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A risk assessment and prioritisation approach to the selection of indicator species for the assessment of multi-species, multi-gear, multi-sector fishery resources

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ABSTRACT

Assessing the stock status of mixed and/or multi-species fishery resources is challenging. This is especially true in highly diverse systems, where landed catches are small, but comprise many species. In these circumstances, whole-of-ecosystem management requires consideration of the impact of harvesting on a plethora of species. However, this is logistically infeasible and cost prohibitive. To overcome this issue, selected 'indicator' species are used to assess the risk to sustainability of all 'like' species susceptible to capture within a fishery resource. Indicator species are determined via information on their (1) inherent vulnerability, i.e. biological attributes; (2) risk to sustainability, i.e. stock status; and (3) management importance, i.e. commercial prominence, social and/or cultural amenity value of the resource. These attributes are used to determine an overall score for each species which is used to identify 'indicator' species. The risk status (i.e. current risk) of the indicator species then determines the risk-level for the biological sustainability of the entire fishery resource and thus the level of priority for management, monitoring, assessment and compliance. A range of fishery management regimes are amenable to the indicator species approach, including both effort limited fisheries (e.g. individually transferable effort systems) and output controlled fisheries (e.g. species-specific catch quotas). The indicator species approach has been used and refined for fisheries resources in Western Australia over two decades. This process is now widely understood and accepted by stakeholders, as it focuses fishery dependent- and/or independent-monitoring, biological sampling, stock assessment and compliance priorities, thereby optimising the use of available jurisdictional resources.

1. Introduction

Most fishery management systems and their stock assessments focus on single species or stocks to enable sustainable management. Many of the world's fisheries however are mixed or multi-species [32,4], where a diverse range of species are caught together by the same gear at the same time [42,45]. For such fisheries it is impractical and unrealistic to assess and manage every species separately using traditional methods [46,49].

Cost effectively dealing with the difficulties of assessing and managing mixed or multi-species fisheries is not restricted to those in developing countries, as this is a common issue facing these fisheries world-wide [45,48]. For example, despite the large size (~109,000 t in 2011) and high value (~US$54 million) of the Pacific Coast Groundfish fishery that operates along the coasts of Washington, Oregon and California (USA) [40] only 1/3 of the 90 species retained by this fishery have formal stock assessments [33, 9, 4].

While multispecies models are being used in some locations to predict the effects of exploitation on species composition, size structure, and biomass (e.g. the Baltic Sea [43]); the majority of mixed or multi-species fisheries are still essentially managed using traditional single-species maximum sustainable yield (MSY) approaches (see [48,45]). For example, in the North Sea, mixed-fisheries considerations are based on species-specific stock assessments combined with knowledge of the catch composition. Five scenarios are presented, taking into account the single-stock advice for fisheries catching Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), saithe (*Pollachius virens*), plaice (*Pleuronectes platessa*), sole (*Solea solea*),

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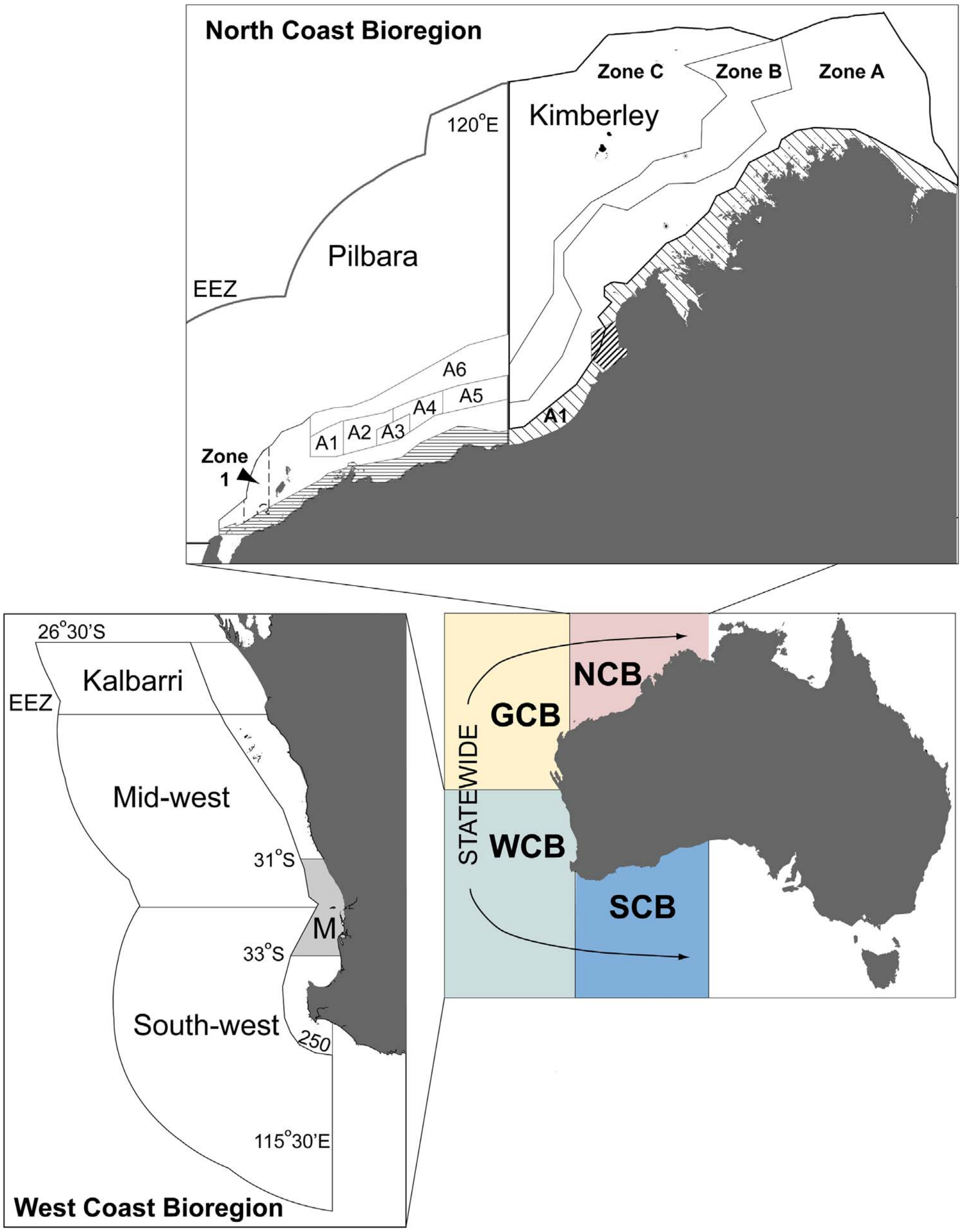

