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Prevalence and composition of fishing gear debris in the nests of northern gannets (*Morus bassanus*) are related to fishing effort

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ABSTRACT

Bycatch and indirect mortality associated with global fishing operations affect non-target species. Northern gannets (*Morus bassanus*) and other seabirds incorporate marine debris, much of it originating in fisheries, into their nests, at times resulting in entanglement. We compared the prevalence and composition of marine debris in nests at two gannet colonies in Newfoundland before and after a basin-wide ground fish closure in 1992, and at the species' largest colony in the Gulf of St. Lawrence, where fishing effort is low. The proportion of nests with marine debris decreased following the fishery closure, and the proportion of nests with fishing gear was related exponentially to the number of gillnets set around breeding colonies. Assessing the composition of gannet nests could provide a useful index of the prevalence of fishing debris and could be used to assess entanglement risk of other animals in the marine environment over decadal scales.

1. Introduction

Fisheries have numerous effects on non-target animals. By-catch and entanglement in active, abandoned, lost or discarded gear can result in direct mortality (Lewison et al., 2004; Good et al., 2010). Plastics and other anthropogenic marine debris, much of it originating in fisheries, are ubiquitous and increasing in the world's oceans (Colton et al., 1974; Robards et al., 1997; Thompson et al., 2004; Howell et al., 2012). This debris can have detrimental effects on wildlife, particularly through entanglement and ingestion by marine birds and mammals (Ryan, 1987; Sievert and Sileo, 1993; Laist, 1997). Despite the observed consequences of marine debris on seabirds, few studies have examined changes in seabirds' association (use, ingestion, entanglement) with debris over time (Robards et al., 1995; Provencher et al., 2009).

Seabirds are used frequently as sentinels of the health of the marine environment (Burger and Gochfeld, 2004; Durant et al., 2009). The frequency of seabird interactions with synthetic debris can provide indices of this persistent marine pollution (Robards et al., 1995; van Franeker et al., 2011) that could be useful in assessing threats at-sea.

Gannets, boobies and gulls frequently collect and incorporate plastic netting and strapping into their nests, where birds can become entangled (Schrey and Vauk, 1987; Norman et al., 1995; Votier et al., 2011). Northern gannets (*Morus bassanus*) have a well-documented practice of incorporating marine debris, and in particular derelict fishing gear, into their nests (Bourne, 1977; Nelson, 1978), and entanglement causing death has been documented (Votier et al., 2011). In the northwest Atlantic Ocean, almost all gannet nests examined at two colonies (Funk Island and Cape St. Mary's, Newfoundland) contained marine debris in the late 1980s, much of it being fishing gear debris (Montevecchi, 1991). While plastic pollution in the ocean has a relatively long half-life, large pieces are over time broken into smaller segments (Andrady, 2008), making is less likely to be collected by a gannet. The amount of exposed debris in gannet nests is dynamic and the result of several factors. Some is eroded away through storms, and snow/ice melt, and a portion is covered by new nesting material, though it may become exposed again through erosion of the nest pedestal.

A fishing moratorium on northern cod (*Gadus morhua*) in the northwest Atlantic Ocean since the early 1990s (Hutchings and Myers, 1994) has greatly reduced the amount of fishing gear in the water. Owing to this massive reduction in fishing effort over an ocean-basin scale in eastern Canada, we expected that the frequency and composition of marine debris in gannet nests changed

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since 1989. We also assessed if gannets could provide an indication of the abundance of marine debris originating in fisheries.

Our objectives in this paper are to: (1) assess changes in plastic debris in gannet nests at colonies in the fisheries closure zone before and after the moratorium; (2) examine differences in plastic debris in nests by colony location, including the species' largest colony in the Gulf of St. Lawrence; and (3) assess the extent to which gannets can provide indication of the amount and type of plastic debris in the ocean.

2. Methods

During the 2007 breeding season, we recorded the number of gannet nests with anthropogenic debris at three of the six North American gannet colonies – Cape St. Mary's (46°50′, 54°12′W), Funk Island (49°46′N, 53°11′W) and Bonaventure Island (48°30′N, 64°09′W; Fig. 1). We used the same methods and categorizations as Montevecchi (1991), whereby the type of debris in each nest was visually recorded (often using 10 × 40 mm binoculars or 15 × 60 power spotting scopes) in the following categories: strapping (thin, flat pieces of plastic used to bundle items), heavy cord, rope, twine, monofilament line, netting, tape, plastic bag/sheet, and other (including hard plastic, straws, ballpoint pens, shotgun shells, and unidentified plastic). These data were compared with data collected at Cape St. Mary's and Funk Island in 1989 (Montevecchi, 1991). We then grouped debris from all colonies and years into two broad categories: debris typically originating in fisheries operations (cord, rope, twine, monofilament line, netting) and other anthropogenic debris (strapping, tape, bags, hard plastic).

