|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Species | Control pH | Experimental pH | Experiment Duration | Reproductive Stage | Key Findings | Collection Location Marine Ecoregion | Reference |  |  |
| **Cnidaria** |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| *Orbicella faveolata* (coral) | 8.20 | 8.00 | 3 hours | Fertilization | No effect of pH on fertilization success. | Tropical Atlantic | Pitts et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Primnoa pacifica* (coral) | 7.75 | 7.55 | 8 months | Fecundity and reproductive output; Gametogenesis and gamete quality | Low pH reduced egg diameters and female fecundity but increased oosorption and advancement of spermatogenesis. | Temperate Northern Pacific | Rossin et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Balanophyllia europaea* (coral)\* | 8.10 | 7.90, 7.70 | 8 months | Fecundity and reproductive output; Gametogenesis and gamete quality | No effect of pH on distribution and morphology of female and male germ cell maturation stages, fertility, egg and spermary abundance, or gonadal index. | Temperate Northern Atlantic | Caroselli et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Leptopsammia pruvoti* (coral)\* | 8.07 | 7.87, 7.74, 7.40 | 3 months | Fecundity and reproductive output; Gametogenesis and gamete quality | No effect of pH on distribution and morphology of female and male germ cell maturation stages, diameter of spermaries or eggs, egg and spermary abundance, fertility, or gonadal index. | Temperate Northern Atlantic | Gizzi et al. (2017) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora digitifera* (coral) | 7.94 - 7.99 | 7.64 - 7.68 | 6 hours | Fertilization | No effect of pH on fertilization rate. | Temperate Northern Pacific | Iguchi et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora hyacinthus* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Favites abdita* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Platygyra contorta* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Orbicella faveolata* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora tenuis* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora palmata* (coral) | 8.15 | 7.85 | 3 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Northern Pacific | Schutter et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora tenuis* (coral) | 7.97 | 8.01, 7.78, 7.74 | 3 hours | Fertilization | Low pH increased minimum sperm concentration required to obtain half of maximum fertilization vastly but no effect of pH on fertilization success. | Central Indo-Pacific | Albright et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora tenuis* (coral) | 8.18 | 8.06 | 2 hours | Fertilization | No effect of pH on fertilization rate. | Central Indo-Pacific | Chua et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora millepora* (coral) | 8.12, 8.18 | 8.06, 8.00 | 2 hours | Fertilization | No effect of pH on fertilization rate. | Central Indo-Pacific | Chua et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora digitifera* (coral) | 8.05 | 8.17, 7.74 | 3 minutes | Fertilization | Low pH reduced sperm motility. | Temperate Northern Pacific | Nakamura et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora hyacinthus* (coral) | 8.10 | 7.90, 7.70 | 4 hours | Fertilization | Low pH caused variation in hybridization success but no effect of pH on fertilization success. | Central Indo-Pacific | Striewski (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora cytherea* (coral) | 8.10 | 7.90, 7.70 | 4 hours | Fertilization | Low pH caused variation in hybridization success but no effect of pH on fertilization success. | Central Indo-Pacific | Striewski (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Goniastrea edwardsi* (coral) | 8.10 | 7.90, 7.70 | 4 hours | Fertilization | Low pH reduced fertilization success. | Central Indo-Pacific | Striewski (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Orbicella faveolata* (coral) | 8.10 | 7.90, 7.70 | 4 hours | Fertilization | Low pH caused variation in hybridization success but no effect of pH on fertilization success. | Central Indo-Pacific | Striewski (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Orbicella annularis* (coral) | 8.10 | 7.90, 7.70 | 4 hours | Fertilization | Low pH caused variation in hybridization success. | Central Indo-Pacific | Striewski (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora palmata* (coral) | 8.00 | 7.85, 7.72, 673 µatm, 998 µatm | 4 hours - a few minutes | Fertilization | Low pH reduced percent fertilization, exacerbated by decreases in sperm concentration but no effect pH on sperm velocity. | Tropical Atlantic | Albright (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Orbicella faveolata* (coral) | 8.00 | 8.94, 7.88, 7.74. 