stocks, where the majority of the fishery is closed to fishing and only discrete beds are open to harvesting is considered to optimise the potential for continuity and sustainability as compared to broader spatial scales of management, such as the existing Commonwealth strategy (Haddon *et al.* 2006).

- The concept of B_0 (unfished biomass) has little meaning in this fishery (due to the patchy distribution of the stock, and the fact that recruitment events are episodic and irregular), but there are useful proxies. For example, it is possible, although theoretically unsound, to obtain estimates of B_0, B_{lim} and B_{targ} based on historical high catch rates.

- TACs should not be the only management control applied to the fishery because of uncertainties associated with survey-based estimates of exploitable biomass (e.g. patchy distribution of scallops and variations in catchability).

- Input controls are still necessary. A minimum legal size allows for two major spawning events and improves yield via a lower number of meats per kilogram. Seasonal closures protect beds during peak settlement periods and optimise scallop condition (the seasonal closure coincides with a loss of condition over summer). Limited entry pertains to fleet capacity and economic efficiency.

- Ultimately the preference would be to manage all scallop fisheries in Bass Strait as a single management entity. However until agreement can be reached between the Commonwealth, Tasmania and Victoria as to if and when such a transition could occur, the BSCZSC must be managed in isolation.

- This is an intermittent fishery that should not be relied on as continuous source of income/product. It may not be possible to open the fishery every year. The fishery has never been implemented sustainably, so expectations based on the past are unrealistic. The fishery must move away from the philosophy that fishing should occur if a viable area is present. This has proven to be economically and ecologically unsustainable and is not consistent with the intent of the Harvest Strategy Policy.

Harvest Strategy Overview

The harvest strategy to be adopted for the BSCZSF includes a detailed spatial management system, which will take into account the following points:

- Biomass estimates will be based on surveys of areas known to contain historically fished beds. This will establish areas of high density (formerly known as "beds") within the fishery. Each area should have the potential to be commercially fished and as such should be of a sensible minimum size. These will be divided into unit-sized spatial management areas 5 nm x 5 nm.
- The fishery will remain closed unless survey results indicate that the specific criteria (see below) for opening one or more areas to fishing can be met. Staged harvesting will occur whereby unit areas are opened sequentially. Additionally, ongoing monitoring will occur on all of these known areas of high density to determine their status each season. Note that by limiting the management approach to these beds/areas of high density, the area required to be monitored is reduced to a more practical subset of Bass Strait.
- All other regions of the fishery are to be open to "scientific survey" (exploratory fishing) via permits and a research allowance process. Note that this is not to be confused with the formal survey process to monitor the status of the known beds (as mentioned in the

previous point), which forms an integral part of the harvest strategy. Rather, this is a provision to allow some ongoing fishery access and gives some flexibility for exploring. If a bed is discovered in the course of these surveys, it may then be included in/added to the pool of defined areas of high density under which the above spatial rotational system of management applies. [This gives an incentive to monitor other areas, as opposed to the current strategy where discovery of a new bed results in its closure].

- As an "insurance policy", a percentage of each open area may be kept closed to maintain local spawner biomass (given that the nature of the stock-recruitment dynamics is largely unknown).
- The condition of scallops will also be taken into account in the decision as to whether to open a bed.
- The above regime will apply independently to the eastern and western regions of the fishery. This mitigates against opening the fishery when only one viable bed is present in each of the eastern and western regions. This also provides an incentive to undertake opportunistic surveys, particularly in the west where knowledge is currently (as at 2007) poor.
- The Harvest Strategy can be updated if/when the quality of available information improves.

Decision Rules (see subsequent section for annotated version with additional explanation and rationale)

1. Total allowable catch:

The TAC set each year will apply to the fishery as a whole (as opposed to area-specific TACs) and will equate to the proportion of the estimated biomass that corresponds to that occurring in the areas to be opened to fishing (see item 6. below). The TAC will be adjustable due both to the variable nature of the fishery and the uncertainty associated with biomass estimation.

A default TAC of 100t will apply to doughboy scallops.

2. Fishing season:

The default fishing season will be 1 June to 31 January each year. However, the fishing season will be subject to review each year based on the survey results and biomass estimations. It may not be possible to open the season each year and the season times may vary. Scallop condition will also be taken into account when determining the season and the opening may be delayed to allow scallops to reach a desired condition prior to harvesting.

