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Estimates of variability of goldband snapper target strength and biomass in three fishing regions within the Northern Demersal Scalefish Fishery (Western Australia)

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ABSTRACT

Goldband snapper (*Pristipomoides multidens*) is an ecologically and economically important species in the Northern Demersal Scalefish Fishery (NDSF). The *Carolina M*, a trap fishing vessel operating in the NDSF, was equipped with Simrad ES70 echosounders, operated at 38 and 120 kHz. In 2014 acoustic data, in combination with optical recordings of the catch, were opportunistically collected during routine fishing operations. In December 2014 pure, low density goldband snapper schools were observed on the echograms. *In situ* target strength (*TS*) estimates were derived and linked to length distributions of catch information with the curve fitting method. Estimated *TS*-Length *(L)* at 38 kHz was 20.1 $\log_{10}(L)$-70.5 and 16.4 $\log_{10}(L)$-77 at 120 kHz. Three fishing grounds, where near simultaneously recorded acoustic and optical information was available were selected. Fish school densities observed within the 38 kHz acoustic data were disaggregated according to catch proportions using kriging. Goldband snapper density estimates ranged between 9518 individuals per nmi^2 in the high-density fishing region and 2512 and 945 individuals per nmi^2 in the two low density fishing regions. Sampling variance was estimated using geostatistics (coefficient of variance, CV = 10–20.9%). Other errors considered were signal-to-noise ratio (CV < 1%), variation in the acoustic signal due to fluctuations in temperature and salinity (CV = 0.5–1.15%), effects of diurnal vertical migration and variability of catch information (CV = 1.2–2%). A total CV of 28.2–50.6% was estimated for all considered sources, for the three fishing regions.

1. Introduction

Goldband snapper (*Pristipomoides multidens*), a member of the Lutjanidae family, is widely distributed within the tropical waters of the Indo-Pacific (Allen, 1985; Newman and Dunk, 2003). It is described as long-lived (up to 30 years) and exhibits low levels of natural mortality (M), with M ranging between 0.10 and 0.14 (Newman and Dunk, 2003). It reaches sexual maturity at a relatively late stage, growing rapidly until age 9 and reaching a maximum length of ~80 cm at ~18 years of age (Newman and Dunk, 2003). Given these life history traits goldband snapper are considered vulnerable to overfishing (Newman and Dunk, 2003). In Western Australia (WA), goldband snapper occur as far South as Cape Pasley (34°S) and are commercially targeted north of the Ningaloo Reef, around Exmouth (23°30′S) (Kailola, 1993). Goldband snapper, together with red emperor (*Lutjanus sebae*), are considered indicator species (*i.e.* species that are considered ecologically important and reflective of the ecosystem characteristics and condition) in the Northern Demersal Scalefish Fishery (NDSF), located in waters off the coast of Broome in Northwest Australia around to the WA-Northern Territory border (Marriott et al., 2013). The NDSF is a trap-based mixed fishery, covering a large area of approximately 408,400 km^2, of which the main fishing effort is concentrated over 226,500 km^2 (Newman et al., 2008).

The NDSF is a relatively low value fishery (approximately 7 million AUD in 2013, Newman et al. (2015)) covering a vast, remote area. Funds for monitoring this resource are limited, in relation to its size, which restricts the ability to conduct effective fisheries ecosystem monitoring with traditional techniques (*e.g.* daily egg production method or trawl surveys). Fisheries acoustics is identified as one of the most promising tools for establishing an ecosystem-based approach

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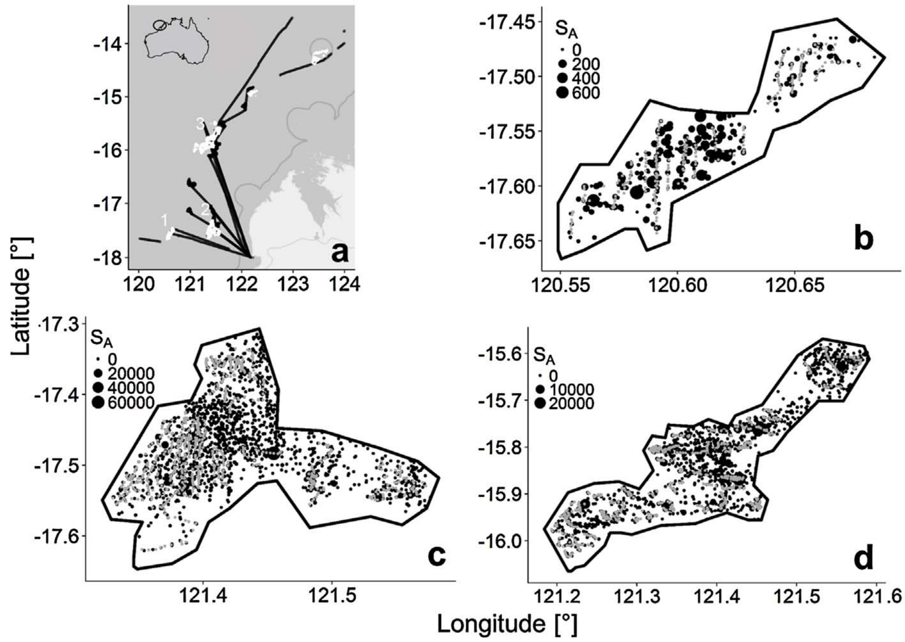