The total number of gillnets set from May to August (northern gannets' breeding season) in the immediate vicinity of Funk Island (North Atlantic Fisheries Organization (NAFO) management area 3KI) and Cape St. Mary's (NAFO areas 3LQ and 3Psc; Fig. 1) were calculated for the pre- and post-moratorium nest survey years (1989 and 2007, respectively). We used gillnet fishing effort data (number of gillnets set) as a proxy of fishing gear available to northern gannets for nest material as most of the fishery-originating debris in 1989 was from gillnet operations.

2.1. Statistical methods

We used a generalized linear model with a binary error structure in SPSS 19 to test for differences in the proportion, and the type of marine debris among colonies, and within colonies before and after the fishing moratorium. Differences were considered significant when 95% confidence intervals around parameter estimates did not overlap.

To test for relationship between the number of gillnets set and fisheries debris in northern gannet nests, we used a logarithmic regression in R 2.12.1 (R Development Core Team, 2010), as we expected the relationship to reach an asymptote where all nests contained debris regardless of the amount of debris available (number of gillnets set).

3. Results

We examined 741 gannet nests in 1989 and 1080 nests in 2007 (Table 1). There was significantly more debris at Funk and Cape St. Mary's in 1989 than 2007 (Wald $\chi^2 = 190.41$, df = 1, $p < 0.001$). In 1989, there was no significant difference in the proportion of nests with marine debris at Funk Island and Cape St. Mary's (Wald $\chi^2 = 3.42$, df = 1, $p = 0.07$), but in 2007, there was a greater proportion of nests with debris at Cape St. Mary's than at Funk Island, and

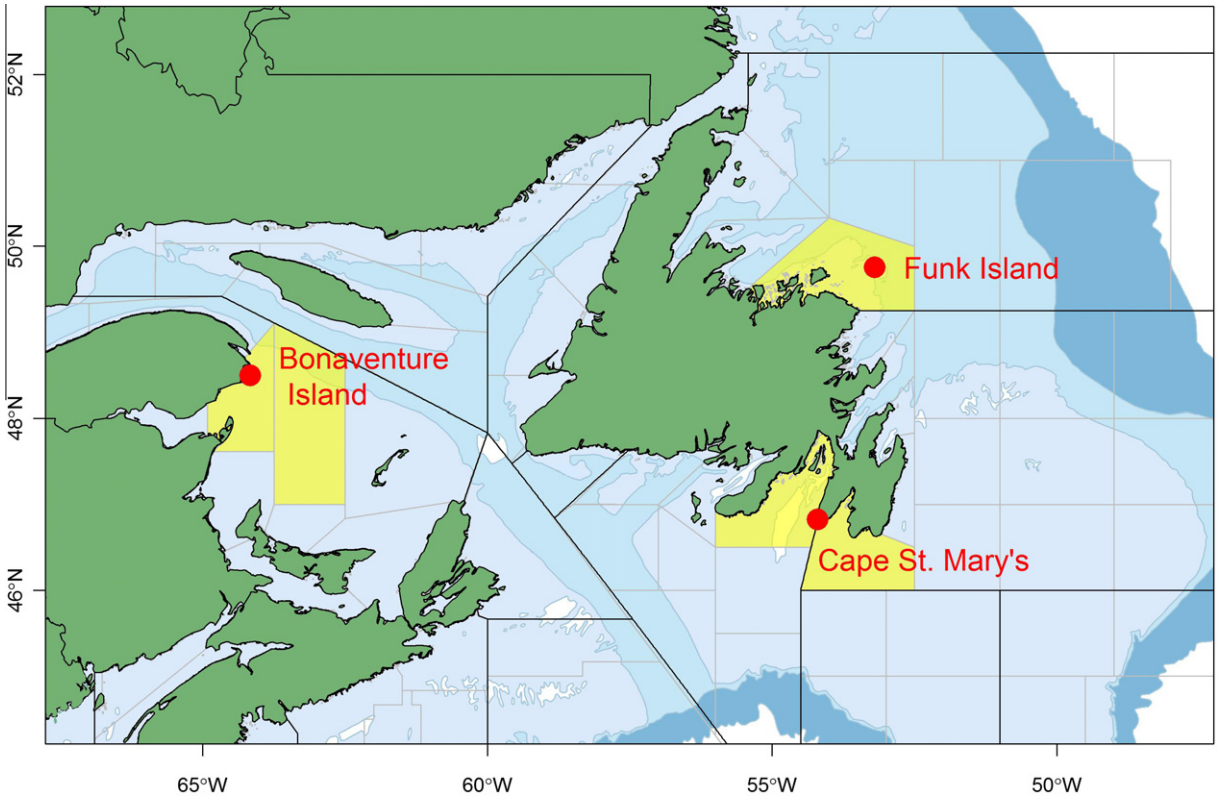

Fig. 1. Marine debris in northern gannet nests was recorded at Funk Island and Cape St. Mary's Newfoundland in 1989 and 2007, and at Bonaventure Island, Quebec in 2007. Yellow fishing zones where northern gannets foraged and for which gillnet fishing effort was documented from Fisheries and Oceans Canada. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)