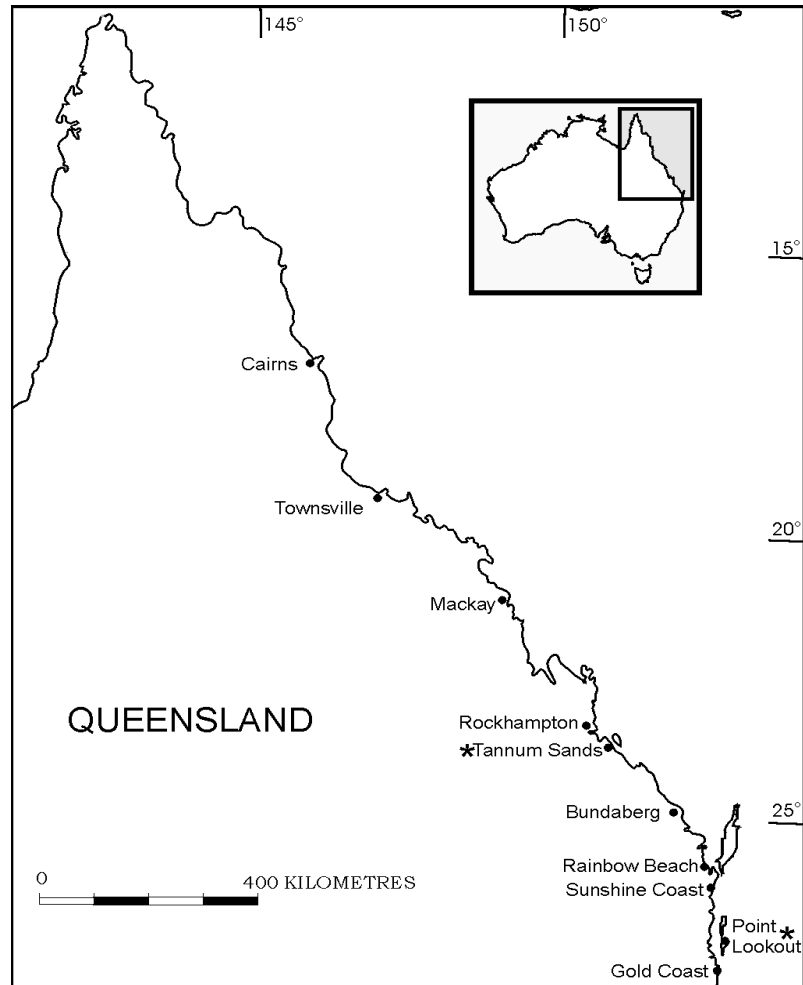


## INTRODUCTION

One of the criteria used by the IUCN (2000) for evaluating the extinction probability of a species is evidence for reduction in population size over a time frame appropriate for that species (10 years or three generations, whichever is the longer). Obtaining the evidence relevant to this criterion is generally very difficult for species which are not harvested commercially, particularly for long-lived species such as the dugong, *Dugong dugon* (Marsh et al. 1999), which can live for over 70 years (Marsh 1980). If dedicated monitoring programs exist at all for such species, they have generally been introduced relatively recently, e.g. mid-1980s for dugongs along the urban coast of Queensland (Marsh & Saalfeld 1990). In addition, low-level chronic declines are very difficult to detect even by dedicated surveys, especially if population sizes are small (Taylor & Gerrodette 1993; Marsh 1995). These difficulties reinforce the importance of taking serendipitous advantage of all information on the status of a population. Indeed the IUCN criteria (2000) allow for the reduction in population size to be 'observed, estimated, inferred or suspected'. In this paper, we use data on dugong by-catch, collected by a government program designed to protect bathers from sharks, to provide information on the status of the dugong on the urban coast of Queensland, Australia. This information is additional to that provided by dedicated monitoring (Marsh & Saalfeld 1990; Marsh et al. 1994, 1996; Marsh & Lawler 2001) and anecdotal reports (see Marsh et al. 1996 for details).

The State Government has conducted the 'Queensland Shark Control Program' by progressively introducing anti-shark measures at popular coastal resort areas from 1962. This program aims to protect swimmers in 10 districts (known as contract areas; figure 1) on the east coast of Queensland between Cairns (16.5°S) and the Gold Coast (28°S) (Paterson 1979, 1986, 1990; Gribble et al. 1998; McPherson et al. 1998). Six of these contract areas are in the Great Barrier Reef World Heritage Area. Each contract area consists of a number of beaches where gear is deployed to reduce the number of large sharks in the local area. Since its inception, the Program has deployed shark nets and baited drum lines in a 'mixed gear strategy' that adapts the type of gear to the characteristics of each beach. There have been numerous temporal changes in the number of contract areas and beaches where the gear is deployed and the number of nets set per beach since the inception of the Program.

In addition to sharks, these nets also catch a variety of non-target species including marine mammals such as dugongs and sea turtles. There has been concern about the ecological sustainability of this by-catch since the early 1970s (Heinsohn 1972; Paterson 1979, 1990). In response to a ministerial Committee of Enquiry (*Review of the operation and maintenance of shark meshing equipment in Queensland waters*, 1992), initiatives were begun in 1992 (Gribble et al. 1998) to reduce the capture of non-target species. Nonetheless, concern over the by-catch increased in the mid-1990s as a result of aerial survey evidence of a decline in the dugong population in the Great Barrier Reef World Heritage Area between the mid-1980s and 1994 (Marsh et al. 1996). The likely reasons for this decline are complex and include habitat loss, traditional hunting and incidental drowning in commercial gill and mesh nets, as well as the Shark Control Program *per se* (Marsh et al. 1999). This concern led to a second inquiry in 1996–1997 which investigated the effect of the Queensland Shark Control Program on vulnerable and endangered species and the outcomes of the initiatives proposed in 1992–1993 (Gribble et al. 1998). Gribble et al. (1998) analysed the shark meshing records and concluded that, on average, the annual mortality of dugongs in shark nets in the southern Great Barrier Reef region represented 0.5% of the estimated dugong population of that region, based on the 1986 aerial survey (Marsh et al. 1996). Their analysis averages dugong mortality over the spatial scale of the entire region and the temporal scale of 1962–1999.



**Figure 1.** Map showing the deployment of shark control nets along the eastern coast of Queensland. The two contract areas marked with an asterisk were excluded from all analyses. No shark nets were deployed at Tannum Sands. Those at Point Lookout were deployed at only one beach and for seven years only (1974–1980).

We reanalysed the dugong by-catch data with two objectives: (1) to investigate factors affecting dugong mortality in nets, and (2) to consider the change in catch per unit effort of dugongs in shark nets as an additional index of change in the status of the dugong population in the region between 1962 and 1999. Our analysis suggests that dugong catch rates declined to 3.1% [95% CI = (1.4, 6.1)] of the initial catch rates over the 38-year sampling period, reinforcing concern about the status of the dugong along the urban coast of Queensland.