Report No. 31 2016

The Status of

Mummichog

Fundulus heteroclitus

in Newfoundland and Labrador

The Species Status Advisory Committee

Newfoundland Labrador

Department of Environment and Climate Change

COVER PHOTOGRAPH

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RECOMMENDED CITATION

Species Status Advisory Committee. 2016. Status Review for Mummichog [(*Fundulus heteroclitus macrolepidotus*)] in Newfoundland and Labrador. Wildlife Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, Corner Brook, Newfoundland and Labrador, Canada**.**

AUTHORS

The initial draft of this preliminary status review was prepared by Roger Gallant with revisions by Dr. Tom Knight.

SSAC ASSESSMENT SUMMARY

Date of Assessment - March 2015

Common Name
Mummichog

Scientific name
Fundulus heteroclitus

Status
Vulnerable

Reasons for Recommendation
The species is near to qualifying for Threatened Status under D2 (i.e. population with a very restricted area of occupancy or number of locations such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus is capable of becoming highly endangered or even extinct in a very short time period. IAO typically <20 km^2 or number of locations <5).

Range in Newfoundland and Labrador
Newfoundland

Status History
No previous assessments

TECHNICAL SUMMARY

Fundulus heteroclitus
Mummichog Choquemort
Saltmarsh Killifish

Range of occurrence in Canada (province/territory/ocean): QC, NB, PEI, NS, NL

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used)	1-2 yrs (full lifespan can be about 3 years)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	n/a
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	1,350 km²
Index of area of occupancy (IAO)	28 km²
Is the total population severely fragmented?	No

Number of locations	4-12 (13)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Unknown
Are there extreme fluctuations in number of populations?	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Grand Bay West	Unknown
Little Codroy River estuary	Unknown
Grand Codroy River estuary	Unknown
Muddy Hole	Unknown
Little Barachois estuary	Unknown
Stephenville Crossing	Unknown
Seal Cove Brook	Unknown
Port-aux-Port	Unknown
Piccadilly	Unknown
Clark's Brook	Unknown
Frenchman's Cove	Unknown
York Harbour	Unknown
*Terrenceville River (historical sample)	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Forest harvest, establishment of green crab (*Carcinus maenas*) populations, American Eel (*Anguilla rostrata*) predation, and commercial American Eel fyke net fisheries.

Rescue Effect (immigration from outside NL)

Status of outside populations?	All Maritime Canadian populations are secure
Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in NL?	Yes
Is there sufficient habitat for immigrants in NL?	Yes
Is rescue from outside populations likely?	Unlikely, without human intervention

Current Status

COSEWIC: Not assessed
SSAC: Not assessed

* Unconfirmed historical sample from Terrenceville River (1960) not included in calculation of Extent of Occurrence or IAO.

Original author of Technical Summary: Roger Gallant

Final version edited and approved by the Species Status Advisory Committee

Recommended Status and Reasons for Designation

Recommended Status:	**Alpha-numeric code:**
Vulnerable	N/A

Reasons for designation:

The species is near to qualifying for Threatened Status under D2 (i.e. population with a very restricted area of occupancy or number of locations such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus is capable of becoming highly endangered or even extinct in a very short time period. IAO typically <20 km2 or number of locations <5).

Applicability of Criteria

Species in Newfoundland is near to qualifying as Threatened status under D2:

1. IAO = 28 km2.
2. Number of locations, is likely >5 (minimum of 4, maximum of 12; or possibly minimum of 5, maximum of 13 if historical sample from Terrenceville River is confirmed).

TABLE OF CONTENTS

STATUS REPORT

Fundulus heteroclitus (Walbaum, 1972)

Primary Common Names:

Mummichog
Saltmarsh Killifish
choquemort [French]

Other Common Names:

gudgeons
mummies
barbel

Names of population(s) or subspecies:

F. heteroclitus macrolepidotus (Walbaum, 1972)

Atlantic Canada, south to northern New Jersey (Newark Bay), with additional relict populations in northern Delaware Bay (southern New Jersey and Delaware) and northern Chesapeake Bay (Maryland, Virginia, and the District of Columbia) (Morin and Able, 1983; Able, 1984; Able and Felley, 1986; Smith, 1989).

Introduced/stocked populations, apparently of this subspecies, are found in freshwater habitats in New Hampshire (Scarola, 1973) and Pennsylvania (Raney, 1938, cited in Trautman, 1981; Denoncourt *et al*., 1975, 1978).

Additional introduced population/s, in SW Spain, apparently of this subspecies, are thought to have been brought from Nova Scotia, sometime before 1973 (Bernardi and Powers, 1995; Bernardi *et al*., 1995; Gutiérrez-Estrada, 1996). A further, introduced, Spanish population has been discovered recently in the Ebro River delta in NE Spain (Gisbert and Lopéz, 2007); it perhaps also represents this subspecies.

F. heteroclitus heteroclitus (Linnaeus, 1766)

Northern New Jersey (Sandy Hook) to Florida (Morin and Able, 1983; Able and Felley, 1986; Smith, 1989).