3. Area closures:

All areas of the fishery will remain closed to fishing unless survey results indicate that criteria for opening the fishery (Decision Rule 6 below) can be met. Rotational or staged harvesting will apply.

4. Size limit:

A shell length of 90mm is the minimum size allowed to be harvested.

However, if it can be demonstrated that an area has scallops that have completed 2 major spawnings (this being the rationale for the size limit), harvesting at sizes less than 90mm may be permitted. In such cases the following criteria must be fulfilled:

- *i) the area has been monitored for a duration of not less than 3 years, such that an indication of age is obtained whereby it is known that two spawning events have occurred, AND*
- *ii) if i) has been met, information on growth rates obtained over the 3 years of monitoring should be taken into account in considering the risk trade-off between taking scallops at a size less than 90mm versus their potential to grow to a more profitable size.*

5. Discard rate:

The maximum discard rate for any area to be opened to fishing is 20%. However, as noted in Decision Rule 4, if an area contains scallops smaller than the minimum size that are known to have completed two major spawnings, the 20% discard rule may be amended.

6. Criteria required for the fishery to be reopened, and below which the fishery will be closed:

B_{LIM} proxy will consist of both spatial <u>and</u> biomass criteria that must be met before any area within the BSCZSF will be reopened to fishing.

Spatial criteria:

- *Must be > 1 "viable" area in terms of scallop density, size and discard rate (area = unit sized blocks of approximately 5 nm x 5 nm)*
- *% of viable areas remaining closed to fishing ≥ 40% at all times.*
- *Area will be opened on a rotational or staged basis (if multiple viable areas are available.)*

Biomass criteria:

- *At all times, the closed areas must contain a total biomass not less than 500t, as estimated by surveys.*
- *If the viable areas available = 2 , in general the smaller of the two areas should be opened, but consideration should be given to accessibility and to the life history stage of the scallops in each of the areas. At least one of the areas must have a biomass estimate greater than 500t.*

Consistency with Harvest Strategy Policy

Given

- the incompatibility of B_0 based reference points with this fishery given its patchy distribution and sporadic recruitment of the stock
- the uncertainty associated with survey biomass estimates
- the need for spatial management
- the low GVP in the fishery

the proposed harvest strategy provides a detailed yet practical spatial management system with inbuilt monitoring requirements (in terms of surveys) that give the best opportunity for optimising both stock sustainability and economic yield. It aligns the Commonwealth approach with the Tasmanian harvest strategy, an approach that is anticipated will maximize the chance for fishery success, and provides for greater consistency between jurisdictions. The harvest strategy provides clear rules in terms of both spatial and biomass-based limit criteria for opening areas to fishing, which can be applied irrespective of whether the fishery has been closed or open. While there is no absolute target reference point, this is not sensible in a highly variable and spatially segregated fishery. Moreover, where the dynamics are such that, it is preferable to completely "fish out" areas in succession, as this appears to provide more desirable habitat for subsequent spatfalls than partially fished areas (Haddon *et al.* 2006), as well as avoiding wastage of scallops due to damage from cross-sectioning an entire bed. As such, maximum economic yield is intended to be achieved by controlling the number of areas that are open to fishing within a season, and setting a TAC that approximates the available biomass in the open area(s). Additional control rules pertaining to season, size limits and discard rates aim to provide maximum opportunity for successful spawning and recruitment events.

Annotated Decision Rules (providing extra explanation and rationale)

1. Total allowable catch:

The TAC set each year will apply to the fishery as a whole (as opposed to area-specific TACs) and will equate to the proportion of the estimated biomass that corresponds to that occurring in the areas to be opened to fishing (see item 6. *below). The TAC will be adjustable due both to the variable nature of the fishery and the uncertainty associated with biomass estimation.*

A default TAC of 100t will apply to doughboy scallops.

Rationale: given the boom-and-bust nature of the fishery, it makes more sense to have an adjustable TAC as opposed to a fixed value. Given the spatial and biomass criteria under which viable areas may be opened, and the uncertainty associated with biomass estimates, the TAC in this context is more an internal allocation method, than it is a biological control. It addresses economic objectives by being set at approximately the biomass that is available to be taken. Having an adjustable TAC accounts for the uncertainty in the estimation of biomass within a viable area.

