Passive Migration of Abalone Offspring Through Utilizations of Water Turbulences by juveniles of *Haliotis irirs* (Gmelin, 1791)

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The crucial first step

Larval settlement is a critical phase in the life of a marine organism[1], and survival rates through this stage have significant implications for the wider population[2,3]. Understanding the mechanisms that underpin the settlement and early life history of marine organisms is essential to managing those populations. The New Zealand Blackfoot abalone (pāua, Fig.1) supports important customary, commercial and recreational fisheries and has been the focus of a burgeoning aquaculture industry. Understanding the settlement dynamics of pāua is essential for effective management and cultivation, but few studies have detailed the key mechanisms of early life stages. Here I examine some important behavioural mechanisms exhibited by pāua larvae throughout the settlement and post-settlement stages.

Fig. 1 *Haliotis irs* (Gmelin, 1791) individual from Kaikoura

Fig. 2 SEM picture of a 19 hr larva of the European *Haliotis tuberculate* (Linnaeus, 1758) Scale: 30µm; after Auzoux-Bordenave et al. (2010)[12]

Hungry larvae are less peckish

The aggregative settlement of *Haliotis iris* (Gmelin, 1791) is largely induced by sugar molecules from coralline algae, substances released by adult pāua, and the presence of diatoms [4–7]. Paua larvae are non-feeding (lecithotrophic, Fig. 2) and can afford to be highly selective of settlement substrate while their energy stores are viable. However, larvae are required to settle once their energy stores are depleted, typically around 14 days after hatching, regardless of cues[8]. This reduction in sensitivity to settlement cues is known as the "desperate larvae hypothesis" (Knight-Jones 1953)[9,10], in which larvae are required to settle on a substrate that is suboptimal, thereby reducing the likelihood of adequate growth and survival.

Is the future sealed?

So, what happens if settler pāua find themselves in an unfavourable environment? Some reports suggest that. *Haliotis* recruits are "doomed" once they settle on poor substrate since they are either isolated by sediments (Fig.3) or are otherwise unable to migrate to greener pastures (pers. Com. Goldstein). However, only recently was it discovered that juvenile *Haliotis sorenseni* (Bartsch 1940) utilize drifting seaweed for long-distance dispersal[11]. Similar behaviour did I observe in an experimental pāua hatchery in Kaikōura with juveniles in rearing tanks. I hypothesize that this behaviour is non-random and is an adapted mechanism to enable juveniles to migrate out from suboptimal conditions. Juveniles were also observed riding air bubbles away from densely populated areas.

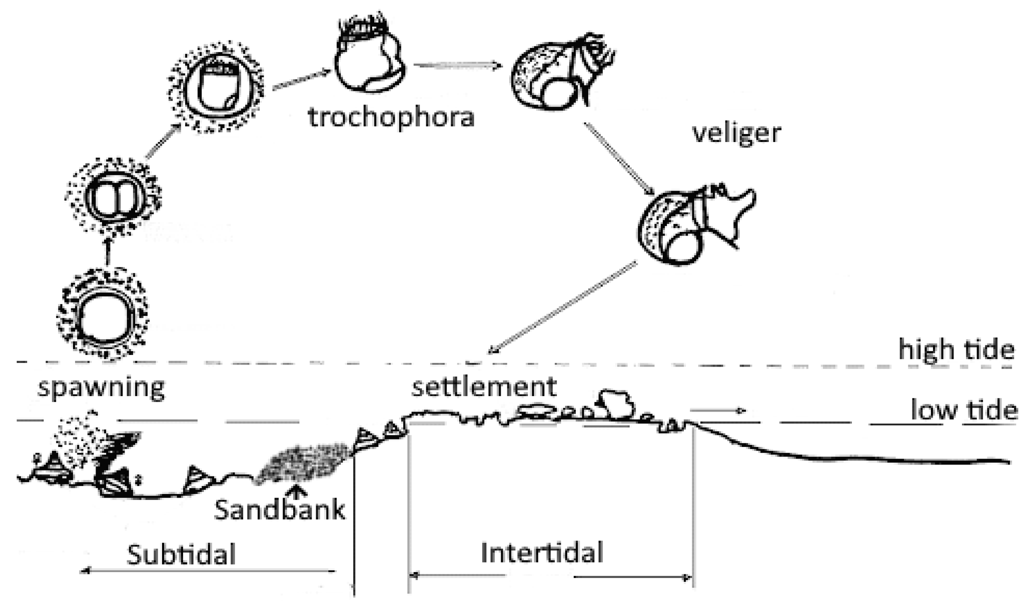

Figure 3 reproduction, larva development, dispersal, and settlement of broadcasting molluscs with lecithotrophic larvae after Kitutania & Yakamakawa 1999

Riding high on air

To test this hypothesis, I suggest placing juveniles of various sizes into smaller compartments in tanks. Possible cues will be presented in these tanks, whereas potential transport motions like air bubbles will be directed under the compartment (see Fig. 4). Such preliminary trials explore the ability of small pāua to utilize air bubbles, water currents, and drift macroalgae. Future trials would test whether these various environmental cues will increase the likelihood of escape behaviour. I also, want to test whether the presence of a predator or the lack of food will increase escapement behaviour. Lab trials should be coupled with field experiments to test whether juveniles are able to use these mechanisms to emigrate from sub-optimal conditions, or to migrate to different populations.

