

## Lagrangian descriptions of marine larval dispersion

D. A. Siegel<sup>1,\*</sup>, B. P. Kinlan<sup>2</sup>, B. Gaylord<sup>3</sup>, S. D. Gaines<sup>2,3</sup>

<sup>1</sup>Institute for Computational Earth System Science and Department of Geography, <sup>2</sup>Department of Ecology, Evolution and Marine Biology, and <sup>3</sup>Marine Science Institute, University of California, Santa Barbara, California 93106, USA

\*Email: davey@icess.ucsb.edu

Marine Ecology Progress Series 260:83–96 (2003)

**Appendix 1.** Genetic estimates of dispersal and corresponding estimates of planktonic larval duration (PLD) for benthic marine species

Species name	Type <sup>a</sup>	Taxonomy <sup>b</sup>	Dispersal scale (km) <sup>c</sup>	PLD (days) <sup>d</sup>	PLD references
<i>Acanthaster planci</i> <sup>e</sup>	I	Echinodermata:Asteroidea	167	21	Nishida & Lucas 1988, Benzie 1994
<i>Acanthurus triostegus</i> <sup>e</sup>	F	Perciformes:Acanthuridae	38.1	65	Planes 1993, Planes 1994
<i>Acropora cuneata</i>	I	Cnidaria	0.053	0.17	Shanks et al. 2003
<i>Acropora palifera</i>	I	Cnidaria	0.089	0.17	Shanks et al. 2003
<i>Adalaria proxima</i>	I	Mollusca:Opisthobranchia	0.067	1.5	Todd et al. 1998
<i>Alaria marginata</i>	M	Phaeophyta	4.2	2	Kusumo & Druehl 2000
<i>Amphiprion clarkii</i>	F	Perciformes:Pomacentridae	25.1	11.5	Froese & Pauly 2002
<i>Amphiprion melanopus</i>	F	Perciformes:Pomacentridae	32	15.5	Doherty et al. 1995
<i>Celleporella hyalina</i>	I	Bryozoa:Cheilostomatida	0.303	0.15	Goldson et al. 2001
<i>Chthamalus montagui</i> <sup>e</sup>	I	Crustacea:Cirripedia	180	19.5	Burrows et al. 1999
<i>Chthamalus stellatus</i> <sup>e</sup>	I	Crustacea:Cirripedia	176	23	Burrows et al. 1999
<i>Dascyllus aruanus</i>	F	Perciformes:Pomacentridae	142	24	Froese & Pauly 2002
<i>Dascyllus trimaculatus</i>	F	Perciformes:Pomacentridae	47.5	23	Froese & Pauly 2002
<i>Echinometra lucunter</i>	I	Echinodermata:Asteroidea	75.5	14	Emlet 1995
<i>Gadus morhua</i>	F	Gadiformes:Gadidae	170	100	Froese & Pauly 2002
<i>Gnatholepis thompsoni</i>	F	Perciformes:Gobiidae	168	81.5	Shulman & Birmingham 1995
<i>Halichoeres bivittatus</i>	F	Perciformes:Labridae	176	24	Shulman & Birmingham 1995
<i>Haliotis cracherodii</i>	I	Mollusca:Gastropoda	24.2	7	Hamm & Burton 2000
<i>Helicidaris erythrogramma</i>	I	Echinodermata:Echinoidea	7.2	4	Emlet 1995
<i>Littorina littorea</i>	I	Mollusca:Gastropoda	22.9	30	Janson 1987, MBA 2002
<i>Ostrea edulis</i>	I	Mollusca:Bivalvia	88.1	12	Borsa et al. 1997
<i>Pandalus borealis</i>	I	Crustacea:Decapoda	112	105	Kartavtsev 1994
<i>Pecten jacobaeus</i>	I	Mollusca:Bivalvia	501	24.5	Ríos et al. 2002
<i>Pocillopora damicornis</i>	I	Cnidaria	0.2	0.17	Shanks et al. 2003
<i>Sciaenops ocellatus</i>	F	Perciformes:Sciaenidae	527	14	Gold & Turner 2002
<i>Semicossyphus pulcher</i>	F	Perciformes:Labridae	94.2	37	Froese & Pauly 2002
<i>Solea solea</i>	F	Pleuronectiformes:Soleidae	134	36	Froese & Pauly 2002
<i>Stegastes leucostictus</i>	F	Perciformes:Pomacentridae	76.7	20	Wellington & Victor 1989
<i>Stylophora pistillata</i>	I	Cnidaria	0.044	0.17	Shanks et al. 2003
<i>Tridacna derasa</i>	I	Mollusca:Bivalvia	144	8.5	Benzie 1994
<i>Tridacna maxima</i> <sup>e</sup>	I	Mollusca:Bivalvia	142	8.5	Benzie & Williams 1997
<i>Zoanthus coppingeri</i>	I	Cnidaria	30.5	21	Burnett et al. 1995

<sup>a</sup>Type of organism; M = Macroalgae, I = Invertebrate, F = Fish

<sup>b</sup>Higher taxonomy; Division (Macroalgae); Phylum:Class (Invertebrates); Order:Family (Fish)

