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Short communication

Assessment of scallop spat (*Pecten novaezelandiae*) transport, handling and tagging mortality for wild fishery enhancement, Golden Bay, New Zealand

Sean J. Handley[a,*], Stephen N. Brown[a], Ian Tuck[b,c]

[a] National Institute of Water & Atmospheric Research, P.O. Box 893, Nelson 7001, New Zealand
[b] National Institute of Water & Atmospheric Research, Private Bag 99940, Newmarket, Auckland 1149, New Zealand
[c] Department of Statistics, University of Auckland, Private Bag 92019, Auckland 1149, New Zealand

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ABSTRACT

The formerly lucrative *Pecten novaezelandiae* Southern Scallop fishery in New Zealand has experienced significant declines that have resulted in changes to spat handling and transport methods, with untested effects on spat survival. Experiments were carried out on board a harvest vessel to test the effects of spat handling, emersion, immersion and transport for up to 6 h post-harvest. Spat were then transferred to lantern cages for 7 d with lantern and spat bag controls, and examined for mortality. Length frequency analysis revealed smaller spat (mean: 20.4 mm ±0.3 95%CI) were more susceptible to handling and transport than larger individuals (mean: 25.9 mm ±0.23), but ANOVA tests did not reveal any differences between emersed or immersed treatments that appeared related to handling stress. The most severe treatment, transporting spat for 3 h at the bottom of a bulk bag to emulate crushing, had no detectable effect. Factors other than spat handling stress potentially responsible for the ongoing lack of recovery via enhanced spat in this fishery are discussed.

1. Introduction

Scallops (Pectinidae) have historically supported important shallow water coastal fisheries in many countries including; Japan, the United States, Canada, China, Norway, Chile, Mexico, Argentina, United Kingdom, France, New Zealand and Australia (Bell et al., 2005; Shumway 1991). An essential requisite of a successful scallop fishery is consistent recruitment. Scallop larvae settle, metamorphose and attach themselves with byssus threads to filamentous materials such as seagrass *Zostera* sp. debris, algae and hydroids on the seabed (Bull 1976). In the absence of consistent or adequate recruitment, the provision of artificial substrate on which scallop larvae can settle and metamorphose can greatly increase production, through additional settlement opportunity (Bell et al., 2005). With the advent of scallop spat catching, pioneered in Japan (Dao et al., 1999), enhancement of wild stocks has been carried out successfully to overcome often large inter-annual variations in natural settlement and survival of juveniles, with the addition of caught-spat leading to more even production from stocks (Bell et al., 2005).

Golden and Tasman Bays at the north of the South Island once contributed greatly to New Zealand's scallop *Pecten novaezelandiae* fisheries. The history of the Southern Scallop fishery started with commercial dredging of wild scallops in Tasman Bay in 1959, and expanded to incorporate Golden Bay and the Marlborough Sounds by 1967. Maximum wild fisheries production was recorded in 1975 at 1246 tonnes meat weight (Mincher 2008). This production crashed leading to the closure of the fishery for two years from 1980 (Mincher 2008). Beginning in the late 1970s, trials of Japanese methods for spat catching and stock enhancement proved very successful, and led to large scale seeding of juvenile scallops in 1983 managed by the Challenger Scallop Enhancement Company (CSEC), with enhanced scallops becoming part of the annual catch landings from 1986 onwards (Arbuckle and Metzger 2000; Mincher 2008). Spat catching methods involve setting spat catching bags (fine mesh encased within an outer, fine mesh bag) on long-lines similar to those used for commercial mussel culture (e.g. Morrisey et al., 2006). Once caught, the spat are on-grown for a period of several months, and then harvested, transported in bulk-bags to the growing site, then 'shaken out' at the surface. This 'direct release' method of re-seeding, without on-growing in lantern cages, was deemed most cost-effective (Bell et al., 2005). Survival of 'direct

* Corresponding author. Fax: +64 3 548 1716.
E-mail addresses: sean.handley@niwa.co.nz, seanjh247@gmail.com (S.J. Handley).

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release' spat in the Southern Scallop fishery has been estimated at 15% (Bell et al., 2005). Seeding of spat collected in both Tasman and Golden Bays was followed by a two year growing period, and harvesting of scallops in a cycle of rotationally fishing nine areas (Arbuckle and Metzger 2000).

Experiments investigating the effects of New Zealand spat handling during seeding indicated that industry handling methods led to sub-acute and chronic stress potentially increasing post-release mortalities when spat transport methods were simulated in the laboratory (Day et al. unpub. data). In attempts to maximise spat survivorship, the industry equipped its seeding barge with elaborate tanks and spraying systems to keep spat moist and cool to reduce stress during transport to release sites (M. Campbell, pers. com.). These methods were used for several years, until declines in scallop production, first in Tasman Bay (2005/06) and then in Golden Bay (2008/09), halted commercially harvesting in these bays (NIWA unpublished review). As the fishery declined, diminishing returns meant that CSEC barge and seeding infrastructure were sold. Enhancement operations have continued at reduced scale in attempts to rebuild the fishery, predominantly in Golden Bay. The fishery for non-enhanced scallops over predominantly sandy habitats continues to operate in the Marlborough Sounds where similar declines have not been as evident (MPI, 2013). Harvested spat are currently transported for up to 3 h via bulk-bags aboard fishing vessels to pre-determined release sites in Golden Bay. En-route, the spat bags are periodically sprayed with seawater pumped from the vessel's deck hose to keep them cool and moist (Handley pers. obs.). The continued lack of recovery of the fishery using simple enhancement methods raised questions regarding the efficacy of enhancement operations. Had operational changes in spat handling methods with the decline of the fishery, affected survivorship of enhanced spat, slowing recovery of the fishery?