The TAC applied should match the biomass in the open beds (i.e. equate to the available biomass), as it is thought best that fishers successively and completely clean out open beds, as opposed to partially fishing a scallop bed, as this allows subsequent recruitment to occur (Haddon *et al.* 2006), and avoids wastage of scallops due to damage from cross-sectioning an entire bed,. For the same reason, a TAC reduction should equate to reducing the number of beds/areas that are open, or not opening any new beds once the open ones have become exhausted. TACs should not be the only management control, as exploitable biomass is never well estimated due to the patchy distribution of scallops and the variable catchability when surveying. As such, a TAC that supposedly equates to the available biomass is not robust as a sole management control.

Other than the default TAC, it is assumed that doughboy scallops will be vicariously managed under commercial scallop measures. Moreover, doughboy scallops fall under DEH requirements and as such are not required to be included in the harvest strategy.

2. Fishing season:

The default fishing season will be 1 June to 31 December each year. However, the fishing season will be subject to review each year based on the survey results and biomass estimations. It may not be possible to open the season each year and the season times may vary. Scallop condition will also be taken into account when determining the season and the opening may be delayed to allow scallops to reach a desired condition prior to harvesting.

Rationale: Despite the other criteria for opening a viable area, a fishing season is still relevant in that it allows spat to settle and scallops to reach desired condition. However, it should be noted that its effectiveness is dependent on the quality of voluntary surveys to assess condition. The key issue is to enforce a minimum 4 month closure to enable spawning and

spat settlement. Scientific evidence is that settlement occurs between October and April, and as such the closure must embrace this period (and note also that as at 2007 there is little knowledge of the nature of the relationship between spawning and spat settlement, although there is some evidence of a stock-recruitment relationship (Semmens, pers. comm.)). While acknowledging this, the previous default season (1 May – 20 December) has been amended to enable optimised marketing opportunities by encompassing the Christmas period. Criteria for alteration of the default season are yet to be determined but are most likely to be based on survey indices of condition.

3. Area closures:

All areas of the fishery will remain closed to fishing unless survey results indicate that criteria for opening the fishery (Decision Rule 6 below) can be met. Rotational or staged harvesting will apply.

4. Size limit:

A shell length of 90mm is the minimum size allowed to be harvested.

However, if it can be demonstrated that an area has scallops that have completed 2 major spawnings (this being the rationale for the size limit), harvesting at sizes less than 90mm may be permitted. In such cases the following criteria must be fulfilled:

iii) the area has been monitored for a duration of not less than 3 years, such that an indication of age is obtained whereby it is known that two spawning events have occurred, AND

iv) if i) has been met, information on growth rates obtained over the 3 years of monitoring should be taken into account in considering the risk trade-off between taking scallops at a size less than 90mm versus their potential to grow to a more profitable size.

The over-rides on the 90mm size acknowledge the observed phenomenon of stunted growth in deep water areas of high density (Semmons, pers. comm.).

5. Discard rate:

The maximum discard rate for any area to be opened to fishing is 20%. However, as noted in Decision Rule 4, if an area contains scallops smaller than the minimum size that are known to have completed two major spawnings, the 20% discard rule may be amended.

This rule allows for the protection of very small scallops (i.e. not those close to the size limit). Note also that this rule that relates to the decision to open the fishery. Survey outcomes determine whether or not it is fulfilled. As such, this rule may lead to areas being/remaining closed. However, scallops less than minimum size are of little commercial value.

Once the fishery is operating, this rule becomes contentious. It is not possible to sort/discriminate sizes once fishing is occurring. If the other criteria for opening the fishery are met, presumably the risk of exceeding the discard rate is irrespectively minimised. There is a key compliance issue whereby the need for "zero tolerance" should be revisited in the

context of the harvest strategy implementation and in implementation of AFMA's Bycatch and Discard Workplan.

6. Criteria required for the fishery to be reopened, and below which the fishery will be closed:

> *B_{LIM} proxy will consist of both spatial and biomass criteria that must be met before any area within the BSCZSF will be reopened to fishing.*

Both spatial and biomass criteria are used because spatial has the benefit of managing this spatially disaggregated fishery at the level of historically fished areas. When more than one area is viable, it is easy to demonstrate some level of stock protection by keeping some of these areas closed. However, the notion of protecting a set number of areas, or keeping a proportion of areas open, also implies that there will always be some stock available to be fished. This is addressed via the inclusion of the biomass criteria.