Fig. 1. a) Map of waters of the Northwest coast of Australia that include the Northern Demersal Scalefish Fishery showing example cruise tracks (black lines) of Carolina M. The white lines show the locations of three fishing regions represented in b) Region 1, c) Region 2 and d) Region 3. The black circles show the acoustic density (Nautical Area Scattering Coefficient, s_A in $m^2\ nmi^{-1}$) and the grey circles show catch locations.

to fisheries management (EBFM) (Koslow, 2009; Trenkel et al., 2011). Active-acoustic methods are considered standard practice for studying a diverse range of marine animals, *e.g.* fish, birds and zooplankton (Kloser et al., 2002, 2009; Simmonds and MacLennan, 2005; ICES, 2015; Campanella and Taylor, 2016). Many commercial fishing vessels are now fitted with scientific echosounders (*i.e.* echosounders which can be calibrated and can store data). This enables fishers to collect acoustic data continuously whilst at sea. Such vessels are often termed 'vessels of opportunity' (Dalen and Karp, 2007; Ryan et al., 2015; Fässler et al., 2016). Combining acoustic (*e.g.* density estimates) and catch data (*e.g.* species, length and weight distributions) collected on board fishing vessels could improve our understanding of the marine resources in the NDSF. This information can help to optimise survey strategies and deliver abundance indices for use in assessment models (Barbeaux, 2012; Fässler et al., 2016).

To convert acoustic density estimates into fish abundance or biomass, *a priori* or *a posteriori* knowledge of the mean target strength (*TS*, in decibels [dB re 1 m^2]) must be available for the size range and species being studied. *TS* is a logarithmic measure of the amount of acoustic energy backscattered from an individual target, usually related to fish length as *TS-L* (Simmonds and MacLennan, 2005). When fish aggregate, echo-integration (Dragesund and Olsen, 1965) can be used to estimate their density (MacLennan et al., 2002). To translate this acoustic density into estimates of biomass or abundance, alternative sampling data (*e.g.* video footage or hand lining; Fernandes et al. (2016)), to verify acoustic observations, is required. This is typically in the form of biological samples, obtained from trawls in traditional acoustic trawl surveys (AT).

Reductions in total allowable catch (TAC), total allowable effort (TAE) and limitations in the available resources for monitoring creates a need for low cost sampling strategies in multiple fisheries, as an alternative to traditional techniques. Here, we combine opportunistically collected echosounder and catch data, obtained on board the commercial fishing vessel *Carolina M* in the NDSF, in 2014, during routine operations. The aim was to deliver an acoustic assessment of goldband snapper in three fishing regions within the NDSF, with associated error estimates. Sampling error was assessed through the application of geostatistical methods (Rivoirard et al., 2000; Gimona, 2003; Woillez et al., 2009; Scoulding et al., 2016). Other sources of error considered were fluctuations in acoustic backscattering properties due to changes in the environment (temperature and salinity), behaviour (diel vertical migration, DVM), detection probability through estimates of signal-to-noise ratio (r_{sn}) and the associated error. Total random error was estimated through bootstrapping.

2. Methods

2.1. Study area

The NDSF extends over a vast area (Fig. 1), composed of smaller, spread out, preferred fishing regions. Generally, fishers revisit those fishing grounds, considered to be the most productive areas, on a regular basis. This study focuses on data collected on board a commercial fishing vessel, *Carolina M*, during normal commercial operation. Fishing grounds could easily be recognised through the availability of high density catch and acoustic data. During time of data collection, three such regions could be identified and were delineated through manually drawn polygons. This study, focussed on goldband snapper within these three regions of interest (Fig. 1b–d).

Region 1 was located in the southwest (area (A) = 33 nmi^2, mean depth ($\overline{d_w}$) = 124 m (water depth range (d_r) = 120–130 m)) (Fig. 1b), Region 2 was located in the southeast (A = 129 nmi^2, $\overline{d_w}$ = 78 m (d_r = 61–90 m)) (Fig. 1c), and Region 3 was located in the more central part (A = 211 nmi^2, $\overline{d_w}$ = 91 m (d_r = 76–103 m)) (Fig. 1d) of the NDSF. Data within each region were collected at different times in 2014 (Region 1: 3rd –7th December, Region 2: 29th October–8th November and Region 3: 19th–30th August).

Salinity (s_w) and temperature (t_w) information were retrieved from the CSIRO Atlas of Regional Seas (CARS), an atlas of seasonal ocean water properties, based on research vessel instrument profiles and autonomous profiling buoys (Ridgway et al., 2002). Data were retrieved for August, November and December at 121.23°E and 15°S. Mean temperatures and salinities fluctuated within the different months of data collection (Table 1). In November, the mean t_w at 10 m was 27.47 °C and in August the t_w was 23.51 °C at 100 m. The mean s_w were 34.53 ppt at 10 m in November and 34.62 ppt at 100 m in August.