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Developing a national spat collection program for pearl oysters in the Fiji Islands supporting pearl industry development and livelihoods

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ABSTRACT

Cultured pearl farming in Fiji relies on wild spat collection to supply the oysters used for pearl production. This supply can be inconsistent and a research program was implemented to determine recruitment of pearl oysters to spat collectors at sites throughout Fiji as a basis for developing a national spat collection program to improve reliability of oyster supply to the industry. Twenty-nine sites across Fiji were used in this study. Spat collectors consisted of a 100 m longline from which 310 individual spat collectors were suspended. Spat collectors were deployed for a period of 10–15 months when the number of pearl oyster (*Pinctada margaritifera* and *Pteria penguin*) spat attached to each collector was counted and shell size recorded. A total of 5478 *P. margaritifera* juveniles were collected from all sites with the highest number of recruits (693) and the highest number of recruits per collector (2.10 ± 0.17) occurring at Nacobau (Vanua Levu). The largest mean dorso-ventral measurement (DVM) of *P. margaritifera* at any site was 8.61 ± 0.30 cm while the smallest was 4.26 ± 0.13 cm. Some sites did not record any *P. margaritifera* recruitment during the study and these were generally sites with relatively turbid water. A total of 4224 *Pt. penguin* were collected from all sites, with the highest number of recruits (495) recorded from Namarai (Viti Levu). The mean DVM of *Pt. penguin* ranged from 7.53 cm to 13.62 cm across sites. Results indicate that *Pt. penguin* have greater tolerance of more turbid inshore sites than *P. margaritifera* based on greater levels of recruitment at these sites. Results identified sites supporting high levels of pearl oyster recruitment as a basis for an ongoing national spat collection program, and support better targeting of spat collection activities that maximise oyster supply to the Fijian pearl industry. The national spat collection program will generate significant livelihood benefits across Fiji and support continued expansion of the Fijian cultured pearl industry.

1. Introduction

Cultured pearls are the Pacific region's highest ranking and highest priority aquaculture commodity (Secretariat of the Pacific Community, 2007). Pearl culture is compatible with traditional lifestyles and provides opportunities for income generation at a number of levels. Individuals may be directly involved in pearl farming, with supply of pearl oysters to pearl farms, and with associated handicraft industries that offer particular opportunity for income generation for women and younger people. Indeed, pearl culture has been introduced to some atolls in French Polynesia to address sociological problems such as depopulation and unemployment (Southgate et al., 2008). Pearl culture itself is environmentally 'benign' and the products are ideal export commodities for Pacific island countries as they are small, light-weight, non-perishable and of high value.

Pearl aquaculture has gained increasing attention in western Pacific countries over the past two decades. The Fiji Islands, for example, has produced cultured pearls since 2000 and has developed an international reputation for some of the finest round pearls from the black-lip pearl oyster, *Pinctada margaritifera* (Anon, 2007; Southgate et al., 2008). The cultured pearl industry in Fiji is now diversifying and production of half-pearls (mabè) from the winged pearl oyster, *Pteria penguin*, has also received attention (Chand et al., 2015; Kishore et al., 2015). However, the lack of a continuous and reliable supply of pearl oysters to pearl farmers utilizing both *P. margaritifera* and *Pt. penguin* is a major bottleneck to further development of the Fijian cultured pearl industry, and has restricted significant increases in the volumes of pearls exported from Fiji, to meet increasing demand.

Atolls enclosing large lagoons in French Polynesia and the Cook Islands experience limited water exchange with the open ocean and this

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restricts dispersal of pearl oyster larvae beyond the lagoons (Coeroli et al., 1984; Gervis and Sims, 1992; Sims, 1993; Friedman and Bell, 1999). 'Spat-collectors' provide a substrate to which pearl oysters recruit (Gervis and Sims, 1992; Haws, 2002; Southgate, 2008). They may be composed of natural materials such as tree branches, oyster shells and pieces of coral, or plastic materials including shade-cloth and frayed rope (Southgate, 2008). Spat collectors are deployed into lagoon waters when oyster larvae are abundant, and resulting juvenile pearl oysters can then be cultured to a size suitable for pearl production. In contrast, the continental islands of western Pacific countries are characterised by open reef systems that are well flushed by ocean currents and support lower levels of pearl oyster recruitment than the lagoons of Polynesia (Friedman and Bell, 1999). Under such conditions, research to determine site-specific levels of pearl oyster recruitment are required to inform and improve efficiency of spat-collection efforts. A number of studies have reported on pearl oyster spat collection in western Pacific countries including the Solomon Islands (Friedman et al., 1998; Friedman and Bell, 1999; Friedman and Bell, 2000) and Australia (Beer and Southgate, 2000), but information on pearl oyster spat collection in Fiji has not previously been reported.

Pearl farming in Fiji became best established in Savusavu Bay on the second largest island of Vanua Levu (16°44′43″S, 179°19′20″E). The industry was established using oysters obtained from spat collectors and a number of sites supporting excellent recruitment were identified within the Bay. A standardised spat collection methodology, using commercially available spat collectors, has been developed, but sites supporting good spat collection outside Savusavu Bay have not yet been identified. The deployment period for spat collectors in Fiji varies because it is influenced by site access, which may be seasonally variable and weather dependent, as well as the availability of extension personnel from pearl farms or Fiji Fisheries Department to assist with harvesting and collection of oysters. Pearl farmers prefer to receive oysters that are close to pearl production size because this minimises their required husbandry inputs prior to pearl seeding. Because of these factors, spat collector deployment, for a period of at least 10 months prior to removal of resulting oysters, is standard practice in Fiji.