Moreover, the use of both spatial and biomass criteria in combination is more defensibly consistent with the intent of the Policy. The Policy states that there must be a minimum level of stock protection, defined in terms of a limit reference point (B_{LIM}). This effectively requires the definition of a suitable proxy for the "necessary biomass" to ensure sufficient recruitment (acknowledging our poor understanding of the stock-recruitment relationship) in this fishery.

Spatial criteria:

- *Must be > 1 "viable" area in terms of scallop density, size and discard rate (area = unit sized blocks of approximately 5 nm x 5 nm)*
- *% of viable areas remaining closed to fishing ≥ 40% at all times.*
- *Area will be opened on a rotational or staged basis (if multiple viable areas are available.)*

"Viable" area definition: "Viable" in this context equates to exceeding the size limit and discard rates described in 4. and 5*.

Areas are defined as unit sized blocks of approximately 5 nm x 5 nm. The unit size facilitates ease of opening areas in a staged manner within a season: a new area may be opened as catch rates decline on currently open areas. Note that it is preferable to completely "fish out" areas in succession than to simultaneously open multiple areas, even when these areas encompass a single scallop "bed" (Haddon *et al.* 2006). Small unit areas circumvent the need to sub-divide a larger area into "strips" of "paddocks" that are then sequentially fished.

In super-imposing 5 nm x 5 nm areas over larger viable areas, invariably some peripheral squares will contain scallops only within a small fraction of their area. However, the biomass criteria outlined below will augment the spatial criteria and thus determine whether the peripheral area may be fished.

When one area come close to fulfilling the size limit and discard rate criteria by which it may be termed "viable", but does not absolutely satisfy these, if it can be justifiably shown that this area has been surveyed for at least 3 years, and that it has the potential to become "viable" within the next 12 months, then it may be included as a candidate area for potential exploitation. Note, however, that this area may NOT be opened to fishing in that season. Rather, its inclusion in the "pool" of "viable" areas may permit the opening of a second viable area, via the fulfillment of the criterion that there must be at least one viable area in order for any area to be fished. If this marginal area does not absolutely fulfill the criteria for it to be considered "viable" within the next 12 months, then this area must be removed from the "pool" of "viable" areas.

[Note: In an earlier phase of harvest strategy development, the MAC considered defining areas as spatial blocks enclosing historically fished beds. Area boundaries were to have been refined by a mapping exercise undertaken to produce a density map of the historically actively managed areas of the fishery. These areas would have been delineated via economic boundaries – i.e. it would not be economically viable to fish below certain densities. Historical information may have been subsequently augmented by survey information. The notion was that a "viable" area should be a viable recruitment entity with respect to the density and maturity of the scallops, and its size and location. However, in a subsequent MAC meeting, unit sized areas were considered preferable in that they provide a common currency for spatial management, and by setting these at a reasonably small size, they could readily facilitate staged harvesting in that the subdivision of larger areas would be circumvented.]

Note that the above-defined spatial blocks were felt to be preferable as spatial units than scallop beds, due to the difficulty associated with the definition of the latter.

Note also that there may be a paucity of information of historically fished beds for the western sector of the fishery.

At any one time, the areas being via monitoring surveys and rotational harvesting may or may not be commercially viable. However, the non-commercially viable areas must be considered to have the potential to become commercially viable. Moreover, within any one season, it is not adequate to protect only the non-commercially viable areas.

*Information on scallop density might also be considered in classifying an area as "viable". If biomass is greater than the required B_{LIM} threshold (defined below), but densities are low, then it is questionable as to whether the area should be considered viable from both a fishery (CPUE) and biological (recruitment) standpoint. Density may also be considered when determining which viable beds are to remain closed, given that closing low-density beds is not in the best interest of future recruitment. In both contexts, the trade-off between recruitment success and the minimum density above which fishing is economically viable must be considered. The opening of any bed must simultaneously be commercially viable (self-regulating in that fishing will cease within a non-viable area) without compromising the sustainable recruitment of the stock (i.e. must maintain a viable recruitment entity with respect to the density and maturity of scallops, and the size and location of viable areas). Resolving this issue is difficult given the lack of understanding of recruitment dynamics as at 2007.

Biomass criteria:

- *At all times, the closed areas must contain a total biomass not less than 500t, as estimated by surveys.*
- *If the viable areas available = 2 , in general the smaller of the two areas should be opened, but consideration should be given to accessibility and to the life history stage of the scallops in each of the areas. At least one of the areas must have a biomass estimate greater than 500.*

While it is more precautionary to open the smaller of the two areas if these are the only two "viable", in practice this is impractical if the larger area is more accessible than the other, and it is not sensible if the smaller area contains younger scallops while the larger contains scallops experiencing a high level of natural mortality due to their age.