Family: Fundulidae (topminnows and killifish)

Life Form: Fish

Systematic/Taxonomic Clarifications

The two subspecies of Mummichog referred to above are distinguishable by skilled researchers.

Morin and Able (1983) used a scanning electron microscope to examine the chorion of Mummichog eggs from Jacksonville, Florida to Mount Desert Island, Maine. They found that chorionic filaments from Mount Desert Island, Maine to Newwark Bay, New Jersey were smooth with filament diameters from 0.8-2.2µ at a density 0-5 per 10,000μ^2. On the other hand, they found that eggs from Sandy Hook, New Jersey to Jacksonville, Florida had pebble-surfaced filaments with diameters from 0.7-0.8µ at a density of 150-220 per 10,000μ^2.

Able and Felley (1986) confirmed the existence and distribution of the northern subspecies, *macrolepidotus*, identifying additional relict populations in the upper portions of Chesapeake Bay and Delaware Bay.

For the main east coast North American populations, Powers *et al*. (1986) found a sharp break in the frequency of the Mdh-A allele at about 40.5^o N, although the corresponding break for the relict Chesapeake Bay populations was found to be located significantly further south, ranging from about 37^o N to about 39^o N.

The origins of the two subspecies remain unclear.

Adams *et al*. (2006) thought that "*F. heteroclitus* was broadly distributed throughout most of its current range during the last glacial event and that an abrupt transition in allele frequencies that separated the "Northern" and "Southern" populations might reflect regional disequilibrium conditions associated with the post-Pleistocene colonization history of habitats in that region".

Brown and Chapman (1991) and Bernardi *et al*. (1993) cited morphological, behavioural, physiological and genetic (both mtDNA and nuclear DNA) differences between the two subspecies. They proposed that the two forms arose in isolation during past glacial epochs, but did not assume their present distributional configuration until sometime after the last glacial maximum.

Powers *et al*. (1986) suggested that "if previous isolation occurred as required for secondary intergradation, it must have been relatively recent and of short duration".

González-Villaseñor and Powers (1990) used mtDNA analysis to show that the northern subspecies was relatively homogeneous, while the southern subspecies is relatively heterogeneous; suggesting, in disagreement with Powers *et al*. (1986), a time of divergence of between 120 and 260 thousand years ago.

Bernardi *et al*. (1993) favoured an even older time, between 0.5 and 1 million years ago, on the basis of *LDH-B* allele sequences (0.5 mya), cytochrome b sequences (0.6 mya), and RFLP data (1 mya).

Stanton (2010) used cytochrome-b mtDNA sequences to confirm the existence of a northern and a southern subspecies; but also found a further, though less dramatic, split between the southern populations of [a] Virginia and [b] North Carolina and Georgia.

Considering all of the above, the “designatable unit”, for the Newfoundland area, should clearly be *Fundulus heteroclitus macrolepidotus*.

While there may be some uncertainty in places, most (though not all) literature references, to the Mummichog, *F. heteroclitus* s.l., can be assigned to one or the other subspecies using geographical location data.

Distribution

Global: (Figure 1)

North America (exclusive of Canada):

United States – Native:

The Mummichog, *F. heteroclitus* is found along the east coast from Maine to northern Florida; in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, the District of Columbia,Virginia, North Carolina, Georgia, and Florida, (NatureServe), plus South Carolina (Able and Felley, 1986).

Within this greater area, the northern subspecies (*macrolepidotus*) ranges primarily from Maine to New Jersey; in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey; with additional, disjunct, populations in northern Delaware Bay (southern New Jersey and Delaware) and northern Chesapeake Bay (Maryland, Virginia, and the District of Columbia) (Morin and Able, 1983; Able, 1984, Able and Felley, 1986, Smith, 1989).

The southern subspecies (*heteroclitus*) ranges from northern New Jersey (Sandy Hook) to Florida; in New Jersey, almost all of Delaware Bay (southern New Jersey and Delaware) and Chesapeake Bay (Maryland, the District of Columbia, Virginia, and Delaware), North Carolina, South

Carolina, Georgia, and Florida, (Morin and Able, 1983, Able and Felley, 1986; Smith, 1989).

A broad transition zone occurs where the two morphs come together, along the coast of northern New Jersey and on Long Island (New York), as well as in Delaware Bay (Delaware and New Jersey), and Chesapeake Bay (Virginia, Maryland, and the District of Columbia (Able and Felley, 1986).

United States – Introduced/Stocked:

"This species was stocked in ponds in Windham, New Hampshire (Scarola 1973). It was collected from the upper Ohio and Beaver river systems in far western Pennsylvania, apparently in the late 1930s and early 1940s (Raney 1938, cited in Trautman 1981). It has also been collected in Pennsylvania from the Juniata River in Blair County [one specimen]; at Sandy Run [two specimens], a tributary of the Little Juniata; in Conowingo Pond in Lancaster County (Denoncourt *et al*. 1975), the Schuylkill and Brandywine drainages of the lower Delaware, and the Lower Susquehanna (Denoncourt *et al*. 1978)."
nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=688

Means of Introduction – United States:

This species was introduced into ponds in New Hampshire, apparently via bait bucket release (Scarola, 1973). It was transferred to far western Pennsylvania from the Delaware River drainage of the eastern part of the state (Raneym 1938, cited in Trautmanm 1981), possibly as a baitfish. The other collections in Pennsylvania are believed to be bait bucket introductions (Denoncourt *et al*., 1975, 1978).
nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=688

Other Continents:

Europe – In SW and NE Spain, the Mummichog is an introduced species (Bernardi *et al*., 1995; Gisbert and López, 2007; Gutiérrez-Estrada *et al*., 1996).

