Marine Pollution Bulletin 83 (2014) 24–31

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Review

Impacts of recreational motorboats on fishes: A review

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ARTICLE INFO

Article history:
Available online 20 April 2014

Keywords:
Boat traffic
Pollution
Disturbance
Degradation
Invasives

ABSTRACT

A considerable amount of research has been conducted on the impacts of recreational boating activities on fishes but little or no synthesis of the information has been undertaken. This review shows that motor boats impact on the biology and ecology of fishes but the effects vary according to the species and even particular size classes. Direct hits on fishes by propellers are an obvious impact but this aspect has been poorly documented. Alterations in the wave climate and water turbidity may also influence fishes and their habitats, especially submerged and emergent plant beds. Sound generated by boat motors can also influence the communication and behaviour of certain species. Pollution arising from fuel spillages, exhaust emissions and antifouling paints all have detrimental effects on fishes. Finally, the use of recreational boats as vectors of aquatic invasive organisms is very real and has created major problems to the ecology of aquatic systems.

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1. Introduction

There has been considerable conjecture among scientists, environmental managers and members of the public regarding the possible influence of recreational boat traffic on fishes and their aquatic environment (Lloret et al., 2008). Since much of this speculation is not based on facts or direct research evidence, the need to collate available information is both overdue and, in some instances, urgent. This review is also timely because coastal regions are experiencing unprecedented human population growth, with densities within 100 km from the ocean now three times greater than the global average (Small and Nicholls, 2003). In addition, there has been a significant rise in coastal recreation and tourism (Davenport and Davenport, 2006), including boating, with recreational motor boats accounting for a large percentage of boating traffic (Sidman and Fik, 2005; Lloret et al., 2008; Gray et al., 2011; Balaguer et al., 2011). For example, in Sydney Harbour, it was found recreational boats accounted for 70% of all boating activity (Widmer and Underwood, 2004). In the USA alone there

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http://dx.doi.org/10.1016/j.marpolbul.2014.03.055
0025-326X/

are more than 12 million registered powerboats (NMMA, 2004), with a further 2.5 million in Canada (NMMA Canada, 2006). In freshwater ecosystems, recreational activities such as waterskiing are also increasing in popularity, with demonstrated environmental impacts (Mosisch and Arthington, 1998). In the opinion of these authors it is obvious, based on their review, that the biological impacts of power boating and water skiing on inland waters have been underestimated and that there is a need for more focused research within this field.

Some evidence is available (e.g. Sarà et al., 2007; Zamani-Ahmadmahmoodi et al., 2013) which suggests that motorboat traffic and the associated disturbance and pollution caused by such activities are having a negative impact on fishes associated with a range of aquatic systems, including freshwater, estuarine and marine waters. Unfortunately, relatively little work appears to have been conducted within this research field when compared to the speculation about the potential harm that such activities may bring to fish and the associated water bodies. For example, it has been proposed that motor boating may have been an important factor in the decline of fishes in the Danube River (Kiwek, 1995) but little scientific information is available to link cause and effect. Similarly, recreational fishers in Barnegat Bay (New Jersey) were of the opinion that personal watercraft (jet skis) were a severe environmental problem that affected fish within this system but could not offer any research evidence that backed up this perception (Burger et al., 1999).

We have chosen to focus our review on motor boat effects on fish, excluding other aquatic animals such as marine mammals and reptiles. The effect of boat noise on marine mammals has received significant previous research attention (e.g. Jensen et al., 2009; Buckstaff, 2004) and will not be covered in this paper. Similarly, we have chosen to limit this review to the effects of all sizes and types of recreational motor boats on fishes and will not assess the potential impacts of larger vessels such as cruise liners, commercial shipping and dredgers. Boating activities have both direct and indirect effects on fishes (Fig. 1). What we have attempted here is to cover the more immediate and direct effects in the first three subheadings after the Introduction and then move on to the more indirect effects in the final five subheadings. It should be noted, however, that both direct and indirect effects are present in all sections of the review and across all the time scalers (Fig. 1).