673 µatm, 998 µatm, 560 µatm, 800 µatm, 912 µatm | 7 hours - a few minutes | Fertilization | Low pH reduced percent fertilization, exacerbated by decreases in sperm concentration but no effect pH on sperm velocity. | Tropical Atlantic | Albright (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acropora digitifera* (coral) | 8.00 | 7.77, 7.69, 7.64, 7.31, 6.55 | Not specified | Fertilization | Low pH reduced sperm motility. | Temperate Northern Pacific | Morita et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Pocillopora damicornis* (coral) | ambient | ambient + 365 µatm | 6 months | Fecundity and reproductive output | No effect of pH on number of spawned bundles, number of eggs within spawned bundles, or total number of spawned eggs. | Eastern Indo-Pacific | Jokiel et al. (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Montipora capitata* (coral) | ambient | ambient + 365 µatm | 6 months | Fecundity and reproductive output | No effect of pH on number of spawned bundles, number of eggs within spawned bundles, or total number of spawned eggs. | Eastern Indo-Pacific | Jokiel et al. (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Oculina patagonica (coral)* | 8.00 - 8.30 | 7.30 - 7.60 | 12 months | Gametogenesis and gamete quality | No effect of pH on gametogenesis. | Temperate Northern Atlantic | Fine et al. (2007) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Madracis pharensis* (coral) | 8.00 - 8.30 | 7.30 - 7.60 | 12 months | Gametogenesis and gamete quality | No effect of pH on gametogenesis. | Temperate Northern Atlantic | Fine et al. (2007) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Crustacea** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| *Acartia ohtsukai* (copepod)\* | 7.90 | 7.60 | 5 days | Fecundity and reproductive output | Low pH affected egg production. | Temperate Northern Pacific | Lee et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Balanus improvisus* (barnacle)*\** | 8.10 | 7.50 | 5 days - 16 months | Gametogenesis and gamete quality | Failed to brood or release embryos in low pH but no effect of pH on gonad development. | Temperate Northern Atlantic | Pansch et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Gammarus locusta* (amphipod)*\** | 8.10 | 7.70 | 1 - 2 months | Fecundity and reproductive output; Mating Behavior | Low pH reduced long-distance mate tracking in males, mate guarding duration, and egg production but no effect of pH on embryonic development. | Temperate Northern Atlantic | Borges et al. (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Cyathura carinata* (isopod)*\** | 8.00 | 7.00, 6.50 | 32 das | Gametogenesis and gamete quality | Unable to produce eggs in low pH conditions. | Temperate Northern Atlantic | Conradi et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Elasmopus rapax* (amphipod)*\** | 8.00 | 7.50, 7.00 | 22 days | Gametogenesis and gamete quality | Unable to produce eggs in low pH conditions. | Temperate Northern Atlantic | Conradi et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Menippe mercenaria* (crab)*\** | 8.00 | 7.50 | 12 days | Fecundity and reproductive output | Low pH reduced hatching success. | Tropical Atlantic | Gravinese (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Chionoecetes bairdi* (crab)*\** | 8.09 | 7.80, 7.50 | 2 years | Fecundity and reproductive output; Gametogenesis and gamete quality | Low pH increased dead hemocyte cells, and resulted in smaller egg clutches, and reduced egg viability. | Temperate Northern Pacific | Mesek et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Cancer magister* (crab)*\** | 8.00 | 7.50, 7.10 | 22 days | Fecundity and reproductive output | Low pH affected hatch time, but no effect of pH on egg hatching probability. | Temperate Northern Pacific | Miller et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia bifilosa* (copepod)*\** | 267 - 565 µatm | 867 - 1525 µatm | 45 days | Fecundity and reproductive output | Low pH affected hatch success but no effect of low pH on egg production. | Temperate Northern Atlantic | Vehmaa et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia tonsa* (copepod)*\** | 8.20 | 7.92 - 7.15 | 30 - 96 hours | Fecundity and reproductive output | Low pH reduced egg production and hatching success when both parents were exposed but no effect of pH on hatching success when only the mother is exposed. | Temperate Northern Atlantic | Cripps et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia bifilosa* (copepod)*\** | 7.87-7.60 | 7.47-7.15 | 24 - 26 hours | Fecundity and reproductive output | Low pH had a positive effect on egg production. | Temperate Northern Atlantic | Engström-Östa et a0. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Hyas araneus* (crab)*\** | 8.13 | 7.20 | 2 weeks | Fecundity and reproductive output | Low pH reduced zoea mortality, developmental delay, weight, and feeding rate. | Arctic† | Schiffer et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Pseudocalanus acuspes* (copepod)*\** | 8.05 | 7.75, 7.54 | 2 weeks | Fecundity and reproductive output | Low pH reduced fecundity. | Temperate Northern Atlantic | Thor and Dupont (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acarita clausi* (copepod)*\** | 8.09 | 7.83 | 24 hours | Fecundity and reproductive output | Low pH reduced egg production. | Temperate Northern Atlantic | Zervoudaki et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Centropages typicusand* (copepod)*\** | 8.04, 7.97 | 7.85, 7.78, 6.71 | 4 days | Fecundity and reproductive output | Extreme low pH reduced hatching rate and egg production. | Temperate Northern Atlantic | McConville et a0. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Temora longicornis* (copepod)*\** | 8.04, 7.97 | 7.85, 7.78, 6.71 | 4 days | Fecundity and reproductive output | No effect of pH on hatching rate or egg production. | Temperate Northern Atlantic | McConville et a0. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia bifilosa* (copepod)*\** | 8.00 | 7.60 | 24 - 38 hours | Fecundity and reproductive output; Gametogenesis and gamete quality | No effect of pH on egg production or egg viability. | Temperate Northern Atlantic | Vehmaa et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Tisbe battagliai* (copepod)*\** | 8.06 - 8.10 | 7.95, 7.82, 7.67 | 72 hours - 4 months | Fecundity and reproductive output; Gametogenesis and gamete quality | Low pH reduced spermatophore size and increased naupliar production, but no effect of pH on spermatophore attachment or female responses. | Temperate Northern Atlantic | Fitzer et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acarita sp.* (copepod)*\** | 8.30-7.65 | 7.60-7.31 | 5 days | Fecundity and reproductive output | Low pH reduced hatch rate and egg production. | Temperate Northern Atlantic | Vehmaa et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Calanus glacalis* (copepod)*\** | 8.20 | 7.60, 6.90 | 7 days | Fecundity and reproductive output | Low pH reduced hatching success but no effect of pH on egg production. | Temperate Northern Atlantic | Weydmann et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia pacifica* (copepod)*\** | 8.17 | 7.84 - 6.92 | 8 days | Fecundity and reproductive output | No effect of pH on egg production or hatching success. | Central Indo-Pacific | Zhang et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia spinicauda* (copepod)*\** | 8.17 | 7.84 - 6.92 | 8 days | Fecundity and reproductive output | Low pH reduced egg production and hatching success. | Central Indo-Pacific | Zhang et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Centropages tenuiremis* (copepod)*\** | 8.17 | 7.84 - 6.92 | 8 days | Fecundity and reproductive output | Low pH reduced egg production and hatching success. | Central Indo-Pacific | Zhang et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinogammarus marinus* (amphipod)*\** | 8.00 | 7.50 | 18 days | Fecundity and reproductive output | Low pH increased embryonic development time increased but no effect of pH on hatch success. | Temperate Northern Atlantic | Egilsdottir et al. (2009) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Amphibalanus amphitrite* (barnacle)*\** | 8.20 | 7.40 | 11 weeks | Gametogenesis and gamete quality | No effect of pH on egg onset time. | Temperate Northern Atlantic | McDonald et al. (2009) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia tsuensis* (copepod)*\** | 8.23 | 7.31 | 9 days | Fecundity and reproductive output | No effect of pH on egg production and hatching rate. | Temperate Northern Pacific | Kurihara and Ishimatsu (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Palaemon pacificus* (shrimp)*\** | 8.17 | 7.89 | 30 days | Gametogenesis and gamete quality | Low pH reduced number of females who bore eggs. | Temperate Northern Pacific | Kurihara et al. (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Calanus finmarchicus* (copepod)*\** | 8.23 | 6.95 | 72 hours | Fecundity and reproductive output | Eggs remained unhatched at low pH but no effect of pH on egg production and disintegration. | Temperate Northern Atlantic | Mayor et al. (2007) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia steueri* (copepod)*\** | 8.14 | 7.40, 6.84 | 8 days | Fecundity and reproductive output | Low pH decreased egg production. | Temperate Northern Pacific | Kurihara et