National:

Within Canada the Mummichog (subspecies *macrolepidotus*) is found in Québec (Anticosti Island and the Magdalen Islands), New Brunswick, Nova Scotia (including Sable Island), Prince Edward Island, and insular

Newfoundland.

Provincial:

Newfoundland – The Mummichog (subspecies *macrolepidotus*) is found along the southwest coast of Newfoundland from Grand Bay West to the Bay of Islands.

Mummichog have been documented from: First Pond, Second Pond, and Salt Water Pond in the Grand Bay West area (Philip Sargent, personal communications); Little Codroy River area (Philip Sargent, personal communications; Gallant, 2006); Grand Codroy River area (Gallant, 2006); Muddy Hole in Flat Bay (Gallant, 2006); Little Barachois estuary (Gallant, 2006); head of St. George's Bay (Scott and Crossman, 1964); Seal Cove Brook (Dickinson, 1974; Philip Sargent, personal communications); the town of Stephenville Crossing (Philip Sargent, personal communications); Port-aux-Port (Scott and Crossman, 1964); Piccadilly (Philip Sargent, personal communications); Clarke's Brook and Frenchman's Cove (Dickinson and Threlfall, 1975); and York Harbour (Philip Sargent, personal communications).

There is a record of two Mummichog samples housed at the Royal Ontario Museum (Ichthyology 23372) that were collected from the Terrenceville River, Burin Peninsula, in 1960 but there has been no subsequent confirmation of the record (John Maunder and Philip Sargent, personal communications). The river was sampled for fish by Philip Sargent in 2015 using a pole seine in salt water and minnow traps in fresh water and no Mummichog were captured. Sargent indicated that the location listed by the Royal Ontario Museum for Mummichog was a more brackish zone where the river joins the saltwater, so he speculates that the 2015 sampling was in the wrong area of the watershed to have captured Mummichog (Philip Sargent, personal communications).

Labrador – The Mummichog is not present in Labrador. Scott and Crossman (1964) stated that previous records of Mummichog occurrence in "Labrador" were actually from Anticosti Island, in Québec.

Annotated Global Range Map

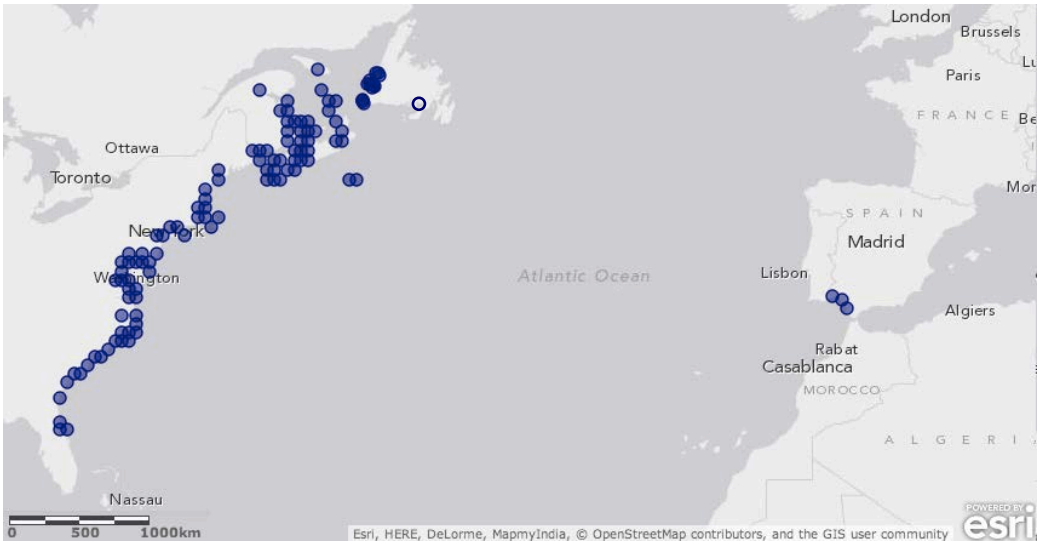

Figure 1. *Native* range of *Fundulus heteroclitus* s.l. in North America plus introduced range in Spain (modified from Kaschner *et al*., 2013) [there is now an additional European locality in the Ebro River delta of NE Spain (Gisbert and Lopéz, 2007)]. Historical (1960) sample from the Terrenceville River on Newfoundland's Burin Peninsula identified with an open symbol.