2. Motorboat traffic and direct hits

Despite this being the most obvious direct impact on fishes, very little work has been done at quantifying fish strikes at different boat speeds and by boats of different sizes. Direct strikes by motorboat propellors on fish have been noted in certain scientific studies (Balazik et al., 2012) and may occasionally reach high levels (Killgore et al., 2011). In addition, some fish species are so disturbed by motorboat traffic that they begin jumping in the same manner as if escaping from an underwater predator. The flathead mullet *Mugil cephalus* is well known to undertake such behaviour (Hoese, 1985) and numerous specimens have been recorded jumping into moving boats in estuaries, especially at night (personal observation).

There is also little information on the direct impact of rapidly rotating boat propellers on delicate fish larvae, especially at night when the ichthyoplankton is concentrated in surface waters. Are these fish too small to be impacted by the propeller blades, or do the water vortices created by the rapid rotation of propellers cause instantaneous mortalities amongst the larvae? A study by Jude et al. (1998) noted that the early life stages of at least three species of fishes in the Great Lakes of North America may be affected by large boats which cause resuspension of sediments, dislodge eggs and can lead to the premature emergence of larvae.

3. Motorboat traffic and fish behaviour

Some fish species do not appear to respond behaviourally to the presence of powered outboard engines, e.g. lake trout *Salvelinus namaycush* in a small Canadian lake did not respond boat traffic, even during detailed manual tracking of individual fish

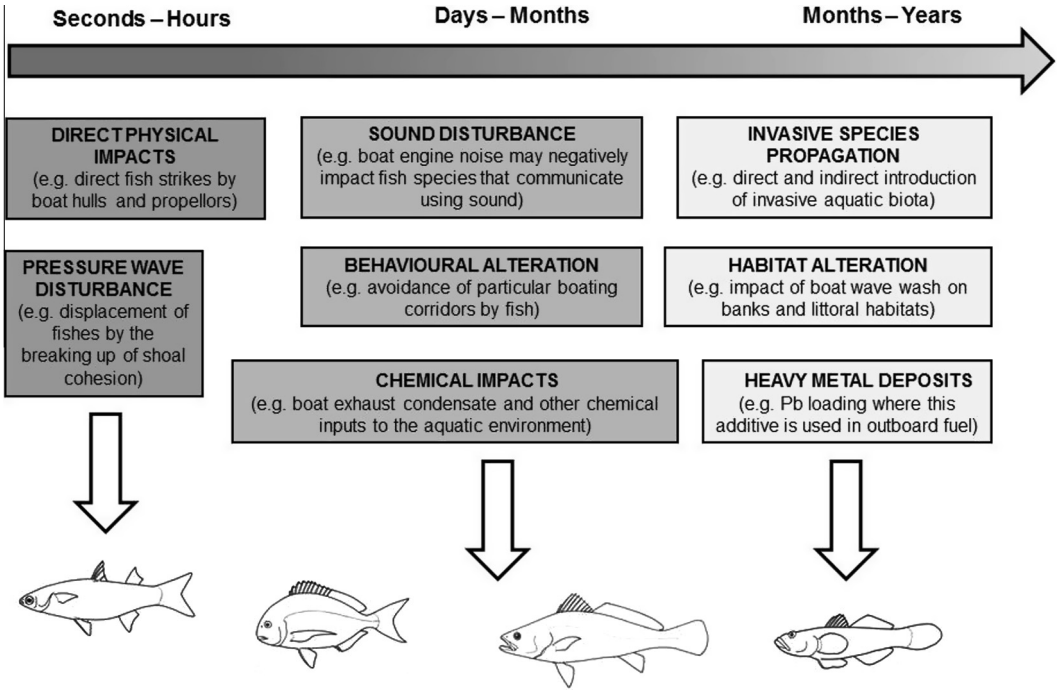

Fig. 1. Likely influences and impacts of power boating activities on fishes and their habitats and the likely time frame over which the impacts may act (for details and references see text).