Fig. 1. The marine bioregion boundaries of Western Australia are based on broad ecological characteristics to facilitate management, monitoring and assessment. These include the North Coast Bioregion (NCB), Gascoyne Coast Bioregion (GCB), West Coast Bioregion (WCB), South Coast Bioregion (SCB) and Statewide (covering all marine bioregions). The NCB inset depicts the location of the demersal scalefish fisheries. In the Pilbara subregion: Areas 1–6 (A1-A6) refer to the management regions in Zone 2 of the fish trawl fishery. Zone 1 has been closed to fish trawling since 1998. In the Kimberley subregion: Zones A, B and C lie in Area 2 of the NDSF. Area 1 (A1) of the NDSF represents the nearshore zone extending from the coast out to a line approximating the 30 m depth contour (see [38]) for more information). The WCB inset depicts the three areas of the West Coast Demersal Scalefish Fishery (Kalbarri, Mid-west and South-west) which extend from the coast to the Exclusive Economic Zone (EEZ) and the Metropolitan Area (M) which is closed to commercial demersal scalefish fishing and extends from the coast to the 250 m contour.

turbot (*Scophthalmus maximus*) and Norway lobster (*Nephrops norvegicus*) [24]. None of the five scenarios are aimed at achieving MSY simultaneously for all stocks. Furthermore, the most conservative scenario, the "cod" scenario, results in all other species being fished at or below F_{MSY}. The preferred scenario that is selected each year depends on the required management objectives (e.g. to re-build Atlantic cod stocks), rather than being true mixed or multi-species fisheries management.

Management of mixed or multi-species fisheries is further complicated as stock assessments are not readily available for all exploited stocks [3,5]. For example, < 50% of federally managed stocks in the USA have stock assessments [1,33]. Similarly, the International Council for the Exploration of the Sea (ICES) provides advice for approximately 200 stocks, of which, 122 are considered data-limited and are assessed using only qualitative methods [23]. One approach to managing mixed or multi-species fisheries is to form stock complexes. Stock complexes are groups of species with a similar geographic distribution, life history, and vulnerability to fisheries (see [46,4]). Grouping species in this way allows management measures to be applied to a group of species that are caught together and respond in a similar way to fishing pressure removing the need for assessments of every retained species. For example, in the USA Pacific Groundfish Fishery only 1/3 of these stocks have traditional assessments, while the remainder are managed in 5 species complexes [33,4].

In Western Australia, demersal scalefish fisheries are mixed or multi-species (> 50 species in each fishery) and are also multi-sectoral (commercial, recreational, charter and customary; e.g [11,12,34,35,36,38,17]). Western Australia's demersal fisheries are relatively small scale (individual fisheries < 3000 t), low value ($15 million) and data limited compared to demersal fisheries in other regions of the world [16,2,27]. Given the retained species for these fisheries include assemblages of more than 50 species, it is cost prohibitive to individually manage or assess each species. Instead they are assessed and managed using an indicator species approach. The development of this cost-effective approach required a process to identify which species should be the focus of monitoring and assessment programs that could be used as the basis for making holistic management decisions for the entire assemblage.

The multi-species nature of the demersal scalefish fisheries in the north of Western Australia meant that it was necessary to select several key species as indicators of the response of the exploited stocks to