Annotated Provincial Range Map

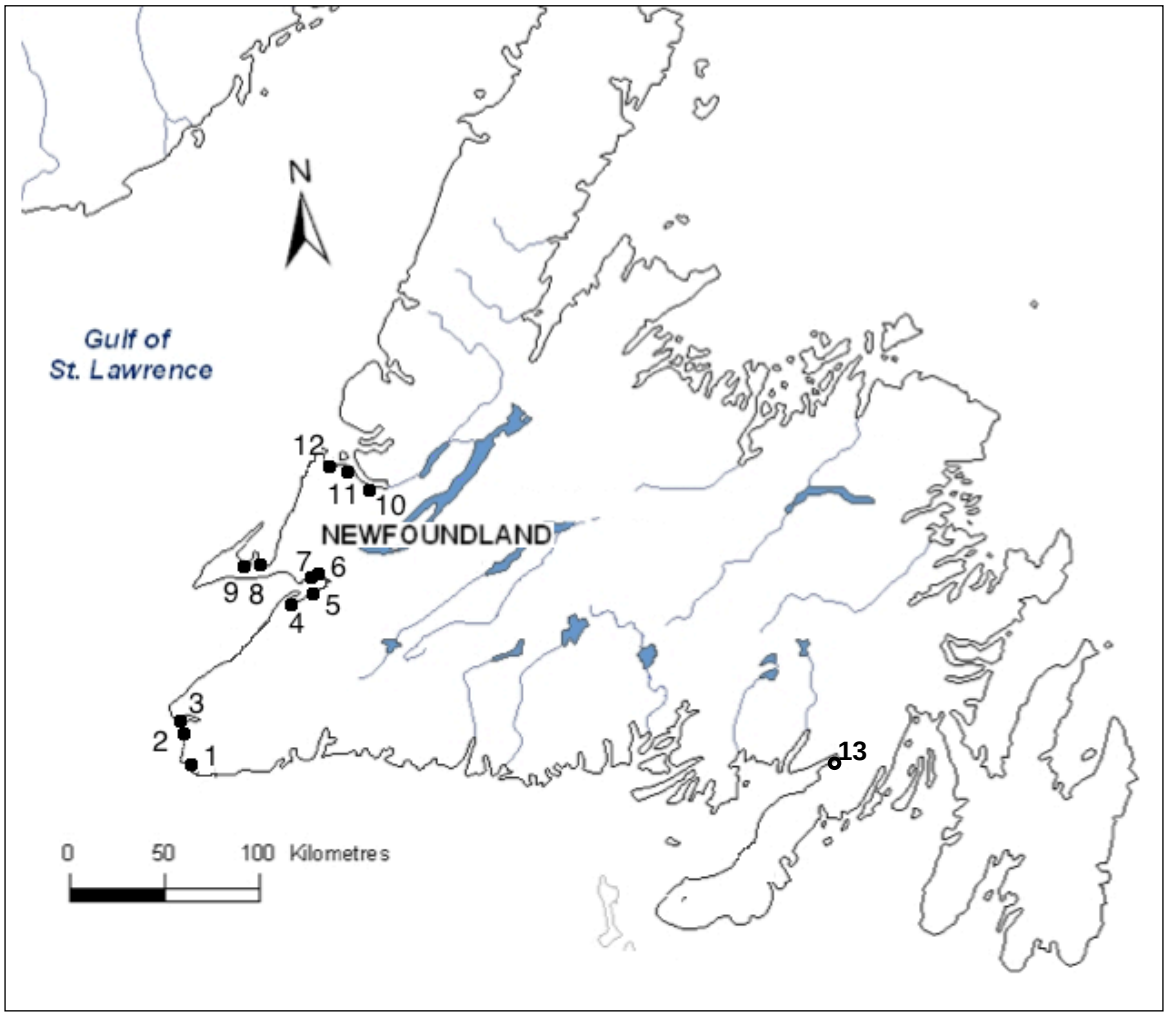

Figure 2. Known occurrence localities for *Fundulus heteroclitus* in Newfoundland and Labrador: (1) Grand Bay West (First Pond, Second Pond, and Salt Water Pond), (2) Little Codroy River estuary, (3) Grand Codroy River estuary, (4) Muddy Hole, (5) Little Barachois estuary, (6) Stephenville Crossing, (7) Seal Cove brook, (8) Port-aux-Port, (9) Piccadilly, (10) Clarke's Brook, (11) Frenchman's Cove, (12) York Harbour, and (13) Terrenceville River (historical sample collected in 1960).

Description

The Mummichog is a small fish with a short broad head, small terminal mouth, and rounded caudal fin (for a good general description, see Scott and Crossman, 1973).

Abraham (1985) noted that adult Mummichogs are commonly 50-100 mm in total body length; however, Johansen (1926) described catching *F. heteroclitus* with a total body length of as much as 120 mm.

Typically the Mummichog has an olive to dark green colour along the dorsal region that blends into a cream-yellow colour along the ventral surface. Tapering dark and light vertical bands alternate along the body of the fish, with dark bands tapering from the dorsal to ventral region and light bands tapering from the ventral to dorsal region.

Mummichogs are sexually dimorphic with males being smaller than females after the first year (Abraham, 1985). Females normally have 13-15 dark vertical bands; whereas males normally have 15 dark vertical bands, plus numerous cream coloured spots. Colour dimorphism does not become noticeable until Mummichog are 38-44 mm in length (Abraham, 1985).

