Chars are salmonid fishes of the genus *Salvelinus* and are widely distributed throughout the circumpolar north from northernmost land areas to temperate regions in the south, i.e., from 84°N south to ~40°N [1]. The distribution of the Arctic char species complex, *sensu stricto*, is shown in Figure 6.1. They occur across a broad range of environments and habitats, and are prominent components of northern aquatic ecosystems including freshwater, estuarine, and nearshore marine habitats. Chars are usually the only fish species present in the relatively simple freshwater ecosystems in Arctic areas north of ~75°N latitude [2].

Chars exhibit wide species diversity but this is poorly understood and unresolved at several taxonomic levels. Firstly, between seven and twenty two (or more) formal species are recognized, although taxonomists disagree on exact boundaries between them [3]. Two major taxonomic groups occur in the Arctic: Arctic char, *Salvelinus alpinus* (L.) (Figure 6.2a), which has a Holarctic distribution and is primarily associated with lake-dominated river systems, and Dolly Varden, *Salvelinus malma* (Walbaum) (Figure 6.2b), which has a north Pacific distribution and is primarily associated with Arctic rivers [1, 4, 5]. Second, both groups exhibit diversity in life history type and migratory patterns below the ‘species’ level being either anadromous (sea-run or migratory), freshwater resident (non-migratory; co-occur with anadromous type) [5, 6], or isolated (lack access to the sea). Lastly, multiple ecophenotypes (i.e., visible physical characteristics that result from environmental conditions) of chars co-occur as adults in the same water body but differ in morphology (e.g., size, color, body form), ecological associations and habitat use (e.g., littoral, benthic, or pelagic), position in food webs, and growth variations. For example, three forms of Arctic char occur in Lake Hazen, northern Ellesmere Island, Canada (Figure 6.2c–e).
Chars are also important to northern communities, both culturally and as a source of consistently available local food. In Nunavut, northern Canada, for example, char constitute 45% by number of the top 15 species harvested as traditional/country food by the local Inuit population [8]. Chars are also fished commercially in many areas of the Arctic, contribute to local economies through sport fisheries, and are cultured in areas where conditions permit (e.g., Norwegian fjords and some areas of Canada).

Chars are of significant importance from a scientific perspective due to their wide and northern distribution in fresh waters, high and unique forms of diversity, high endemism (i.e., local diversity found only in one area) of many taxa, and the wide range of evolutionary patterns observed.

As a direct consequence of their local diversity and their occupancy of many habitats, and their wide functional, cultural, socio-economic, and scientific importance, chars are not only an essential component of Arctic aquatic biodiversity, but are also fundamentally well-suited as indicator species of both the specific circumstances and the general health of northern freshwater ecosystems.

Figure 6.1: The distribution of Arctic char species complex, *sensu stricto*, and the location of introduced populations [7].
Population/ecosystem status and trends

Although studies of the status of char populations in Arctic regions are generally lacking, some assessments exist for non-Arctic nations and their findings may be applied to Arctic populations. Unlike their southern counterparts, char populations in the Arctic generally appear to be mostly healthy, although this in part may simply be due to greater numbers being present and/or inadequate information. For example, in the Arctic regions of nations with natural populations of Arctic char, it is likely that no populations have gone extinct (information interpolated from Table 1, p. 114 in [9]). However, significant extinctions have occurred in more southerly regions (e.g., 12 of 258 known populations in Scotland and 30% of the known populations in Ireland have gone extinct [10]), despite these being in more remote areas of these countries. This is not to say that Arctic populations are unstressed. Rather, several examples of stressed char populations are known for the Arctic particularly near to communities (e.g., for the Canadian Arctic: Dolly Varden, Big Fish River [11]; Arctic char, Hornaday River [12]), especially where over-fishing perhaps combined with habitat changes has resulted in local population collapse.

Assessments of trends for chars tend to be population specific, episodic, and of short duration. Widespread geographic comparisons and assessments of status are

Figure 6.2: (A) Arctic char, *Salvelinus alpinus* (L.) (B) Dolly Varden, *Salvelinus malma* (Walbaum) (C) Lake Hazen dwarf benthic form Arctic char (D) Lake Hazen small form Arctic char (E) Lake Hazen large form Arctic char.
Concerns for the future

Chars generally, and Arctic char in particular, represent the unique diversity present in northern aquatic ecosystems. This diversity, however, is very poorly known, as are the mechanisms which maintain and generate it.

It is in this context that significant anthropogenic stressors are presently affecting char and are likely to continue to do so in the future. We are possibly altering char biodiversity without documenting it and understanding its relevance. Concerted pan-Arctic biodiversity assessments, sustained research, and coordinated monitoring of chars are required to outline the scope of diversity present and its significance, and the mechanisms responsible for maintaining it and documenting changes.

Catch records for the last century for the commercial fishery of non-migratory Arctic char in Mývatn, northeastern Iceland indicate that average annual catches remained relatively stable until 1970, after which they declined due to the combined effects of exploitation and industrially induced environmental change [13]. Other studies, however, show that at least some anadromous populations of Arctic char appear to be resilient to heavy exploitation to some degree [14]. Typical shifts expected from commercial fishing (e.g., age and length distributions) were relatively stable over time, and populations have returned to earlier conditions with reduced intensity of exploitation and environmental amelioration [14]. Thus, sustainable fisheries on the anadromous form, at least in sub-Arctic situations, are possible [14].

Diversity in chars, particularly in life history, increases the exposure of populations to effects of different natural drivers and anthropogenic stressors. These range in scope from global, pervasive stressors affecting all populations in some fashion (e.g., climate variability and change), to local stressors affecting single populations (e.g., exploitation).

Climate variability and change will differentially affect char populations principally through latitudinal and regional effects acting directly upon the fish (e.g., thermal regimes enhancing growth) or indirectly through ecosystem or habitat pathways (e.g., shifts in competitors, predators, prey, or parasites and diseases) [15–17]. Thus, climate change effects on chars may range from positive (e.g., enhanced growth) to negative (e.g., shift in balance among or loss of life history types). An additional significant effect from climate change is alteration of habitat quantity (see [18]) and quality [19, 20]. Other pervasive stressors include long-lived contaminants particularly those which biomagnify and accumulate at higher levels of food chains (e.g., mercury, PCBs).

Locally acting stressors particularly important in the Arctic include exploitation as commercial, subsistence, and/or recreational fisheries; industrial development; eutrophication; habitat change; contamination; species introduction and colonization; translocations of chars; and barriers to migration ([10], references therein). In addition to being the direct result of a particular local stressor, effects observed on local char populations may also result from the pervasive stressors noted above (e.g., habitat and hydrological shifts from climate change). While it may be difficult to distinguish the ultimate cause for a specific effect, the potential for significant synergistic cumulative effects resulting from the suite of stressors may be very high in particular populations.