Scallops are considered sensitive to environmental factors including minimum temperature at spat transfer, aerial exposure, transport and handling (Dao et al., 1999). Experiments investigating handling stress with juvenile discards of the great scallop *Pecten maximus* found negative effects on the escape response after aerial exposure for 20 min that were still evident after 24 h. These results suggested potential for higher vulnerability to predation and mortality in undersized discards (Bremec et al., 2004). However experiments with the Patagonian scallops, *Zygochlamys patagonica* found no effect on survival after about 30 min of handling and aerial exposure (Bremec et al., 2004). Aerial exposure at elevated temperatures had negative effects for *P. maximus* with chilling during transport improving spat vitality (Minchin et al., 2000). Size of spat and transport duration also affected vulnerability to stress with a maxium of 9 h recommended to maximise survival (Christophersen et al., 2008). We are not aware of any published studies on effects of aerial exposure during transportation in *P. novaezelandiae*. The aim of this study was to determine if current protocols for handling of scallop spat during transport from collection to enhancement sites caused significant spat mortality prior to spat reaching the seabed. In addition, incidental mortality from tagging of *P. novaezelandiae* spat using cyanoacrylate glue and plastic tags was assessed for post-release enhancement validation. Tag mortality has been estimated at 11.9% for *Aequipecten opercularis* (Allison and Brand 1995), 3.2% for *Amusium balloti* (Heald 1978) and 0% for *P. maximus* (Ross et al., 2001).

2. Methods

2.1. Spat handling and transport mortality

Scallop spat were caught on seasonally erected longlines in Golden Bay, New Zealand (WGS84 −40.7703S, 172.8659E) with experiments carried out aboard a mussel farm servicing barge. Twenty-four spat-bags were taken from the spat collecting site in April 2013. Bags were lifted at 07:30. Twelve bags were placed in a bin exposed to ambient air (emersion treatment) and 12 were immersed in a tank with flow-through seawater from a deck hose (immersion treatment). At time T1 (1.5 h), 40 spat from each treatment were removed from the bags and placed in each of 3 replicate pairs of pearl nets, that were then returned to a separate tank containing flow-through seawater. This was repeated at times T2 (3 h), T3 (4.5 h) and T4 (6 h). Paired pearl nets were subsequently hung on mussel farm longlines at 3 m depth (WGS84 −40.7698, 172.8648). In addition to the emersion treatments, spat were taken from bags kept at the bottom of a bulk-bag (1.5 m^2) that had been transported to and from a seeding site aboard a fishing vessel, a 3 h journey to emulate conditions experienced by spat at the bottom of a bulk-bag during the seeding out process (treatments Crush1 and Crush 2). A Control treatment comprised spat lifted from spat catching lines, and immediately placed in pearl nets and deployed at 3 m depth on longlines in the water column; T0. A further control treatment comprised spat bags lifted and immediately hung unopened on longlines at 3 m depth; Control Bags.

After 7 days in-situ, pearl nets and spat bags were lifted and spat were examined to enumerate survival in each treatment. Pearl nets and spat bags were transported back to port in tanks supplied with flowing seawater from a vessel deck hose. In port, spat were placed in tanks with flowing seawater supplied from a bilge pump and hose for the ca. 5 h it took to destructively sample all the treatments, recording size of spat and levels of mortality. Spat were counted as dead if they were clocks (empty connected valves), or could not keep their valve closed when depressed by touching.

2.2. Tagging mortality

Spat bags containing scallop spat were transported aboard the seeding barge from the spat catching site to Tarakohe harbour (WGS84 −40.82157S, 172.89725E) in a tank under ambient seawater supplied from a deck hose (journey taking ca.1 h). At port, spat were held in the water column next to the dock (ca. 400 m from open water). Spat were measured (length) and tagged with numbered Shellfish tags (Hallprint) attached near the shell margin with a cyanoacrylate adhesive (Ross et al., 2001) in groups of 40 that were placed in each of 2 replicate strings of 4 x pearl nets (Tagged treatment) and a further 320 spat without tags were measured (length) and placed in another 2 replicate strings of 4 pearl nets, also in groups of 40 spat in each pearl net (Control treatment). Scallops in control treatment were subjected to all handling stresses and conditions associated with tagging. Pearl nets were hung from the side of the seeding barge overnight then transported immersed in flowing seawater in tanks on-board the seeding vessel to mussel growing lines in Golden Bay and hung from the longlines at 3 m depth as above. After 7 days in situ, pearl nets were lifted and spat were examined to enumerate survival as above.

2.3. Statistical analysis

Data were plotted with 95 % confidence intervals and transport and tagging treatments were tested for treatment effects using fixed model ANOVA after first checking for homogeneity of variance using Statistica (©StatSoft 2011). Tests were first conducted to determine no difference between replicates, before combining treatment scores. Data were checked for homogeneity of variances before analysis and *a-posteriori* power analysis was performed for ANOVA to determine the power of not committing a "Type II" error or accepting a false H_o (Handley 1998; Koele 1982; Searcy-Bernal 1994).