Deep cold-water corals as nurseries for fish larvae

Sandrine Baillon[1], Jean-François Hamel[2], Vonda E Wareham[3], and Annie Mercier[1*]

As a consequence of the decline of numerous commercial fish populations, an ecosystem-based approach to fisheries management, which includes the protection of essential fish habitat (EFH), has emerged. Cold-water coral (CWC) sites are recognized as biodiversity hotspots, but numerous examples of CWC destruction and degradation as a result of anthropogenic activities are well documented. However, although functional connections between CWCs and fish stocks are suspected, based on correlative evidence, proof of any close or direct relationship identifying CWCs as EFH is still lacking. Here, we provide evidence of the utilization of CWCs by fish larvae, mainly those of redfish (*Sebastes* spp). In multiyear surveys, fish larvae were consistently found closely associated with five species of sea pen (Octocorallia: Pennatulacea) in April and May. Prevalence and/or yields of fish larvae varied with coral host species, depth, location, and colony size. Evidence of the role of CWCs in the early life history of some fish species provides the strongest argument yet for the categorization of CWCs as EFH in the design of management programs.

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In light of the global decline and poor recovery of many fish populations, including commercial stocks, as a result of historical and anthropogenic factors (Pauly *et al.* 2002; Devine *et al.* 2006), the need for a holistic ecosystem-based approach to fisheries management is increasingly being recognized. Greater emphasis is being placed on habitat health and productivity, notably through the designation of essential fish habitat (EFH), which can be defined as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity" (Rosenberg *et al.* 2000). Concomitantly, cold-water coral (CWC) ecosystems are emerging as systems of ecological and economic value, raising concern over their rapid destruction (Fosså *et al.* 2002; Foley *et al.* 2010a). CWCs form one of the most complex biological habitats on continental slopes, where they act as biogenic substrates by offering a variety of microhabitats presumed to serve as feeding and spawning sites for other species (Buhl-Mortensen *et al.* 2010; Watling *et al.* 2011). Studies of their associated fauna have shown that biodiversity in deep-sea CWCs is comparable to that of tropical coral reefs (Buhl-Mortensen *et al.* 2010; Watling *et al.* 2011). However, contrary to the association between shallow coral reefs and fish, the exact relationship between CWCs and fish is not clear (Auster 2005), and CWCs are mostly considered to be facultative habitat (important but non-essential for the survival of a species). Evidence of a functional role that would qualify CWCs as EFH in support of their protection (Foley *et al.* 2010a) is still lacking.

The putative ecological importance of CWCs is magnified by their widespread distribution on continental slopes, canyons, and seamounts worldwide, in water depths ranging from 39 m to more than 3000 m (Foley *et al.* 2010a). It has often been suggested that CWCs may be used as nursery grounds by fish (Etnoyer and Warrenchuk 2007; Buhl-Mortensen *et al.* 2010), based on the assumption that corals offer protection against predators (Auster 2005). It has been further suggested that CWCs fit the definition of essential habitat for redfish (*Sebastes* spp) in Norway, on the basis of habitat–fish models (Foley *et al.* 2010b). However, to date, no direct evidence of the presence of juvenile or larval fish in CWCs has been presented (Husebø *et al.* 2002; Foley *et al.* 2010a). Correlative studies and predictive models have shown increasing adult fish densities and sizes around deep-water corals compared with non-coral areas (Husebø *et al.* 2002; Auster 2005). Spring aggregations of swollen (presumably gravid) redfish females were detected around the scleractinian coral *Lophelia pertusa* in Norway (Fosså *et al.* 2002), and catshark (Family Scyliorhinidae) egg cases were found attached to the gorgonian coral *Callogorgia* sp in the Mississippi Canyon, Gulf of Mexico (Etnoyer and Warrenchuk 2007). Nevertheless, the potential importance of CWCs remains unclear because studies do not cover the period when fish might use this habitat (ie for spawning or as juveniles; Auster 2007).

To date, most of the limited studies on the distribution and biology of CWCs have focused on the Subclass Hexacorallia, Order Scleractinia (stony corals), and to a lesser degree on some species of the Subclass Octocorallia, particularly gorgonians (sea fans) and other members of the Order Alcyonacea (soft corals) (Buhl-

[1]*Ocean Sciences Centre, Memorial University, St John's, Newfoundland and Labrador, Canada* [*]*(amercier@mun.ca)*; [2]*Society for the Exploration & Valuing of the Environment, St Philips, Newfoundland and Labrador, Canada*; [3]*Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, St John's, Newfoundland and Labrador, Canada*

