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FORAGE FISH PROVISIONING PELAGICS OFF GRAND MANAN, AND GUIDANCE FOR FISHERIES MANAGEMENT

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ABSTRACT

Migrant Atlantic herring frequent Grand Manan waters, a major regional trophic hub, providing forage for seabirds, dolphins and other animals. Predators reveal much about the availability of the prey they eat. Publicly accessible monitoring data illustrate linkages between razorbill chick diets and juvenile herring via weir-fishery landings. Having been overfished, the status of extra-regional Gulf of Maine herring is dire, seemingly without institutional resolution. Many people hope that ocean 'literacy' – increased marine scientific knowledge in individuals across society at large – will guide legislative and bureaucratic institutions to be more responsible, take ethical actions and demonstrate accountability with respect to marine ecosystem conservation.

The waters around Grand Manan Island (Fig 1) serve as a major regional trophic hub for a great number of species, such as Atlantic herring (*Clupea harengus*). Herring in turn provide forage for other hub constituents. For many associated species, knowledge about food sources tells much about consumer populations. The reverse is also readily apparent. Ruefully, the Grand Manan region has lost many disparate ecological components at the hands of humans over at least the last 2 centuries (Lotze and Milewski 2004), however breeding populations of several seabird species, particularly Atlantic puffins (*Fratercula arctica*) and razorbills (*Alca torda*) (Fig 2) have rebounded in recent decades (Diamond 2021). Atlantic herring have a varied history in the region, mainly as a result of human fishing. With the prosecution of an intense gill-net fishery through the late 1800s, large (older?) herring effectively disappeared long ago (Huntsman 1953).

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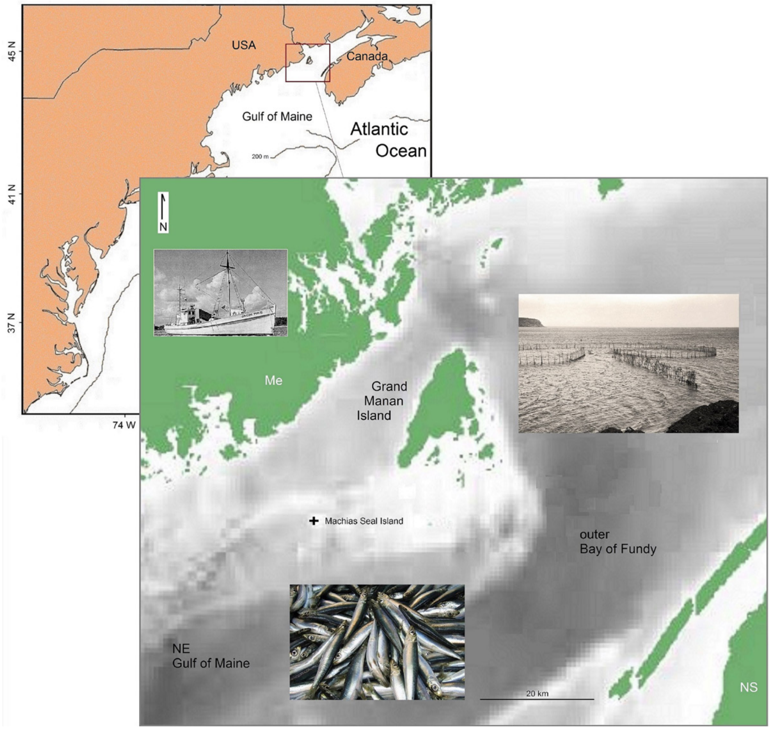

Fig 1 Map showing locations, including Grand Manan and Machias Seal Islands. Maine herring carrier – source M. Crowe; Grand Manan weir – source D. Ingalls; juvenile herring – FishWatch.

Juvenile herring aged 1-3y ('sardines') constitute the mainstay of the fish-based forage provisioning many pelagics off Grand Manan. These fish migrate from across the greater Gulf of Maine (GoM). A concentrated weir fishery for the juveniles, preferred age-2y but mixed ages developed in the 1880s, after many decades of widespread fishing along GoM coasts. Starting in the mid 1960s, intense offshore fishing by Soviet-era and later mobile-gear fleets brought the demise of herring over much of the greater gulf. After all this time, the decline of juvenile herring proximal to Grand Manan is dire – the juvenile population exhibits the basic characteristics of chronic extra-regional overfishing (Fig 3; see ASMFC 2024).