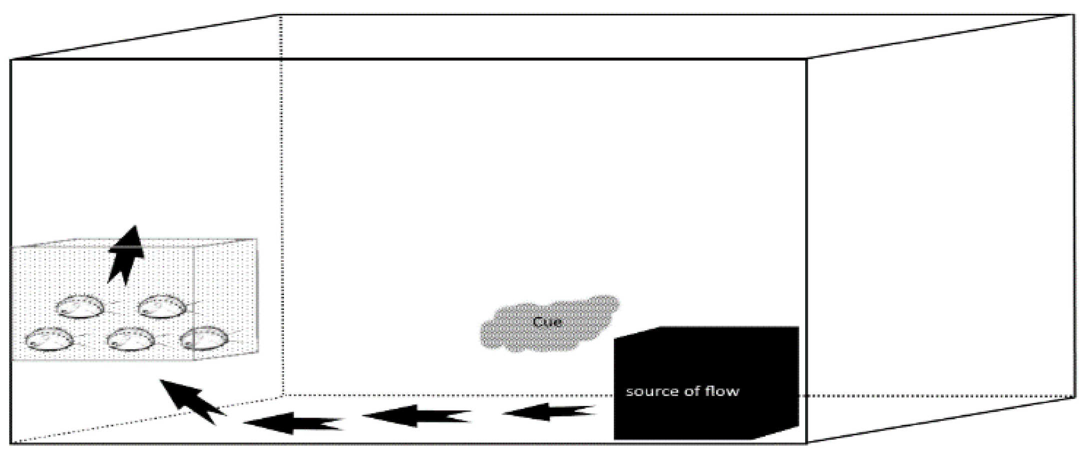

Figure 4 experimental set-up to explore the ability of *Haliotis irsis* juv. to secondary migration. Juvenile sketch out off: Jardillier et al. 2008 Fig. 1[14]

REFERENCES

1. Hadfield M, Paul V. Natural chemical cues for settlement and metamorphosis of marine invertebrate larvae. In: McClintock J, Baker B, eds. *Marine Chemical Ecology.* CRC Press-Taylor & Francis Group, 6000 Broken Sound Parkway NW, STE 300, Boca Raton, FL 33487-2742 USA; 2001:431-461. **2.** Pineda J. Linking larval settlement to larval transport: Assumptions, potentials, and pitfalls. *Oceanogr East Pacific*. 2000;1:84-105. **3.** Eckman J.E. Closing the larval loop: Linking larval ecology to the population dynamics of marine benthic invertebrates. *J Exp Mar Bio Ecol*. 1996;200(1-2):207-237. **4.** Searcy-Bernal R, Salas-Garza AE, Flores-Aguilar RA, Hinojosa-Rivera PR. Simultaneous comparison of methods for settlement and metamorphosis induction in the Red abalone (*Haliotis rufescens*). *Aquaculture*. 1992;105(3-4):241-250. **5.** Slattery M. Larval settlement and juvenile survival in the red abalone (*Haliotis rufescens*), an examination of inductive cues and substrate selection. *Aquaculture*. 1992;102(1-2):143-153. **6.** Daume S, Brand-Gardner S, Woelkerling WJ. Settlement of abalone larvae (*Haliotis laevigata* Donovan) in response to non-geniculate coralline red algae (Corallinales, Rhodophyta). J Exp Mar Bio Ecol. 1999;234(1):125-143. **7**. Gordon N, Shpigel M, Neori A, Harpaz S, Lee JJ. The settlement of abalone (*Haliotis discus hannai ino*) larvae on culture layers of different diatoms. J Shellfish Res. 2004;23(2):561-568. **8**. Kohn AJ, Palmer AR, Shimek RL. Phylum Mollusca, class Gastopoda, subclass Prosobranchia. In: Strathmann MF, ed. Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast. Seattle, London: University of Washington Press; 1987:220-267. **9**. Knight-Jones EW. Decreased Discrimination During Setting After Prolonged Planktonic Life in Larvae of *Spjrorbis Borealis* (Serpulidae). J Mar Biol Assoc United Kingdom. 1953;32(02). **10**. Toonen RJ, Pawlik JR. Foundations of gregariousness. Nature. 1994;370(6490):511-512. **11.** McCormick TB, Buckley LM, Brogan J, Perry LM. Drift macroalgae as a potential dispersal mechanism for the white abalone *Haliotis sorenseni*. Mar Ecol Prog Ser. 2008;362:225-232. **12.** Auzoux-Bordenave S, Badou A, Gaume B, et al. Ultrastructure, chemistry and mineralogy of the growing shell of the European abalone *Haliotis tuberculata*. J Struct Biol. 2010;171(3):277-290. **13.** Kitutiani K, Yamakawa H. Marine Snails Seed Production towards Restocking Enhacement Basic Manual.; 1999. **14**. Jardillier E, Rousseau M, Gendron-Badou A, et al. A morphological and structural study of the larval shell from the abalone *Haliotis tuberculata*. Mar Biol. 2008;154:735-744.

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