It is again reiterated that the concept of B_0 has little meaning for this fishery, but a proxy must be provided given the lack of plasticity of the Policy with respect to the nature of this fishery. Under the Policy, there must be a minimum level of stock protection, defined in terms of a limit reference point. This effectively requires the definition of a suitable proxy for the "necessary biomass" to ensure sufficient future recruitment (acknowledging our poor understanding of the stock-recruitment relationship). (Note also that in this context, the nature of the relationship of BSCZ scallop abundance with that of Victoria and Tasmania needs to be more explicitly considered).

Historical high catch, obtained by taking an average of "high catch" years, may be scaled and to give a B_0 estimate on which the limit reference point may be based. The simplest option is to assume the catch equates to total biomass, but catch should probably be upscaled, given that it is unlikely the catch removed all biomass. Such a B_{LIM} is certainly not defensible on its own, but it sits as one of a suite of decision rules comprising the harvest strategy, and it provides a range of values within which negotiation can occur and that may be reconciled against survey outcomes.

Clearly, the range of choices for both the number of years considered to be "high catch", and for the catchability factor by which the average catch is upscaled (implying that biomass proxies can encompass both target and limit reference points, depending on the assumed catchability), can result in a range of B_0 estimates. Given this uncertainty, together with the poor quality of reporting and the fact that catch has been largely market-driven, the choice of B_{LIM} should be refined using economic criteria. Given that the Policy advocates economic viability, it goes without saying that there should be a reasonable assumption of economic viability before the fishery is opened.

An upper and lower value for a proxy B_{LIM} may be obtained by scaling historical high catches. (For years 1993-2004, this equates to 6683 t and 529 t respectively, depending on the choice of years used and the scaling factor – see worked example below). In practice, a range of values for B_{LIM} may be calculated where the emphasis is not on using high catches but whether earlier or later catch data is used. For example, separate values for B_{LIM} could be based on catches averaged

i) over the last few years of the available time series: as B_0 is a meaningless concept for this fishery, calculating B_{LIM} in the currency of recent years may be more appropriate.

ii) over the initial few years of the most recent 12 year time series: this may be considered more defensible from a theoretical/purist viewpoint when assuming this to be a B_0 proxy, while still pertaining to a relatively recent regime

iii) all available years: placing equal weighting on each year and thus obtaining an overall average across a highly variable fishery

iv) over the very early years of the fishery (e.g. 1980's): from a theoretical/purist viewpoint, this would be the closest available proxy to B_0. However, in a practical sense, it is likely to result in values of such high magnitude that the current population may never exceed.

The resulting range of values provides a basis for determining a minimum biomass that must be protected. The lowest value obtained from the worked examples below was 529t, when the average catch across all years was taken. A calculation based on the average catch from 2002-2004 (i.e. "recent" years only) and assuming 100% catchability gave a value of 356t.

On the basis that these values are the result of a transparent, albeit shaky (given the incompatibility of scallop population dynamics with the Policy reference points, which assume a stock in equilibrium), process by which to determine a B_{LIM} proxy, and that scallop stocks have demonstrably recovered from depletion to levels lower than these values, the minimum level of stock protection that is required is set at 500t.

This biomass criterion provides an absolute threshold of stock protection and thus augments the spatial criteria in determining whether or not the fishery may operate.

It should be noted that if it is not economically viable to fish given the current state of the stock, there is no reason to open the fishery now or in the near future. (In saying this, there is a need to beware that the fishery may be economically viable below B_{LIM} [if only for a short time]).

Worked example of calculating B_{LIM} proxy

It is reiterated that these are not robust estimates, due to both the issues with confounding economic factors influencing catch, and the difficulties of upscaling due to the poor estimation of catchability (between 20% and 100%, implying that biomass estimates from survey catches can embrace both target and limit reference points). Some examples of possible proxies for B_{LIM} under different assumptions and scaling factors are provided below, ranging from 530t-6700t. Values included those derived from relaxing the criteria for "high catch" years in deriving the estimate of B_0 to include most or all catch years, to directly take into account the inherent year to year variability in the fishery.

