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Evaluation of fishery-dependent sampling strategies for monitoring a small-scale beach clam fishery

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ABSTRACT

This study examined industry logbooks, and beach- and port-based fishery-dependent data sources for monitoring and assessing catch, effort, catch-per-unit-of-effort (CPUE) and size compositions of beach clams in a small-scale fishery in eastern Australia. The study was conducted across the six-month fishing season and encompassed two management regions, serving as a model for elsewhere. In general, values of catch, effort and CPUE did not differ significantly between logbooks and beach sampling, and spatial and temporal trends in examined indices were similar across both data sources. Beach sampling captured additional data that included the partitioning of fishing effort into search and dig time, and also the number and location of sites fished each day, which could be useful in addressing uncertainty in CPUE-clam density relationships and potential fishing impacts, and assist in spatial management of fishing across beaches. These data could be future sourced from industry and provided on modified logbooks. Compared to port sampling, the beach-based size composition data appeared to be biased and influenced by fisher behaviour. Cost-effective future monitoring of the fishery could be conducted using a combination of logbooks for catch and effort that includes strategic periodic validations using beach-observers, and port sampling for size compositions. The success of such a strategy is reliant on strong fisher cooperation that requires open co-management arrangements. Future assessments of the beach clam resources need to account for inherent differences in populations across individual beaches, including non-fished (control) beaches.

1. Introduction

Fishery-dependent sampling strategies such as industry logbooks, and boat- and port-based sampling of catches are commonly used as a primary means to monitor and assess many commercial fisheries and harvested species (Ricker, 1975; Hilborn and Walters, 1992). The data collected in such sampling schemes are typically used to assess trends across time and space in catches, catch-per-unit-of-effort (CPUE), and sizes and ages of organisms. Ideally, the appropriateness, cost-benefits and inherent biases associated with each data collection scheme need to be understood and assessed prior to long-term implementation. This is particularly pertinent to the many small-scale, low monetary valued (and typically data-poor) fisheries for which all but the basic monitoring is often logistically and cost prohibitive, and any form of cost recovery limited.

For many such fisheries, the only (if any) data available are the landed catch information supplied by harvesters, and this is often of limited value for population and fisheries assessments and management (Castilla and Defeo, 2005; Salas et al., 2007; Defeo et al., 2014). Typical of such scenarios are various fisheries for beach clams (Bivalvia: Donacidae, Mesodermatidae, Veneridae). Beach clams are harvested for food and bait on sandy beaches worldwide, but many populations have been depleted due to over exploitation, primarily because they are easily accessible, simple and cheap to harvest, and harvesting has been largely unregulated (McLachlan et al., 1996; Defeo, 2003). Beach ecosystems are also subject to much other anthropogenic and environmental stressors, further impacting clams (Defeo et al., 2009; Ortega et al., 2012). Determination of appropriate management arrangements in such fisheries is difficult, and the data streams and data collection strategies for long-term monitoring and management often have not been assessed.

This study evaluated alternative fishery-dependent data sources for monitoring a small-scale beach clam (*Donax deltoides*) fishery in eastern Australia. The species has a substantial history of indigenous, and more recently recreational and commercial, exploitation (Ferguson et al., 2014). Commercially exploited populations have displayed considerable fluctuations in production, with notable declines and recent management interventions across the

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different management jurisdictions (Gray et al., 2014; Ferguson et al., 2014; Gray, 2016a,b). Clam harvesters that participate in the New South Wales (NSW) commercial fishery currently provide catch and effort information via logbooks, but other fishery-dependent data streams such as beach and port-based sampling of catches, which can also provide data on size compositions of catches, warrant investigation as potential data sources for long-term monitoring. Such strategies have been successfully implemented in other regional small-scale fisheries (Gray, 2008).

Specifically, catch, effort and CPUE data supplied by industry logbooks were compared with those obtained from beach-based sampling, and similarly size composition data of catches from port- and beach-based samples were contrasted. This was done across two regions to test the generality of results and was part of a broader study to assess both fishery-dependent and -independent strategies to monitor and assess beach clams (Gray et al., 2014; Gray, 2016a,b,c). This study serves as a model for other small-scale fisheries and the alternative fishery-dependent data sources are discussed in terms of their value and cost-efficiencies for future population and fishery monitoring and assessment.