The Mummichog can be mistaken for the Banded Killifish (*Fundulus diaphanus*). The most obvious difference is that Mummichogs have a wider caudal peduncle than banded killifishes. Scott and Crossman (1964) noted that lateral scale and gill raker counts can also be used to distinguish the two species. The mean number of lateral scale rows of Mummichogs was found to be 34.6, while the mean number of lateral scale rows of killifish was found to be 44.2. The mean number of gill rakers of Mummichogs was found to be 9.8, while the mean number of gill rakers of killifish was found to be 5.1.

Habitat

Mummichogs are normally found in shallow brackish waters of estuaries, salt marshes, or tidal streams but can occasionally be found in freshwater streams and rivers (Abraham, 1985). Fritz and Garside (1974a), in Nova Scotia, indicated that Mummichogs [*F. h. macrolepidotus*] show a high preference for 20‰ salinity and a lower preference for 8‰, whereas killifish have a strong preference for fresh water. It is therefore most likely that Mummichogs will be found in brackish water and banded killifish will be found in fresh water. *F. heteroclitus* normally spawns in the brackish waters of estuaries or salt marshes, but is, nonetheless, also able to spawn in fresh, brackish, or salt water (Abraham, 1985).

During the winter, Mummichogs will normally move out of salt marshes to salt water, or remain close to the mouths of rivers where the water will not freeze over (Abraham, 1985).

In contrast, Raposa (2003) stated that Mummichogs [*F. h. macrolepidotus*] from the Harches Harbour salt marsh in Provincetown, Massachusetts move to upstream pools where they burrow into sediments to overwinter; the sediments at that locality, which maintained a winter temperature over 1ºC, were composed of fine-grained particles and organic matter and provided an overwintering location safe from freezing temperatures.

Indeed, Lotrich (1975) stated that, near Lewes, southern Delaware [the transition zone area], from November through March, fish were present in the headwaters, but not the lower parts, of a tidal creek.

Mummichogs have very wide salt/freshwater tolerances. Introduced / stocked populations occur in freshwater in [1] Windham, New Hampshire (Scarola, 1973), [2] the upper Ohio and Beaver river systems in far western Pennsylvania (Raney, 1938, cited in Trautman, 1981), [3] in the Juniata River in Blair County, Pennsylvania; [4] Sandy Run, a tributary of the Little Juniata, Pennsylvania; [5] Conowingo Pond in Lancaster County, Pennsylvania (Denoncourt *et al*., 1975), and [6] the Schuylkill and Brandywine drainages of the lower Delaware River and the Lower Susquehanna River, Pennsylvania (Denoncourt *et al*., 1978)." nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=688

As well, freshwater populations are known from Sable Island and Digby Neck, Nova Scotia, Prince Edward Island; and the Bronx River, New York (Klawe, 1957; Samaritan and Schmidt, 1982).

On a day to day basis, where they are native/endemic, Mummichogs seem to display a very small home range, usually inhabiting the same habitat patch for extended periods of time (Lotrich, 1975 [southern Delaware]; Skinner *et al*., 2005 [New Brunswick]). Indeed, Bigelow and Schroeder (1953) stated that Mummichogs are "one of the most stationary of fishes".

Nonetheless, in the populations introduced to SW Spain [apparently *F. h. macrolepidotus*], the founding population dispersed along about 300 km of shoreline within about 25 years of its introduction (Gutiérrez-Estrada, 1996). The dispersal mechanism involved in this instance is unknown, although it would appear to be anthropogenic; as is, most probably, the more recently discovered population in NE Spain.

Overview of Biology

For good general summaries, see Scott and Crossman (1973), and Abraham (1985).

Salinity and Temperature

Mummichog is an euryhaline species that can live in fresh and salt waters. Laboratory tests indicate survival of *F. h. heteroclitus* in salinities of up to 100‰ and water temperatures of up to 36ºC (Abraham, 1985; Bulger and Tremaine, 1985); seawater averages 32-33‰. Vince *et al*. (1976) stated that the fish "move in and out of salt marshes with the tidal waters. As soon as the flooding tide allows, the fish swim onto the surface of the marsh and seem to seek its furthest landward reaches".

Tay and Garside (1975) investigated the optimal salinity and temperature for egg incubation and found that a salinity of 19-20‰ at 18ºC yielded the best results in the laboratory. Abraham (1985) stated that Mummichog eggs will hatch in 7-8 days when water temperatures are 22-34ºC.

Age and Maturity

Kneib and Stiven (1978) presented a survivorship curve (for *F. h. heteroclitus*) in North Carolina that shows a survivorship of zero by the end of the fourth growing season. The average age in a population is about 1-2 years old.

Mummichogs generally become sexually mature within 1-2 years and will spawn in summer and fall when water temperatures in salt marshes are sufficient for eggs to develop.

However, Kneib and Stiven (1978) noted that females became sexually mature in 5-6 months (i.e., the beginning of the second growing season) in North Carolina .