The following table shows a range of B_{LIM} proxy values, obtained by scaling average catch over a different range of years and using different values for catchability (i.e. the assumed proportion of "B_0" taken by the catch.

year	catch (kg)
1993	2128000
1994	8063000
1995	7711000
1996	5642000
1997	5313000
1998	818000
1999	0
2000	5001
2001	14060
2002	1419412
2003	431719
2004	172532

average	1994-1997	6682250
average	1993-1997,2002	5046069
average	all years	2643144

	assumed proportion of Bo				
	0.2	0.4	0.6	0.9	1
average across	scaled values giving Bo estimates				
1994-1997	33411250	16705625	11137083	7424722	6682250
1993-1997,2002	25230343	12615172	8410114	5606743	5046069
all years	13215718	6607859	4405239	2936826	2643144

average across	Blim proxy assuming Blim=0.2Bo (tonnes)				
1994-1997	6682	3341	2227	1485	1336
1993-1997,2002	5046	2523	1682	1121	1009
all years	2643	1322	881	587	529

Justification of choice of biomass component of B_{LIM} proxy

Clearly there is much uncertainty associated with deriving a B_{LIM} proxy for this fishery bsed on the scaling of historical high catches. At the March 2007 HS meeting in Melbourne, several other options for the biomass proxy were suggested. These are listed below, together with their rationale for rejection:

i) Minimum number of beds to be protected

Rationale for rejection: Considering a B_{LIM} in terms of a number of beds has the problem (noted above) of implying that there is always some stock available to be fished. It is desirable to move away from this philosophy, which has proven to be ineffective in the past management of the fishery. Also, spatial criteria alone are

difficult to defend against the intent of the Policy, particularly when there is only one identified bed.

ii) Minimum proportion of the total bed area to be protected (takes into account that beds may be of different sizes and as such should not be treated as equal units)

Rationale for rejection: As for i) above

iii) Proportion of the total estimated tonnage able to be taken across all viable beds to be protected

Rationale for rejection: This requires a comprehensive survey to obtain the total estimated tonnage in each year of fishing, which is unlikely to be economically viable or logistically practical. This approach also has issues with being defensible against the Harvest Strategy Policy in that it implies that a percentage of available biomass may always be taken.

iv) Investigate values associated with stable and increasing recruitment in other scallop fisheries (e.g. Georges Bank)

Rationale for rejection: It was agreed that the unique local and sporadic dynamics of scallop fisheries means that values associated with stable and increasing recruitment in other fisheries are likely to not be directly applicable to the Bass Strait Central Zone Scallop Fishery. Indeed, even within the fishery, biomass values associated with stable or increasing recruitment are likely to be variable over time.

<u>Bottom Line</u>

- Under the Policy, we are obliged to provide a defensible B_{LIM} proxy.
- We are limited by the available data
- Continuous comprehensive surveys are impractical
- A B_{LIM} based solely on spatial units (e.g. number of beds) is undesirable in that it supports the philosophy that there is always stock available to be fished, and it is difficult to defend against the intent of the Policy.
- Thus the current notion is to define a B_{LIM} both in terms of spatial and biomass criteria, where the latter is based on scaling of historical high catches to obtain an approximation of unfished biomass.

Note also that the agreed biomass criterion (that all times, the closed areas must contain a total biomass not less than 500t, as estimated by surveys) replaces an earlier biomass criterion which stated that "Total surveyed biomass must be $\geq B_{LIM}$ approximating 20% of B_0 based on scaling of historical high catches". This is actually inconsistent with the intent of the Policy, as it implies that fishing may occur when total survey biomass is at the limit reference point – which would immediately and undesirably drive the stock below B_{LIM}. Additionally, the earlier criterion specified that a range of B_{LIM} values would be presented

based on various scalings of historical high/average catches, and that this would be refined on economic grounds, by considering the minimal acceptable harvest when B_{LIM} is equated to catch and divided among licences. This was replaced with the absolute value of 500t, which was based on the lower values obtained from the catch-scaling exercise, because a range of values against a B_{LIM} is somewhat meaningless. The main issue is defining a minimum level of stock that should be protected, giving considering to the levels of biomass from which the fishery has historically recovered].

Survey design

As at 2007, the fishery is assumed to be below B_{LIM}. Prior to the opening of the fishery, a comprehensive survey is required to obtain an understanding of the current stock status and thus inform the harvest strategy.