2. Materials and methods

2.1. Fishery overview

The commercial fishery for beach clams in NSW developed throughout the 1950s, and through a period of unrestricted fishing regulations, the numbers of clam harvesters and beaches accessed increased until total production peaked at 670,000 kilograms (kg) in 2001. This was followed by a sharp decline in commercial landings to 9000 kg in 2011, despite increasing product prices and markets (Rowling et al., 2010). Recreational and indigenous catches throughout this period were also unrestricted and unchecked, and were probably large across many beaches (Murray-Jones and Steffe, 2000; Henry and Lyle, 2003). Although the reasons for the rapid decline in commercial catches remain unclear, and potentially related to beach conditions and environmental variability, unrestricted harvesting probably contributed (Ferguson and Ward, 2014).

In response to the decade of decline in commercial catches of clams, several management initiatives designed to substantially reduce commercial fishing effort and harvest, and therefore halt further population declines were introduced to the NSW fishery in 2012. These included a six-month total commercial fishing closure, spatially-explicit commercial fishing closures of whole beaches and specific zones along particular beaches, a maximum daily catch quota of 40 kg per-commercial fisher, and a minimum legal size limit (45 mm shell length, SL). Concomitant restrictions to recreational and indigenous fishers were also introduced, but these were primarily in response to concerns over human health issues associated with bio-toxins. These latter two groups can still harvest clams year-round across most beaches, but this is limited to 50 clams per day for immediate in-situ bait use only (unless for specific indigenous cultural events). The current combined harvest from these two sectors is therefore considered to be much smaller than the commercial harvest (Murray-Jones and Steffe, 2000; Rowling et al., 2010). Harvesting of clams by all sectors is restricted to digging by hand, with no mechanical apparatus permitted.

The NSW commercial beach clam fishery is presently compartmentalised into seven designated regions, with clam harvesters being able to access specified beaches within each region. However, the number and sizes of permitted fishing beaches, along with the numbers of commercial harvesters and hence commercial production, differ greatly among regions. Currently, there are 76 license endorsements to harvest clams in NSW and the current value of the commercial fishery is approximately $AUD 2 million per annum (Rowling et al., 2010).

2.2. Sampling strategy

This study was done throughout the 2013 fishing season (1 June to 30 November) across two commercial beach clam fishing regions in NSW: Region 1 (latitude 29°00′–29°15′S), which solely comprised one commercially fished beach (South Ballina, length 30 km), and Region 3 (latitude 29°45′–31°44′S) that encompassed several commercially fished beaches (the main three being: Smoky, 16 km; Killick, 12 km; and Goolawah, 7 km). The field sampling and analyses were stratified at the spatial management level of Region, as opposed to individual beaches. This was also necessary for logistic purposes for the beach-based sampling component because it was not possible to accompany fishers across any predetermined beach as they often moved among beaches depending on beach conditions and clam densities. Three fishery-dependent data streams were assessed; industry logbooks, and beach- and port-based sampling of catches.

2.2.1. Industry logbooks

Commercial fishers are mandated to report to the NSW Government the beach and region, effort in hours spent harvesting (time on beach) and the total retained catch (kg) of clams for each day of fishing each month.

2.2.2. Beach-based sampling

A scientific observer accompanied a commercial clam harvester on four (Region 1) or five (Region 3) randomly selected fishing trips (days) each month during the fishing season. The exception was in Region 1 when only one day was sampled in October due to the fishery being predominantly closed because of bio-toxins in water samples. For Region 3, observed trips covered the three predominantly harvested beaches: Smoky, Killick and Goolawah. On each trip the observer recorded the time spent searching and that actively digging clams (minutes), the number, location (GPS) and habitat (swash versus dry sand) of each harvesting event, and the total retained and discarded catch (kg) and sizes (shell length—SL, mm) of clams.

2.2.3. Port-based sampling

Retained clam catches were sampled for size composition on a weekly basis at a local cooperative in Region 3 throughout the study. The shell length (mm) of all clams in 1 kg subsamples of available catches (generally 2 or 3 per sampling day) were measured and pooled to form a monthly total size composition.

2.3. Analyses

Permutational analyses of variance (PERMANOVA, Anderson et al., 2008) was used to test for differences between data collection strategies. Three factorial analyses with the levels data source (i.e., logbook v beach), Region and Month were used to test for differences in fishing effort (hours per day) and CPUE (catch-per-day and catch-per-hour/day). A two factor design tested for differences in size compositions of catches between the port- and beach-based samples (Factors: Data and Month) obtained in Region 3, and between the beach-based samples obtained across both regions (Factors: Region and Month). Two factorial PERMANOVA were also used to test for differences between regions and across months in the time spent searching and digging for clams, the number of locations (patches) of clams fished per day, and the ratio of retained to discarded clams in observed (beach-based) catches. All factors were considered fixed and each univariate analysis was based on the