al. (2004) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acartia erythraea* (copepod)*\** | 8.20 | 7.02, 6.86 | 8 days | Fecundity and reproductive output | Low pH decreased hatching rate and increased egg production but no effect of pH on egg production. | Temperate Northern Pacific | Kurihara et al. (2004) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Echinoderm** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acanthaster* spp. (sea star) | 8.01 | 7.74 | 130 - 145 days | Fertilization; Gametogenesis and gamete quality | Low pH reduced egg volume was but there was no effect of pH on gonadosomatic index or fertilization. | Central Indo-Pacific | Hue et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 6.80 | 8.20 | 20 minutes | Fertilization | Low pH compromised egg actin dynamics but there was no effect of pH on sperm production. | Temperate Northern Atlantic | Limatola et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.00 | 7.40, 7.70 | 60 days | Gametogenesis and gamete quality | Low pH increased gonadosomatic index in females and decreased in males. | Temperate Northern Atlantic | Marčeta et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra* sp. *A* (sea urchin) | 8.06 | 7.89, 7.79 | 20 months | Gametogenesis and gamete quality | No effect of pH on gamete development. | Central Indo-Pacific† | Uthicke et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Odontaster validus* (sea star) | 8.12 | 7.80, 7.60 | 2 months | Gametogenesis and gamete quality | No effect of pH on gonado-somatic index and individual variability. | Southern Ocean | Dell'Acqua et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Sterechinus neumayeri* (sea urchin) | 8.12 | 7.80, 7.60 | 1 month | Gametogenesis and gamete quality | No effect of pH on gonado-somatic index but variability exists between individuals. | Southern Ocean | Dell'Acqua et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.00 | 7.90, 7.70 | 10 minutes | Fertilization | Low pH caused inter-individual variability in fertilization success. | Temperate Australasia | Smith et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Lytechinus pictus* (sea urchin) | 8.00 | 7.90, 7.70 | 10 minutes | Fertilization | Low pH caused inter-individual variability in fertilization success. | Temperate Australasia | Smith et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus purpuratus* (sea urchin) | 7.87 | 7.57 | 4 months | Fecundity and reproductive output; Gametogenesis and gamete quality | Females exposed to low pH had wider egg variability and reduced lipid content but no effect of low pH on egg size and protein content. | Temperate Northern Pacific | Wong et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Tripneustes gratilla* (sea urchin) | 8.10 | 7.80, 7.60 | 140 days | Gametogenesis and gamete quality | Low pH reduced gonad index. | Temperate Australasia | Dworjanyn and Byrne (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Asterias rubens* (sea star) | 7.90 | 7.50, 7.20 | 85 days | Gametogenesis and gamete quality | Lowest pH reduced gonad weight. | Temperate Northern Atlantic | Hu et al. (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus purpuratus* (sea urchin) | 8.03 | 7.87, 7.76, 7.61 | 30 seconds | Fertilization | Low pH improved fertilization success, but this effect varied by site. | Temperate Northern Pacific | Kapsenberg et al. (2017) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.18 | 7.71 | N/A | Fertilization | Low pH reduced sperm speed, count, motility, path linearity, and straightness, and fertilization. | Temperate Northern Atlantic | Campbell et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.00 | 6.00, 6.50, 7.00, 7.50 | N/A | Fertilization | Low pH reduced fertilization. | Temperate Northern Atlantic | Riba et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Cucumaria frondosa* (sea cucumber) | 8.03 | 7.63 | 19 weeks | Fecundity and reproductive output; Gametogenesis and gamete quality; Timing of reproduction and synchronization | Low pH and time affected male gonad index, gonad maturation, and spawning events. Low pH affected female egg shape, spawning success, and lipid profile. | Temperate Northern Atlantic | Verkaik et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Centrostephanus rodgersii* (sea urchin) | 8.10 | 7.60 | 1 - 30 minutes | Fertilization | Low pH reduced jelly coat area more quickly. | Temperate Australasia | Foo (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra mathaei* (sea urchin) | 8.10 | 7.60 | 1 - 30 minutes | Fertilization | Low pH reduced jelly coat area more quickly. | Temperate Australasia | Foo (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.08 | 7.93 | 2 hours - 6 months | Fertilization | Low pH increased sperm swimming speed but decreased fertilization success. | Temperate Northern Pacific | Graham et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Centrostephanus rodgersii* (sea urchin) | 8.10 | 7.80, 7.60 | 2 seconds | Fertilization | No effect of pH on sperm swimming behavior. | Temperate Australasia | Schlegel et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Sterechinus neumayeri* (sea urchin) | 7.99 | 7.99, 7.70, 7.54 | 6 - 17 months | Gametogenesis and gamete quality | Low pH reduced egg size, but after some time eggs were larger at low pH. | Southern Ocean† | Suckling et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus franciscanus* (sea urchin) | 7.99 - 8.00 | 7.36 - 7.94 | 20 minutes | Fertilization | Low pH had an effect on fertilization sensitivity depending on sperm:egg ratios | Temperate Northern Pacific | Frieder (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus purpuratus* (sea urchin) | 7.95 - 7.96 | 7.26 - 7.88 | 20 minutes | Fertilization | Low pH had an effect on fertilization sensitivity depending on sperm:egg ratios | Temperate Northern Pacific | Frieder (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra* sp. *EE* (sea urchin) | 8.10 | 7.70 | 11 months | Gametogenesis and gamete quality | No effect of pH on gametogenesis. | Temperate Northern Atlantic | Hazan et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Psammechinus miliaris* (sea urchin) | 7.98 | 7.70 | 70 days | Fertilization; Gametogenesis and gamete quality | Low pH resulted in smaller eggs but higher fertilization rates. | Temperate Northern Atlantic | Suckling et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus droebachiensis* (sea urchin) | 8.13 | 8.05, 7.63, 7.58, 7.20 | 1 - 3 hours | Fertilization | Low pH conditions decreased egg intracellular pH. | Arctic† | Bögner et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Hemicentrotus pulcherrimus* (sea urchin) | 7.99 | 7.96, 7.92, 7.78, 7.69, 7.59 | N/A | Fertilization | No effect of pH on sperm motility and speed. | Temperate Northern Pacific | Sung et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus nudus* (sea urchin) | 7.99 | 7.96, 7.92, 7.78, 7.69, 7.59 | N/A | Fertilization | Sperm and eggs exposed to low pH had reduced fertilization rates but ther was no effect of pH on sperm motility and speed. | Temperate Northern Pacific | Sung et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra* sp. *A* (sea urchin) | 8.10 | 7.90 | 77 days | Gametogenesis and gamete quality | No effect of pH on gonad weight and condition. | Central Indo-Pacific† | Uthicke et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Patiriella regularis* (sea star) | 8.15 | 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on fertilization. | Temperate Australasia | Byrne et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus droebachiensis* (sea urchin) | 8.07 | 7.69 | 4 - 16 months | Fecundity and reproductive output; Gametogenesis and gamete quality | Low pH reduced egg production but had no effect on egg quality. | Temperate Northern Atlantic | Dupont et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Arachnoides placenta* (sand dollar) | 8.10 | 7.80, 7.60, 7.00 | 17 hours | Fertilization | Low pH reduced fertilization. | Temperate Australasia | Gonzalez-Bernat et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Odontaster validus* (sea star) | 8.10 | 7.80, 7.60, 7.00 | 17 hours | Fertilization | Low pH only impacted percent fertilization at low sperm concentrations. | Temperate Australasia | Gonzalez-Bernat et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Hemicentrotus pulcherrimus* (sea urchin) | 7.61 | 7.03 | 9 months | Gametogenesis and gamete quality | No effect of pH on gametogenesis. | Temperate Northern Pacific | Kurihara et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Acanthaster planci* (sea star) | 8.10 | 7.90, 7.60 | 2 seconds - 10 minutes | Fertilization | Low pH reduced sperm motility, velocity, and fertilization. | Central Indo-Pacific† | Uthicke et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra mathaei* (sea urchin) | 8.10 | 7.90, 7.70, 7.50 | 15 minutes - 7 weeks | Gametogenesis and gamete quality | No effect of pH on egg size. | Central Indo-Pacific† | Uthicke et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.12 | 7.80, 7.60 | 10 minutes | Fertilization | Low pH reduced sperm motility, with inter-individual variability in fertilization. | Temperate Australasia | Schlegel et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus droebachiensis* (sea urchin) | 7.80 | 7.51, 7.10 | 10 - 45 days | Gametogenesis and gamete quality | Low pH reduced energy expenditure on developing gonads. | Temperate