Spawning

In the southern populations, Mummichog [*F. h. heteroclitus*] spawning is greatly influenced by the lunar cycle (Taylor *et al*., 1979). The highest tides during the lunar cycle allow Mummichog to deposit eggs away from strong tidal currents. During the spawning season Mummichog may spawn at least 8 times and peak spawning will last at least five days (Abraham, 1985).

In contrast, Petersen *et al*. (2010) found that in Maine "unlike more southern populations, northern *F. h.* [*macrolepidotus*] spawns daily during its two-month spawning season, with no preference for spring tides over the entire season.

However, within consecutive semidiurnal tides significantly more spawning was associated with the higher high tide. Spawning occurred on bare gravel and on mud associated with the grass *Spartina patens*. Spawning was highly promiscuous with males typically spawning in groups with females in very shallow water during receding tides. These temporal and spatial patterns of oviposition caused eggs to be deposited in a much broader range of habitats than in southern populations of this species."

Hybridization

Mummichogs and banded killifish have been documented schooling together within brackish water habitats (Abraham, 1985). Fritz and Garside (1975b) stated that hybridisation between these species has been documented in the wild, in Prince Edward Island (1 fish) and Nova Scotia, and, possibly, in Connecticut. These authors analyzed 2143 *Fundulus spp.* and documented 170 hybrids (8%) between *F. heteroclitus* and *F. diaphanus* in the brackish Porter's Lake, NS (28 km NE of Halifax). Dawley *et al.* (1990) found that 14-38% of their samples from Porter's Lake, and 20% of their samples from the St. Mary's River estuary, were hybrids.

Dawley *et al.* (1990) found that the hybrids from Porter's Lake, and, also, from the St. Mary's River estuary, Nova Scotia, were all unisexual (i.e., all-female) hybrids, which produced diploid eggs without recombination. All hybrid offspring were, thus, diploid, unisexual females. Interestingly, according to Dawley *et al.* (1990), all or at least mostof these hybrids appear to have been members of a *single* clone.

In Newfoundland there are, so far, no documented accounts of hybridization between Mummichogs and banded killifish.

Food

Kneib (1986) reviewed the role of Mummichogs (*F. h. heteroclitus*) in salt marsh trophic dynamics in Georgia.

Vince *et al*. (1976) stated that although *F. heteroclitus* commonly ingests a variety of materials, including detritus, it seems to assimilate mainly animal food (including molluscs and crustaceans).

James-Pirri *et al*. (2001) stated that the major diet components of Mummichogs (specifically, subspecies *macrolepidotus*) in Rhode Island (other than detritus which does not, apparently, contribute materially to nutrition (Baker-Dittus, 1978)) were copepods, diatoms and insects (occurring in 30% of the fish sampled), and ostracods and chironomids (occurring in about 20% of the fish sampled).

Nonetheless, they noted that food items differ somewhat from study to study.

Kneib and Stiven (1978) recorded that the southern subspecies (*F. h. heteroclitus*) feed largely on small amphipods, tanaids, and copepods, as well as polychaetes, insects, small crabs, algae, and detritus, in North Carolina.

Able *et al*. (2007) found that "both cannibalism (0.2–9.1% of stomachs) and scavenging (0.5–9.9%) are common feeding modes of *F. heteroclitus* in salt marshes" of southern New Jersey.

Population Size and Area of Occupancy

A population estimate has not been conducted for the Mummichog over its entire range. NatureServe indicates that globally there are >300 occurrences of the species and the population size is estimated to be >1,000,000 individuals.

More specifically, there are no population data for Mummichog within insular Newfoundland.

However, several sources of information do provide specimen counts for scientific collection samples that seem to suggest that the species is not particularly uncommon where it occurs. Scott and Crossman (1964) collected 194 specimens from Port au Port Bay and 152 specimens from the head of Bay St. George. Dickinson and Threlfall (1975) used a 10-meter seine with 4 mm mesh to capture Mummichog from several sites in western Newfoundland (194 Mummichog from Clark's Brook, 194 from Frenchman's Cove, 79 from Mummichog Park, and 90 from Seal Cove Brook). Since 2009, Fisheries and Oceans Canada has been conducting beach seine tows and have caught approximately 1400 Mummichog (and potentially some banded killifish) within the town of Stephenville Crossing and more than 600 from a site in Little Codroy River (Philip Sargent, personal communication).

The area of occupancy for Newfoundland Mummichogs was calculated to be 28 km^2 (excluding the historical record from the Terrenceville River) using the 2x2 km grid methods outlined by COSEWIC (2010).

<u>The number of distinct locations for Mummichog is somewhat unclear.</u> The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. Mummichog in Newfoundland have been reported from twelve populations, each associated with a separate watershed. The twelve populations can be roughly grouped into four areas (Codroy, Stephenville Crossing, Port aux Port, and Bay of Islands) of southwestern Newfoundland, each area separated by over 80 km of

coastline from the adjacent area. Within each area, Mummichog populations are separated by as little as a few kilometres to over 30 km. It is unlikely that a single threatening event would affect all of the individuals in one of the four areas but it is possible that more than one population in an area would be affected by a large-scale threat. As such, while four could be considered the minimum number of locations, it is expected that the number of locations is closer to twelve. The historical sample from the Terrenceville River, if confirmed, would represent a fifth area (and thirteenth population) separated from others by over 300 km.

