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Three decades of sea water abstraction by Kapar power plant (Malaysia): What impacts on tropical zooplankton community?

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ABSTRACT

Zooplankton samples collected before (1985–86) and after (2013–14) the establishment of Kapar power station (KPS) were examined to test the hypothesis that increased sea surface temperature (SST) and other water quality changes have altered the zooplankton community structure. Elevated SST and reduced pH were detected between before and after impact pairs, with the greatest impact at the station closest to KPS. Present PAHs and heavy metal concentrations are unlikely causal factors. Water parameter changes did not affect diversity but community structure of the zooplankton. Tolerant small crustaceans, salps and larvaceans likely benefited from elevated temperature, reduced pH and shift to a more significant microbial loop exacerbated by eutrophication, while large crustaceans were more vulnerable to such changes. It is predicted that any further rise in SST will remove more large-bodied crustacean zooplankton, the preferred food for fish larvae and other meroplankton, with grave consequences to fishery production.

1. Introduction

Power plants that abstract seawater to cool down its superheated power turbines generating electricity have the reputation of not only directly causing massive mortality of marine organisms by impingement and entrainment (Lewis and Seegert, 2000; Greenwood, 2008; Azila and Chong, 2010), but also indirectly killing or undermining organisms via thermal discharges that increase temperature, acidification and chemical pollution of the receiving waters (Bamber and Spencer, 1984; Poornima et al., 2005; Ferry-Graham et al., 2008; Chuang et al., 2009; Coulter et al., 2014). A single once-through cooled (OTC) power plant can withdraw millions of cubic meters of cooling-water daily before discharging the heated water including chemical biocides into the sea. Impingement mortality at the intake screens is highly variable, ranging from annual fish deaths of about 13,000 in a 930 MW power plant in USA to 214 million in a 5706 MW power plant in France (see Azila and Chong, 2010). Small nekton and plankton are however subject to entrainment into the power plant's heat-cooling system. The annual entrainment mortality of larval fish is usually very high ranging from 132 million fish eggs and larvae (or 23% of the total ichthyoplankton) through a single small direct-cooled power plant such as at the Wabash River, USA (Lewis and Seegert, 2000) to an estimated 10^{14} fish larvae in north European waters where 45 large power plants were located (Henderson, 2015).

Discharged thermal waters are 2–12 °C warmer than intake temperatures in temperate regions (Bamber, 1995; Hoffmeyer et al., 2005; Coulter et al., 2014), 8–12 °C in a subtropical region (Chuang et al., 2009), while differences of 7–10 °C are reported in tropical regions (Anton, 1990; Poornima et al., 2005; Pokale, 2012). Phytoplankton biomass especially during spring was significantly greater in the intake region than in the outlet region of a nuclear power plant in subtropical Taiwan (Chuang et al., 2009). Warmed water seems to limit the growth of more nutritious and palatable large diatom species, but favors the less palatable and small diatom species, cyanobacteria and harmful algae (Hutchins et al., 2007). Mortality of copepods, cirriped and crab larvae was higher at the water discharge outlets compared to intake points (Hoffmeyer et al., 2005; Choi et al., 2012), with increased thermal sensitivity in the presence of chlorine (Choi et al., 2012). Warm water also induces high productivity of heterotrophic bacteria in the microbial loop of marine food webs (Berglund et al., 2007; Sarmento et al., 2010), which may alter the zooplankton community in such a way that species (for instance, large-sized copepods) that rely on large nutritious diatoms are eliminated from the system, whereas species (small-sized ones) that rely on heterotrophic microbes and small plankton become dominant in the system (Richardson, 2008). Richardson (2008) concluded that the replacement of large-sized copepods by small-sized ones (as well as the blooming of jellyfish and ctenophores) is the likely consequence of sea warming. Striking phenological changes due to sea warming have been documented in temperate waters including for dinoflagellates, diatoms, holozooplankton and meroplanktonic larvae where their seasonal peaks advanced by 23 days, 22 days, 10 days and

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