Northern Atlantic | Stumpp et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Psammechinus miliaris* (sea urchin) | 8.06 | 7.96, 7.82, 7.67 | N/A | Fertilization | Low pH improved sperm swimming speed. | Temperate Northern Atlantic | Caldwell et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.10 | 7.90, 7.70, 7.50, 7.25, 7.00 | 3 days | Fertilization | No effect of pH on fertilization. | Temperate Northern Atlantic | Martin et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Paracentrotus lividus* (sea urchin) | 8.00 | 7.60, 6.80 | 2 hours | Fertilization | Lower pH decreased fertilization but those collected from tidepools with higher pH fluctuations were less impacted | Temperate Northern Atlantic | Moulin et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus franciscanus* (sea urchin) | 8.04 | 7.81, 7.55 | 30 seconds | Fertilization | Low pH reduced ability to block polyspermy. | Temperate Northern Pacific | Reuter et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Centrostephanus rodgeresii* (sea urchin) | 8.25 | 7.90, 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on percent fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.25 | 7.90, 7.80, 7.70 | 2 hours | Fertilization | No effect of pH on fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.25 | 7.90, 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on percent fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris tuberculata* (sea urchin) | 8.25 | 7.90, 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on percent fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Patiriella regularis* (sea star) | 8.25 | 7.90, 7.80, 7.60 | 2 hours | Fertilization | No effect of pH on percent fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Tripneustes gratilla* (sea urchin) | 8.25 | 7.90, 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on percent fertilization. | Temperate Australasia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Sterechinus neumayeri* (sea urchin) | 8.01 | 7.70, 7.30, 7.00 | 7 hours | Fertilization | Low pH reduced fertilization, but the effect was dependent on sperm concentration. | Southern Ocean | Ericson et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Holothuria* spp. (sea cucumber) | 8.00 | 7.80, 7.70, 7.60, 7.30, 6.60 | N/A | Fertilization | Low pH decreased sperm motility. | Temperate Northern Pacific | Morita et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.20 | 7.60 , 7.80, 7.90 | 20 hours | Fertilization | No effect of pH on fertilization. | Temperate Australasia | Byrne et al. (2009) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Heliocidaris erythrogramma* (sea urchin) | 8.10 | 7.70 | 4 hours | Fertilization | Low pH reduced sperm swimming speed, motility, and fertilization success. | Temperate Australasia | Havenhand et al. (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Hemicentrotus pulcherrimus* (sea urchin) | N/A | 7.8 | 8 months | Gametogenesis and gamete quality | Low pH delayed gonad development and shortened spawning period. | Temperate Northern Pacific | Kurihara (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Amphiura filiformis* (brittle star) | 8.00 | 7.70, 7.30, 6.80 | 40 days | Gametogenesis and gamete quality | No effect of pH on gametogenesis but experiment was conducted during a period generally classified with latent reproductive growth | Temperate Northern Atlantic | Wood et al. (2008) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Strongylocentrotus droebachiensis* (sea urchin) | 8.10 | 6.98 | 56 days | Gametogenesis and gamete quality | Low pH hindered gonad growth. | Temperate Northern Atlantic | Siikavuopio et al. (2007) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Echinometra mathaei* (sea urchin) | 8.11 | 7.82, 7.71, 7.33, 7.12, 6.79 | 3 days | Fertilization | Low pH reduced fertilization and cleavage rates. | Temperate Northern Pacific | Kurihara and Shirayama (2004) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Hemicentrotus pulcherrimus* (sea urchin) | 8.01 | 7.77, 7.61, 7.38, 7.03, 6.83 | 3 days | Fertilization | Low pH reduced fertilization and cleavage rates. | Temperate Northern Pacific | Kurihara and Shirayama (2004) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Arbacia* sp.(sea urchin) | 8.15 | 7.60, 7.40, 7.30, 7.20, 7.10, 7.00, 6.90, 6.80, 6.70, 6.60 | 5 minutes | Fertilization | Lower pH treatments blocked fertilization. | N/A | Smith and Clowes (1924) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Asterias* sp.