Search Effort

A number of freshwater fish surveys have been conducted within insular Newfoundland.

Scott and Crossman (1964) surveyed 32 sites along the Trans-Canada Highway, from the Avalon Peninsula to Port au Port Bay, but documented Mummichogs only in southwestern Newfoundland.

Dickinson (1974) used a 10-meter seine to sample Mummichog, from May to December 1973, at Clark's Brook estuary and Frenchman's Cove in the Bay of Islands, Little Codroy River, and Seal Cove Brook near Stephenville Crossing.

Methven *et al.* (2001) did not record any Mummichogs during surveys at Bellevue, in Trinity Bay, from July 1982 – September 1983 and from July 1989 – September 1990.

Knight (2002) surveyed for Banded Killifish (*F. diaphanus*) in Gros Morne National Park. He did not document any Mummichogs.

In eastern Newfoundland, surveys in Terra Nova National Park, for banded killifish, did not document any Mummichogs (Cote, 2002).

Currie *et al*. (2009) conducted beach seine surveys from 2002-2009 in Bonne Bay, but did not document any Mummichogs.

Melanson and Campbell (2012) used beach seines and minnow traps in surveys at St. Pauls Inlet, but did not capture any Mummichogs.

Aboriginal, Traditional and Local Ecological Knowledge

There is no Aboriginal, traditional or local ecological knowledge regarding Mummichog; however, the species is caught as by-catch within the commercial

American Eel fyke net fishery in south-western Newfoundland (Gallant, 2006).

Trends

NatureServe states that the short term population trend for the species is relatively stable and that the global trend, over three generations, is unknown but may be relatively stable.

There is no time series of population estimates for Mummichog in Newfoundland. However, two different Mummichog locations have been surveyed at various times within the past 50 years. Dickinson and Threlfall (1975) documented Mummichog in Mummichog Provincial Park (Little Codroy River); the population was still present following surveys by Fisheries and Oceans in 2009. Scott and Crossman (1964) documented Mummichog at the head of St. George's Bay; the population was still present when Gallant (2006) and Fisheries and Oceans Canada conducted surveys near the same area approximately 50 years later.

Threats and Limiting Factors

NatureServe states that no major threats to Mummichogs are known. Perhaps this is at least partly because the Mummichog is an extremely tolerant species that can survive at very low oxygen levels (Stierhoff *et al*., 2003 [near Lewes, Delaware]), and within heavily polluted ecosystems (Schmalz *et al*., 2002 [Linden, New Jersey]; Weis, 2002). Nonetheless, in heavily-polluted areas, this tolerance is not entirely without cost (Vogelbein *et al*., 1990 [Virginia (Chesapeake Bay); Weis and Candelmo, 2012). The species is also very temperature-tolerant. In Virginia, the Mummichog can withstand seasonal temperature changes ranging from 7°C to 36°C (44.6° F to 96.8°C) (Bulger and Tremaine, 1985); and, presumably, temperatures cooler than 7°C further to the north.

That said, several specific threats may be present within insular Newfoundland.

The recent establishment of invasive green crab (*Carcinus maenas*) in western Newfoundland could be detrimental to the Mummichog. Green crabs are now present within St. George's Bay (Fisheries and Oceans Canada, 2010) and the Bay of Islands. There is no published information on the impact of Green Crab on Mummichog populations; however, the blue crab (*Callinectes sapidus*) is a major predator of Mummichogs [*F. h. heteroclitus*] within an intertidal salt marsh at Sapelo Island, Georgia (Kneib, 1982, 1986).

MAMKA (2013) monitored by-catch from the commercial American Eel fyke net fishery in the Muddy Hole area of Flat Bay, NL where Mummichog and green

crab were both documented as by-catch.

"Yellow-phased" American Eel (i.e., the primary, 3-5 year old, growth stage of the species, between the elver stage and the sexually-mature silver-phase stage) often utilize estuaries to feed, and may prey upon Mummichogs. Indeed, Meredith and Lotrich (1979) found Mummichogs within the gut contents of American Eel from a tidal creek northwest of Lewes, Delaware. High American Eel densities may thus be a threat to Mummichogs within estuaries and it is possible that American Eel fisheries could be responsible for reducing the predation threat.

It is also possible that by-catch mortality from American Eel fisheries could be a threat to Mummichogs in Newfoundland although Newfoundland by-catches are released. Gallant (2006) conducted a study to determine if the commercial American Eel fyke net fishery has any impact on banded killifish populations. During the study Mummichog by-catch was also documented and analyzed. A total of 183 Mummichogs were documented as by-catch with 3 mortalities (approximately 1% mortality). The mortality rate for Mummichog by-catch is low, but could potentially be at least a minor threat to the species.

Significantly, in May 2012, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed American Eel as "Threatened". A listing to Schedule 1, under the federal Species at Risk Act, could reduce or close all eel fisheries.