Due to resource limitation, it is proposed that this survey be undertaken as a two-stage process: 1) a broad-scale "sweeping" survey of areas known to contain historically fished beds, in order to determine general scallop availability and location, followed by 2) a more focused/directed survey to estimate scallop biomass in each location where scallops were found to be present. Doing this as a single survey would result in days being lost when a "bed" is discovered, and hence the risk that the entire fishery may not be covered in the allotted time.

1. Broad-scale "sweeping" survey to ascertain what is where: ideally with coverage of entire fishery. Overriding caveat: no survey implies zero biomass assumption implies zero fishing

a. Approach industry re: willingness GIVEN a transparent survey design (i.e. give industry opportunity to show desire for best practice)

b. If industry reluctant/not willing to undertake survey tows in western Bass St., then assume zero biomass from the west (and this area remains closed). This will imply more conservative overall performance indicators. Note also that it may be logistically sensible to manage the east and west of Bass St. as two separate zones [but NOT in an environmental/stock structure sense], given the historical paucity of scallops in western Bass St., together with its general inaccessibility.

Based on the results of the sweeping survey:

- if ≤1 scallop bed is found, the fishery remains closed, to be revisited later with another sweeping survey
- Otherwise:

2. More focused/directed and "opportunistic" surveys allowing estimation of biomass

- Based on results of broad-scale/sweeping survery, MAC to dictate areas to be more intensively surveyed in order to obtain biomass estimates

- Opportunistic: as vessels pass through an area, undertake *x* tows (certain areas would lend themselves to opportunistic surveying as they lie on "trade routes")

- OR direct vessels to fish in designated areas for *y* days, with a reimbursement of a set amount of research quota

- having industry undertake these surveys sets a good precedent – the Tasmanian system works due to industry faith and responsibility. Must include Victorian vessels in these surveys

- must be pragmatic and transparent in terms of risk, AND must build in processes whereby there is reasonable chance of allowing industry to capitalise on transient opportunities (particularly given the natural variability inherent in scallop populations) in order to break even.

For example, major (sweeping) surveys might be required every 3-5 years (should be explicitly stated), noting that the fishery is closed unless fulfilling the criteria for opening, as determined by voluntary surveys of potentially viable areas. The sweeping surveys should not be too onerous. Exploratory fishing under scientific permit should be on the proviso that no catch is permitted to be kept. A closed fishery should provide an incentive for fishers to inform management when viable areas are discovered.

Background notes from initial harvest strategy discussions: broad options initially considered for spatial management

The following outlines the broad options for spatial management that were initially formulated and presented for discussion at a stakeholder/MAC meeting in November 2006.

The acknowledged requirement for spatial management (Ward *et al.* 2001; Gell and Roberts 2003; Halpern 2003; Beukers-Stewart *et al.* 2005), together with the success of the Tasmanian management system (Haddon *et al.* 2006), implied that the focus for harvest strategy development was always based around a spatial management regime. The existing Commonwealth spatial management system was effectively a harvest strategy, albeit with some inconsistencies against the intent of the Policy. Moreover, the existing Commonwealth spatial management system was considered to have been unsuccessful to date, and, as the fishery was currently closed, this provided an opportunity to consider alternative spatial management options, as outlined below. However, many of the existing rules relating to season, size limit and discard rate were able to be incorporated in the harvest strategy.

Note that at the November 2006 stakeholder meeting, options 1a) and 1b) below were rejected outright. Option 2a) was rejected as it provided no incentive to explore and report new beds. Option 2b) would need to be robust to variability in recruitment, or able to accept this [noting that high spatfalls and abundance in known beds have fortuitously augmented the success of the Tasmanian system to date]. At this meeting, the preferred option of a closed fishery with viable areas sequentially opened to fishing, and described in detail in the "Harvest Strategy Overview" section, was formulated.

1a. Close a large area, e.g. 40% (suggested as an indirect proxy target reference point given the $B_{MSY} \approx 0.4B_0$ target reference point of the late-2006 version of the draft Policy) of the historically fished area. Management could then be

i. Rotational (adaptive) without information, i.e. fixed/pre-specified areas

ii. Fixed (not rotational)

Advantages:

- low cost of little required information, preservation of spawning biomass (spatial proxy), low management costs, including cost-effective compliance, preservation of juveniles & habitats, protects economic efficiency

Disadvantages:

- missed opportunities, may not reflect standing stock (i.e. closure may need to be larger than 40% of fished area), no voluntary information, lack of updated knowledge, lack of opportunistic surveys, not adaptive if things change, if beds are very scarce, rotational harvesting may not be helpful.