Seabird characteristics are well established as indicators of prey abundance internationally (Cairns 1987). Scopel *et al*. (2018) investigated the possibility that seabirds could serve the same function in the northern GoM. They used yearly chick diets, an immediate surrogate for prey availability (Parsons *et al.* 2008) in their analyses. Their study included Machias Seal Island (MSI; Fig 1), 19 km SW of Grand Manan, the largest seabird colony in the greater GoM and nesting grounds for several cold-water species (Diamond 2021). Although variable, the results of the chick study suggest relationships which could in turn aid the development of herring recruitment forecasts, thus enhance stock assessments. Currently, interest in the potential application of the findings to herring fishing management is mixed, and particularly problematic for the Grand Manan trophic hub. Fisheries managers responsible for most of the region are cited as dismissing use of the seabird analyses in their estimations, ostensibly because they and their industrial partners do not control the seabird monitoring (McBride 2023). In this respect, McBride also cites a lament of failure by seabird researchers, in view of fisheries attitudes that disregard the body of solid scientific work contributing fisheries-related knowledge of seabirds. These sentiments provide the impetus, at least in part, for the commentary here.

This document presents exemplary evidence that herring quantities in razorbill chick diets, the seabird catch, on MSI are positively correlated with herring weir-landings, the human catch (n = 27 years), in the Grand Manan region. Scopel *et al.* (2018) did not find any relationships between razorbills at MSI and regional weir-landings over a 22-year subset of very similar data. The fisheries management path referred to previously (McBride 2023) introduces another dimension – ocean ‘literacy’ (e.g., Salazar *et al.* 2022), recognized by UNESCO and an added qualification for the development of this presentation. Proponents aim to increase marine scientific literacy in individuals (e.g., MacKenzie 2006) across society at large, with emphasis on egalitarian inputs to scientific knowledge. In keeping with inclusiveness, I examine the seabird-fish example using published data, images and methods that are credible, readily available and referenced appropriately. The chick diet data (converted from graphed proportions to numerical ranks here) are published by Atlantic Laboratory Avian Research (ALAR 2023), the juvenile fish landings data originate with DFO (2023, and references), and robust analytical procedures can be found easily e.g., Statistics Kingdom (2017). Chick diets expressed as ranks provide the most reliable data type, at least in an initial analysis in that: ranks retain essential

Fig 2 **Examples of a razorbill pair – on Skomer, a chick (top) and an oblique view of Machias Seal Island (MSI; bottom), seabird nesting sanctuary. Pair photo – C.J. Sharp/CC-BY-4.0; chick photo – K.W. Wade; MSI -UNB.**

information, data are compared in a relative manner, no assumptions are made about underlying data distributions, and the rank form is more relevant to decision-model construction. Compared to standardized data, one can also preempt possible interpretive issues in analyses of data with a strong temporal component.

Data indicate a moderately strong association (Pearson $r = 0.588$, $P = 0.002$, df = 24, open circle outlier excluded) between the landings of juvenile herring and relative quantities (ranks) of herring fed to razorbill chicks (Fig 4). The smallest diet proportion is ranked the

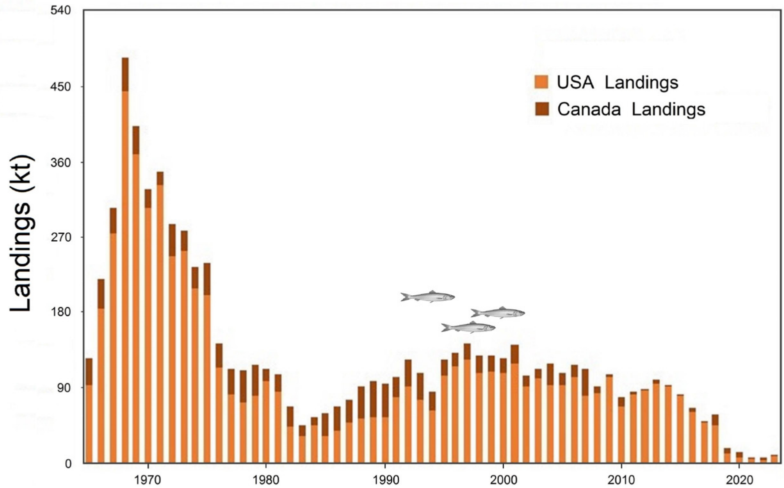

Fig 3 Decline of USA GoM herring landings, primarily because of overfishing, the current retrospective designation by the NEFSC-NOAA (ASMFS 2024). Canada landings, ~ages 1-3y, fixed-gear areas adjacent boundary. Redrafted after ASMFS (2024).

lowest, = 1, the largest proportion is ranked the highest and so on with the order of intermediate diet proportions Nominally, the landings for any given year represent herring aged 1-2+yr, therefore herring age distributions in landings are probably proportionately older than in chick diets (latter ~ more 1s, less 2s). This age bias probably adds to the scatter in Fig 4. Association assumes at least some herring are available to both fishers and razorbills. The figure indicates the extent of the residual data scatter accompanying relatively strong association metrics faced by fisheries modelers, even after exploring a datum as an (unexplained) outlier.