(sea star) | 8.15 | 7.60, 7.40, 7.30, 7.20, 7.10, 7.00, 6.90, 6.80, 6.70, 6.60 | 5 minutes | Fertilization | Lower pH treatments blocked fertilization. | N/A | Smith and Clowes (1924) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Mollusc** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 8.10 | 7.80 | 4 hours | Fertilization | Low pH decreased sperm motility, mitochondrial activity, and pHi but no effect of pH on sperm vitality and oxidative state. | Temperate North Atlantic | Esposito et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 8.10 | 7.80 | 21 days | Fertilization; Gametogenesis and gamete quality | Low pH increased percent abnormal sperm but sperm motility, mitochondrial membrane potential, intracellular pH, and lipid peroxidation differed temporally. | Temperate North Atlantic | Gallo et al. (2020) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas* (oyster) | 8.03 | 7.86, 7.74 | 10 minutes | Fertilization | Low pH increased sperm motility in an established population but no effect of pH in a recently invaded population. | Temperate North Atlantic | Falkenberg et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus edulis* (mussel) | 8.10 | 7.70, 7.30 | 8 hours - 4 weeks | Fertilization | Low pH decreased fertilization rate, but effect was mitigated by parental exposure. | Temperate Northern Pacific | Kong et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 8.00 | 7.60 | 10 minutes - 2 hours | Fertilization | Low pH increased fertilization rate in the presence of egg-derived chemicals. | Temperate Australia | Lymbery et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas* (oyster) | 8.10 | 7.50, 7.80 | 4 weeks | Fertilization | Low pH decreased sperm motility but when spawned, egg rupture prevalence increased. | Temperate Southern Africa | Omoregie et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Idiosepius pygmaeus* (squid)*\** | 8.05 | 7.78 | 14 days | Fecundity and reproductive output; Gametogenesis and gamete quality; Mating behavior | Low pH decreased egg clutch size and vitelli size but increased egg swelling and clutch density when breeding pairs were exposed. No effect of low pH on fertilization rate or egg area. No other mating behaviors were affected by low pH. | Central Indo-Pacific | Spady et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Ostrea lurida* (oyster)\* | 7.80 | 7.30 | 52 days | Gametogenesis and gamete quality; Sex determination, differentiation, and ratio; Timing of reproduction and synchronization | Low pH decreased spermatogenesis rate but there was no effect of pH on timing or magnitude of spawning, oogenesis, and sex ratio. | Temperate Northern Pacific | Spencer et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas* (oyster) | 7.80 | 7.30 | 52 days | Gametogenesis and gamete quality; Sex determination, differentiation, and ratio | No effect of pH on gametogenesis or sex ratio. | Temperate Northern Pacific | Venkataraman et al. (2019) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Saccostrea glomerata* (oyster) | 8.20 | 7.91 | 8 weeks | Fecundity and reproductive output; Gametogenesis and gamete quality; Sex determination, differentiation, and ratio; Timing of reproduction and synchronization | Low pH decreased gametogenesis, gonad area, and fecundity but increased female prevalence. | Temperate Australia | Parker et al. (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Saccostrea glomerata* (oyster) | 8.12 | 7.83 | 8 weeks | Gametogenesis and gamete quality | No effect of low pH on egg size or lipid content. | Temperate Australia | Scanes et al. (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Limecola balthica* (clam) | 7.70 | 7.00, 6.30 | 1 hour | Fertilization | Low pH decreased fertilization rate. | Temperate North Atlantic | Świeżak et al. (2018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea virginica* (oyster) | 7.50 | 7.10, 6.70 | 5 weeks | Fertilization; Gametogenesis and gamete quality; Sex determination, differentiation, and ratio | Low pH reduced or inhibited gametogenesis rate and female prevalence but no effect of pH on fertilization. | Temperate North Atlantic | Boulais et al. (2017) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Saccostrea glomerata* (oyster) | 8.20 | 7.91 | 8 weeks | Gametogenesis and gamete quality | No effect of pH on egg lipid content or egg size. | Temperate Australia | Parker et al. (2017) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Tegillarca granosa* (clam) | 8.10 | 7.80, 7.40 | 30 - 60 minutes | Fertilization | Low pH decreased fertilization rate and sperm velocity. | Temperate Northern Pacific | Shi et al. (2017a) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Tegillarca granosa* (clam) | 8.07 | 7.80, 7.40 | 1 hour | Fertilization | Low pH decreased fertilization rate and sperm motility when eggs were exposed, and effect was amplified when both gametes were