Existing Protection

The Mummichog is not yet listed under the federal *Species at Risk Act* or the provincial *Endangered Species Act* and therefore does not receive protection under either act. There are no documented occurrences of Mummichogs within Gros Morne National Park (Knight, 2002) or Terra Nova National Park (Cote, 2002) and therefore the species does not receive any protection under the *Canada National Parks Act*. The Mummichog is not present within any of the Province's remaining provincial parks and does not receive any protection under the *Provincial Parks Act*. The Mummichog does share habitat with Atlantic Salmon (*Salmo salar*) and American Eel (*Anguilla rostrata*) both of which receive protection under the *Newfoundland and Labrador Fishery Regulations* of the federal *Fisheries Act*. It might be expected that the Mummichog would receive some benefit from the habitat protection provisions within the *Fisheries Act*, but recent changes to the *Fisheries Act* may negate this protection.

Special Significance

Within estuaries the Mummichog acts as a predator to both invertebrates and small juvenile fish, and as prey to larger fish and (possibly) avian species (Kneib, 1986).

Vince *et al*. (1976) found that, in Massachusetts, Mummichogs seem to be an important factor in regulating the abundance and size-distribution of the snail *Melampus bidentatus* and the amphipod *Orchestia grillus*.

The Mummichog has been used as a bait fish, within the United States, for Summer Flounder (*Paralichthys dentatus*) and Bluefish (*Pomatomus saltatrix*) fisheries (Abraham, 1985).

Mummichogs have been used extensively in laboratory research. Burnett *et al.* (2007) indicated that Mummichogs are an ideal species for toxicology, genetic, ecological, and physiological research on teleost fish. They stated that Mummichogs can tolerate relatively large changes in salinity, oxygen levels, and temperature; are easy to capture within the wild; can adapt to laboratory conditions with little difficulty. Their embryonic development is also easily observed, so they are often used in teaching. A considerable amount of information has been collected on Mummichog cell signalling and gene expression related to environmental disturbances (Burnett *et al.*, 2007).

For Prince Edward Island, Finley *et al.* (2013) indicated that Mummichog population demographics can be used as an indicator for eutrophication; concluding that population increases in adult and young-of-the-year Mummichogs were the result of habitat changes caused by nutrient increases within the study area.

Leblanc *et al.* (1997) conducted research on Mummichogs in the Miramichi Estuary, New Brunswick, to document anthropogenic impacts from a pulp mill. In this study, the Mummichog reproductive season began 1-2 weeks later, and eggs were smaller, for sites closer to the mill effluent (4 km and 21 km downstream), when compared with sites located away from the effluent (39 km downstream). Moreover,GSI (= gonadosomatic index = weight of gonad/weight of fish x 100, given as a percent), fecundity, and breeding effort were found to be highest at the closest study site (4km downstream) to the mill effluent.

Trivia: In 1973, the Mummichog became the first fish in space when carried on Skylab 3 as part of the biological experiments package. Later space missions by the U.S., such as Bion 3, have also carried Mummichog (See: Wikipedia and tinyurl.com/om66enb).

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Personal Communications

Timothy Birt, Queen's University – Research Associate

Keith Clarke, Fisheries and Oceans Canada – Ecological Sciences Section

Ross Hinks, Miawpukek First Nation, Newfoundland – Director of Natural Resources

Tom Knight, Parks Canada Agency – Ecosystem Scientist

Mervin Langdon, Parks Canada Agency – Resource Management Officer

Shayne MacDonald, Mi'kmaq Alsumk Mowimsikik Koqoey Association, Newfoundland – Executive Director

Rob Perry, Department of Environment and Conservation – Senior Wildlife Biologist

Craig Purchase, Memorial University of Newfoundland – Department of Biology

Philip Sargent, Fisheries and Oceans Canada – Ecological Sciences Section

Eric Schultz, University of Connecticut – Department of Ecology and Evolutionary Biology

Jonathan Strickland, Qalipu Mi'kmaq First Nation Band, Newfoundland – Aquatic Policy and Planning Manager

Kirby Tulk, Parks Canada Agency – Acting Manager, Resource Conservation

Additional Sources of information

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Collections Examined

None

Rank or Status
G, N, and S-rank information taken from NatureServe (2013a). General status from listed provinces taken from National General Status Working Group (2012). Provincial status information taken from Department of Environment and Conservation (2013). IUCN status taken from NatureServe (2013b)

Global	
G-rank	G5 (Secure)
IUCN	LC (Least Concern)
National	
N-rank	NNR (Unranked)
National General Status	4 (Secure)
COSEWIC	Not Assessed
Provincial	
Provincial General Status	Sensitive
Newfoundland S-rank	S3 (Vulnerable)
Newfoundland General Status	3 (Sensitive)
Labrador S-rank	NA
Labrador General Status	NA
Adjacent Jurisdictions	
Nova Scotia S-Rank	S5 (Secure)
Nova Scotia General Status	4 (Secure)
Prince Edward Island S-Rank	S5 (Secure)
Prince Edward Island General Status	4 (Secure)
New Brunswick S-Rank	S5 (Secure)
New Brunswick General Status	4 (Secure)
Québec S-Rank	S4 (Apparently Secure)
Québec General Status	4 (Secure)