The herring-related patterns highlight the importance of ecological resilience across the complex predator-prey GoM ecosystem (e.g., Melville 2018). As a result of continued overexploitation, the herring prey-base has become highly unstable in the last few decades, with recovery from previous collapse in the western GoM arrested and decline accelerating in the east. Knowledge of the deleterious effects on other species caused by the herring exploitation is not new. After 2000, productivity in the puffin declined at MSI with the loss of juvenile herring as the principal food source (Diamond and Devlin 2003). Starting in the mid 2010s, unexplained near-shore deaths of humpback and minke whales increased dramatically, as herring

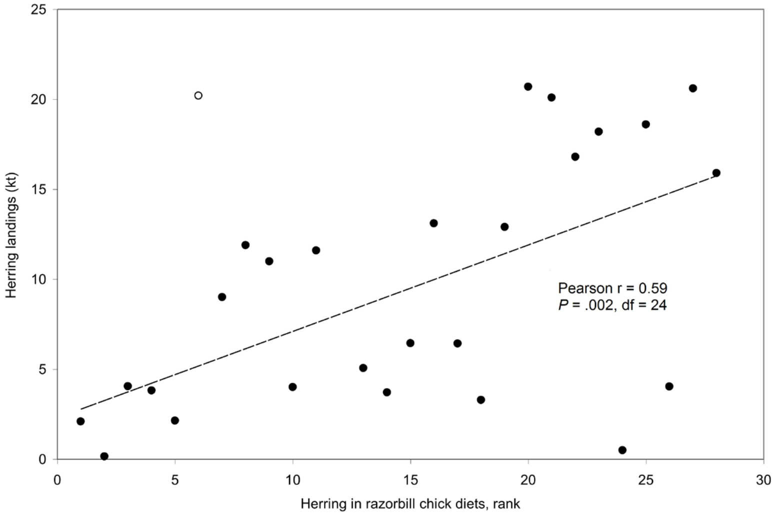

Fig 4 Association between the landings of juvenile herring and the relative quantities (ranks) of herring fed to razorbill chicks. Line – estimate of potential linearity, pretesting. Landings data, ages ~1-2+ from DFO (2018) and references. Diet data, ages ~1(-2). Open circle, prospective outlier excluded.

landings dwindled in and contiguous with the GoM region (Melville 2018); mortalities have probably resulted from poor nutrition, ultimately because of herring over-fishing. Alternate prey such as mackerel (*Scomber scombrus*) and pollock (*Pollachius virens*) for larger predators are even less abundant because of over-fishing (e.g., Sosebee 2022).

This commentary contributes independently to the continued development of potential ecosystem-based inputs (Cury *et al.* 2008), by non-fishery research, to herring fishery models. Archibald *et al.* (2021) conclude that progress is slow if not inadequate in the implementation of institutional tools to ensure a precautionary approach in Canadian fisheries management. Barnett and Anderies (2014) indicate that by restricting decision-making through centralization, the process fails to recognize the rights of individuals to organize and make collective choices. Often, 'jobs' becomes the 'straw man', deflecting attention away from the fact that a smaller number of well-compensated individuals make decisions which disrupt the long-term security of a great many hands-on fisherfolk. Security is obtained by way of broadly-based integrated social, economic and ecological structures (e.g. Andrews and Knott 2023) accommodating hands-on people who steward the conservation of marine ecosystems and resources. Some researchers go so far as to argue that tangible indicators of sense of place support the management of social-ecological systems (Knaps *et al*. 2022), which in this case would focus on herring fisheries. What better indicator to convey meaningfulness with respect to sense of place than a fuzzy razorbill chick making its way on a pile of rock such as MSI (Fig 2)?

Without robust ecological conservation, there are no positive social, economic and governance fisheries outcomes. Ultimately, fisheries legislation must include explicit fundamental statements about 'fisheries in an ecosystem context'. To this point, my report also illustrates the potential for reciprocal non-fishery inputs to scientific knowledge, central to current incarnations of ocean literacy (Salazar *et al*. 2022). The seabird-herring example can be repeated by a competent naturalist with a computer, internet, basic statistical skills and an interest in the subject. Furthermore, science-based approaches must be solid before other knowledge – experiential, local, and cultural – can be effectively incorporated into fisheries management.

A hint of optimism, 'Old Thom', the Fundy male killer whale (*Orcinus orca*) made several brief late-summer forays north of Grand

Fig 5 Male killer whale Old Thom with white-sided dolphins in Canadian waters north of Grand Manan, August 2022. Photo – FTRWW.

Manan starting in 2022 (Fig 5), but had not been reported there in previous years. He often appears to subsist on small schooling fish in the GoM, feeding with white-sided dolphins (*Lagenorhynchus acutus*). The northward excursions might be associated with a slight short-lived increase of local herring landings in the early 2020s. His movements have not included sightings to the NW in American waters, along the Maine coast; this absence was also observed in earlier years (Melville 2023).

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