<sup>c</sup>Mean dispersal distance estimated from genetic isolation-by-distance slope, from Kinlan & Gaines (2003)

<sup>d</sup>Mean PLD estimated from otolith aging, laboratory culture studies, and/or field observations

<sup>e</sup>Average of multiple independent genetic dispersal estimates for this species

## LITERATURE CITED

- Benzie JAH (1994) Patterns of gene flow in the Great Barrier Reef and Coral Sea. In: Beaumont A (ed) Genetics and evolution of aquatic organisms. Chapman and Hall, London, p 67–79
- Benzie JAH, Williams ST (1997) Genetic structure of giant clam (*Tridacna maxima*) populations in the West Pacific is not consistent with dispersal by present-day ocean currents. *Evolution* 51:768–783
- Borsig P, Naciri M, Bahri L, Chikhi L, and 3 others (1997) Zoogéographie intra-spécifique de la mer Méditerranée. Analyse des données génétiques populationnelles sur seize espèces atlantico-méditerranéennes (Poissons et Invertébrés). *Vie Milieu* 47(4):295–305
- Burnett WJ, Benzie JAH, Beardmore JA, Ryland JS (1995) Patterns of genetic subdivision in populations of a clonal cnidarian, *Zoanthus coppingeri*, from the Great Barrier Reef. *Mar Biol* 122:665–673
- Burrows MT, Hawkins SJ, Southward AJ (1999) Larval development of the intertidal barnacles *Chthamalus stellatus* (Poli) and *Chthamalus montagui* Southward. *J Mar Biol Assoc UK* 79:93–101
- Doherty PJ, Planes S, Mather P (1995) Gene flow and larval duration in seven species of fish from the Great Barrier Reef. *Ecology* 76:2373–2391
- Emlet RB (1995) Developmental mode and species geographic range in regular sea urchins (Echinodermata: Echinoidea). *Evolution* 49:476–489
- Froese R, Pauly D (2002) FishBase. <http://www.fishbase.org>
- Gold JR, Turner TF (2002) Population structure of red drum (*Sciaenops ocellatus*) in the northern Gulf of Mexico, as inferred from variation in nuclear-encoded microsatellites. *Mar Biol* 140:249–265
- Goldson AJ, Hughes RN, Gliddon CJ (2001) Population genetic consequences of larval dispersal mode and hydrography: a case study with bryozoans. *Mar Biol* 138:1037–1042
- Hamm DE, Burton RS (2000) Population genetics of black abalone, *Haliotis cracherodii*, along the central California coast. *J Exp Mar Biol Ecol* 254:235–247
- Janson K (1987) Allozyme and shell variation in two marine snails (Littorina, Prosobranchia) with different dispersal abilities. *Biol J Linn Soc* 30:245–256
- Kartavtsev YP (1994) Wide-scale genetic differentiation among pink shrimp *Pandalus borealis* populations. In: Beaumont A (ed) Genetics and evolution of aquatic organisms. Chapman and Hall, London, p 41–53
- Kinlan BP, Gaines SD (2003) Propagule dispersal in marine and terrestrial environments: a community perspective. *Ecology* 84:2007–2020
- Kusumo HT, Druehl LD (2000) Variability over space and time in the genetic structure of the winged kelp *Alaria marginata*. *Mar Biol* 136:397–409
- MBA (Marine Biological Association of the UK) (2002) MARLIN: The Marine Life Information Network for Britain and Ireland. <http://www.marlin.ac.uk/>
- Nishida M, Lucas JS (1988) Genetic differences between geographic populations of the crown-of-thorns starfish throughout the Pacific region. *Mar Biol* 98:359–368
- Planes S (1993) Genetic differentiation in relation to restricted larval dispersal of the convict surgeonfish *Acanthurus triostegus* in French Polynesia. *Mar Ecol Prog Ser* 98:237–246
- Planes S (1994) Geographic structure and gene flow in the manini (convict surgeonfish, *Acanthurus triostegus*) in the south-central Pacific. In: Beaumont A (ed) Genetics and evolution of aquatic organisms. Chapman and Hall, London, p 113–123
- Rios C, Sanz S, Saavedra C, Pena JB (2002) Allozyme variation in populations of scallops, *Pecten jacobaeus* (L.) and *P. maximus* (L.) (Bivalvia:Pectinidae), across the Almeria-Oran front. *J Exp Mar Biol Ecol* 267:223–244
- Shanks AL, Grantham B, Carr MH (2003) Propagule dispersal distance and the size and spacing of marine reserves. *Ecol Appl* 13: S159–S169
- Shulman MJ, Bermingham E (1995) Early life histories, ocean currents, and the population genetics of Caribbean reef fishes. *Evolution* 49:897–910
- Todd CD, Lambert WJ, Thorpe JP (1998) The genetic structure of intertidal populations of two species of nudibranch molluscs with planktrophic and pelagic lecithotrophic larval stages: Are pelagic larvae 'for' dispersal? *J Exp Mar Biol Ecol* 228:1–28
- Wellington GM, Victor BC (1989) Planktonic larval duration of one hundred species of Pacific and Atlantic damselfishes (Pomacentridae). *Mar Biol* 101:557–56