1b. Close a large area – open areas rotationally based on information

Advantages:

- allows for learning by being adaptive, better marrying of fishery to resource, potentially increased yield, greater security of resource, more vested interest in self-regulation, incentive for information flow

Disadvantages:

- costs of information

2. Adaptive spatial management:

The following have the common factor of focusing on the closure/opening of specific areas at the size of the scallop bed.

a) Fishery open with certain beds closed (e.g. ~80-90% of total area open, as per the current Commonwealth practice)

[Note that the number of BEDS closed should ensure an adequate level of stock protection – e.g. 40% of beds as an indirect proxy target reference point given the $B_{MSY} \approx 0.4B_0$ target reference point of the late-2006 version of the draft Policy].

Advantages:

- Relatively inexpensive due to large area of Central Zone
- Would not need to change current arrangements
- Cheaper to search for single bed and close it, than to search out a number of beds and choose which ones to open.

Disadvantages:

- Has led to boom & bust
- No real incentive for fishers to survey

Other:

- Closed beds would have to equate to adequate stock protection to meet intent of Policy
- How often are there sufficient numbers of beds to enable some to be opened and some closed?
- Beware of expectations given historical patterns when those historical patterns always led to collapse.
- Beware "Rolls Royce" management if the fishery will not have many participants, and the fishery is an adjunct to other fisheries. Shifts in the perception of the fishery will colour the Harvest Strategy. Is the Bass Strait scallop fishery best viewed as a supplement to other fishing activities?

b) Fishery closed (e.g. 80-90% closed?) with certain beds open (as per the current Tasmanian system)

This is a system of informed spatial management where voluntary pre-season surveys are undertaken to determine which beds are able to be opened to fishing. Beds are then opened on a rotational basis.

Advantages:

- Incentives for learning
- Currently works well in Tasmanian fishery
- Beds protected until ready for harvesting

Disadvantages:

- Relatively expensive if stock status is poor (if not the expense is negated by quota), due to the ongoing survey requirement associated with informed rotational spatial management.
- Unclear if this approach is appropriate for Bass Strait, given its large size (due to the high associated survey costs) and whether multiple beds occur (it is impossible to implement rotational harvesting if the fishery is reduced to a single bed, unless the bed is sub-divided).

Other:

- This represents a marked shift in the management approach, but given that the fishery is currently closed, this may facilitate an easier transition.
- Research quota to be allocated so that fishers can undertake exploratory surveys?
- Is Bass Strait boom and bust by nature? It has possibly exhibited this pattern only because it has been so heavily fished that a single year class only is available in each fishing event, resulting in boom and bust behaviour. It is unlikely that stakeholders would want to return to original catch levels.
- If beds are very scarce, rotational harvesting may not be helpful.

Adaptive spatial management at the scale of the scallop bed (2) is preferable to closures of, or rotations about large areas (1), as it is based on more information (i.e. actual beds), than that associated with closing a large proportion of the fished area.

Process for review

A qualitative evaluation of this harvest strategy should consider the following:

- Outcome of initial survey- is there now more than one "viable" scallop bed in Bass Strait?
- Effectiveness of size of unit areas – is 5nmx5nm practical, in terms of opening these areas sequentially?
- The biomass-based B_{LIM} criterion – how does this play out in practice, when confronted with survey estimates of available biomass? Is the approach yielding values consistent with what survey outcomes suggest regarding the status of the stock?
- Given the cost of ongoing surveys to assess the condition of known scallop areas, and the size of Bass Strait, will the proposed spatial management approach be economically feasible? As at October 2007, industry members of the MAC voted unanimously to oppose the proposed reconnaissance survey, as they believed it was not an economically viable exercise, even if it yielded results that could lead to the fishery being re-opened.

A more quantitative evaluation of the performance of the harvest strategy against the stock status and the Policy reference points cannot occur until i) a survey has been undertaken and

ii) results from a survey lead to the fishery being re-opened. At such a time, the extent of evaluation able to be undertaken will depend on the GVP of the fishery and hence the available funds.

Meanwhile, the status of the state-based fisheries should be monitored, as should the progress of the Tasmanian Aquaculture and Fisheries Institute Project seeking to resolve the issue of stock structure. If there is strong evidence of a single stock in Bass Strait, the harvest strategy should be reviewed with a view to adopting a unified strategy across the three management jurisdictions.

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