Supply of pearl oyster spat from spat collection is sometimes inconsistent and affected by weather phenomena such as Tropical Cyclone Thomas in March 2010. In order to mitigate the potential impacts of adverse weather systems on the Fijian cultured pearl industry, and to improve reliability of spat supply to the industry, the Department of Fisheries in Fiji implemented a research program to determine recruitment of pearl oysters to spat collectors at a number of sites throughout the Fiji Islands. The major goal was to establish a national spat collection program as a basis for industry expansion, and to disseminate the potential socio-economic benefits of pearl oyster spat collection. Both *P. margaritifera* and *Pt. penguin* recruit to spat collectors in Fiji, for example, providing spat collecting communities with the opportunity to generate income from sales of *P. margaritifera* to pearl farms, while retaining *Pt. penguin* for later production of half-pearls and pearl shell handicrafts.

The aim of this study was to determine recruitment of pearl oysters at 29 sites across the Fiji Islands using standard spat collection methods already used in Fiji. The data generated will identify sites with high recruitment rates, where future spat collection activities can be focused, and sites where recruitment is low, that do not justify further spat collection activity. Results will provide a basis for fine-tuning the Fijian national spat collection program, supporting improved availability of pearl oysters to pearl farmers, increased pearl production, and development of pearl industry based livelihoods.

2. Material and methods

2.1. Study sites and spat collection

Twenty-nine sites across Fiji were selected for this study (Fig. 1) that ranged in depth from 17 m to 39 m. All sites were either close to a coastal community or to an existing pearl farm. The spat collectors used in this study were purchased commercially (Honor Stand Enterprise Limited, Zhejiang, China). They were composed of lengths of black perforated plastic ribbon sewn concertina style (Haws, 2002) onto an 8-mm diameter black rope in lengths of 1 m (Fig. 2). Individual spat collectors were tied to a 12-mm diameter rope, making up the factory standard 200 m spat collector long line with a total of 620 spat collectors tied approximately 300 mm apart (Fig. 2). Each factory standard long line (200 m long) was cut in half so that the standard unit used in this study was 100 m long and contained 310 individual spat collectors.

Single spat collector long lines were deployed at each of the 29 study sites between August and December 2013. Long lines were deployed at a depth of 5 m at all sites and held in place by two 70–80 kg anchors attached to each end, with two additional 70–80 kg anchors attached to the middle of each long line. Five plastic 300 mm diameter buoys were used per long line to provide buoyancy and to maintain spat collectors at a depth of 4–5 m. Additional buoys of the same size were added later as required to provide extra buoyancy to counteract increased weight from oyster recruits and fouling organisms. Sites were visited on a monthly basis to maintain the spat collectors in good condition and carry out necessary maintenance work where required.

Spat collectors were deployed for a period of 10–15 months depending on logistic considerations. At the end of this period, the number of *P. margaritifera* and *Pt. penguin* spat attached to each spat collector was counted and the dorso-ventral (DVM) and antero-posterior (APM) measurements of each were recorded to the nearest 0.01 mm using a vernier caliper (Saucedo and Southgate, 2008). While fouling of spat collectors was not quantified when oysters were counted, notes were made of the predominant fouling organisms at each site.

2.2. Statistical analysis

The numbers of pearl oysters that recruited at different sites was tested for normality (Kolmogrov-Smirnov test) and homogeneity of variance (Levene's test). Because some sites did not record any recruits, there were a number of zero counts in the dataset requiring arcsinh transformation before one way-ANOVA, and Tukey's test was used to determine significant differences in the number of pearl oyster recruits at different sites. All analyses were performed using IBM SPSS Ver. 20 statistics software. Differences in the shell dimensions of pearl oyster recruits between sites were not analysed because the period of spat collector deployment varied between sites hindering exact determination of growth rates.

3. Results

3.1. Recruitment of Pinctada margaritifera

The mean (± SE) number of *P. margaritifera* recovered per spat collector at each of the 29 sites used in this study is shown in Fig. 3. A total of 5478 *P. margaritifera* juveniles were collected across sites with Nacobau recording the highest number of recruits (693) (Table 1) and the highest number of *P. margaritifera* per collector (2.10 ± 0.17) (Fig. 3). Some sites (e.g. Tavulomo A, Tavulomo C and Raviravi C) did not record any recruitment during the study (Table 1). Spat collectors at these sites were relatively clean with little molluscan recruitment or biofouling. The overall difference in the number of *P. margaritifera* between sites was highly significant ($P = 0.00$) with greatest difference ($P = 0.001$) recorded between Nacobau and Malake D/Malake F (Fig. 3).

The largest *P. margaritifera* with a mean DVM of 8.61 ± 0.30 cm were recorded from Namarai B, while the smallest (4.26 ± 0.13 cm) were from Vitawa. These sites also recorded the highest (8.10 ± 0.32 cm) and lowest (3.67 ± 0.15 cm) mean APM of