exposed. | Temperate Northern Pacific | Shi et al. (2017b) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 8.00 | 7.60, 7.80 | 10 minutes - 2 hours | Fertilization | Low pH decreased fertilization rate and sperm motility. | Temperate Australia | Eads et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus edulis (mussel)* | 8.00 | 6.00, 6.50, 7.00, 7.50 | N/A | Fertilization | Low pH decreased or inhibited fertilization rate. | Temperate North Atlantic | Riba et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas* (oyster) | 8.00 | 6.00, 6.50, 7.00, 7.50 | N/A | Fertilization | Low pH decreased or inhibited fertilization rate. | Temperate North Atlantic | Riba et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Macoma calcarea* (clam) | 380 µatm | 1000 µatm | N/A | Fertilization | Low pH decreased sperm swimming speed decreased but no effect of pH on fertilization rate or sperm motility. | Temperate North Atlantic | Vihtakari et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 380 µatm | 1000 µatm | N/A | Fertilization | Low pH decreased fertilization success, sperm motility and swimming speed. | Temperate North Atlantic | Vihtakari et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Argopecten irradians* (scallop) | 8.30 | 7.60 | 15 minutes | Fertilization | Low pH decreased fertilization rate. | Temperate Northern Pacific | Wang et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Ruditapes philippinarum* (clam) | 8.00 | 7.70, 7.40 | 70 days | Gametogenesis and gamete quality, Timing of reproduction and synchronization | Low pH reduced number of animals to successfully spawn. | Temperate Northern Pacific | Xu et al. (2016) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Laternula elliptica* (clam) | 7.98 | 7.65 - 7.80 | 4 - 48 hours | Fertilization | No effect of pH on fertilization. | Southern Ocean† | Bylenga et al. (2015) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mimachlamys asperrima* (scallop) | 8.20 | 7.89, 7.81, 7.69 | 2 - 24 hours | Fertilization | Low pH decreased fertilization rate. | Temperate Australia | Scanes et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Argopecten irradians* (scallop) | 7.96 | 7.30 | 45 minutes - 24 hours | Fertilization | Low pH decreased fertilization rate. | Temperate North Atlantic | White et al. (2014) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus galloprovincialis* (mussel) | 8.00 | 7.60 | a few minutes | Fertilization | Low pH decreased sperm motility and swimming speed. | Temperate North Atlantic | Vihtakari et al. (2013) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Macoma balthica* (clam) | 8.10 | 7.80, 7.50 | 24 hours | Fertilization | Low pH decreased fertilization rate. | Temperate North Atlantic | Van Colen et al. (2012) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Mytilus edulis* (mussel) | 8.10 | 7.60 | 2 hours | Fertilization | No effect of pH on fertilization. | Temperate North Atlantic | Bechmann et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Haliotis discus hannai (abalone)* | 8.01 | 7.96 , 7.83, 7.79, 7.73 | 15 hours | Fertilization | Low pH decreased fertilization rate. | Temperate Northern Pacific | Kimura et al. (2011) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Haliotis coccoradiata* (abalone) | 8.25 | 7.90, 7.80, 7.60 | 15 minutes | Fertilization | No effect of pH on fertilization. | Temperate Australia | Byrne et al. (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Saccostrea glomerata (oyster)* | 8.20 | 8.00, 7.94, 7.83 | 2 hours | Fertilization | Low pH decreased fertilization rate. | Temperate Australia | Parker, Ross and O'Connor (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas (oyster)* | 8.20 | 8.00, 7.94, 7.83 | 2 hours | Fertilization | Low pH decreased fertilization rate. | Temperate Australia | Parker, Ross and O'Connor (2010) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Crassostrea gigas* (oyster) | 8.15 | 7.85 | 12 - 60 minutes | Fertilization | No effect of pH on fertilization. | Temperate North Atlantic | Havenhand and Schlegel (2009) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| *Saccostrea glomerata* (oyster) | 375 µatm | 600 µatm, 750 µatm, 1000 µatm | 2 hours | Fertilization | Low pH decreased fertilization rate. | Temperate Australasia | Parker et al. (2009) |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

\* An asterisk after the species name indicates that the species is a brooder (or copulation using ovipositor in the case of the squid).  
† The obelisk symbol next to the collection location indicates that the collection Ecoregion is different from the experimental Ecoregion.  
In the case were pH was not reported, pCO2 values were used in this table.