Big Fish River Dolly Varden

Background

The northern form of Dolly Varden, Salvelinus malma (Walbaum), inhabits the Big Fish River, which is located within the Inuvialuit Settlement Region (ISR). The Inuvialuktun name is iqaluqpiq, however, most local people call them char (Papik et al. 2003).

The over-wintering area, known as "Fish Hole", was an important source of fish for the residents of Aklavik in the 1960s and 1970s, but declines in the size and number of fish caught led to a community consensus to close the river to all fishing in 1987 (Sandstrom and Harwood 2002). Limited subsistence fisheries were reopened on the river in 1992 (Stephenson 1999). Big Fish River Dolly Varden are also harvested annually at Shingle Point as a portion of a "mixed stock" harvest of anadromous fish (Sandstrom and Harwood 2002).

The Inuvialuit Final Agreement (1984) established a resource co-management arrangement for the ISR. The status of this stock is being reviewed to assess the impacts of current harvest levels in support of management needs of Fisheries and Oceans Canada (DFO), the Fisheries Joint Management Committee (FJMC), and the community of Aklavik. The West Side Working Group (WSWG) was established in 2001 by DFO, FJMC, the Aklavik Hunters and Trappers Committee (HTC) and Parks Canada to develop an integrated fisheries management plan for this and other stocks of North Slope Dolly Varden.

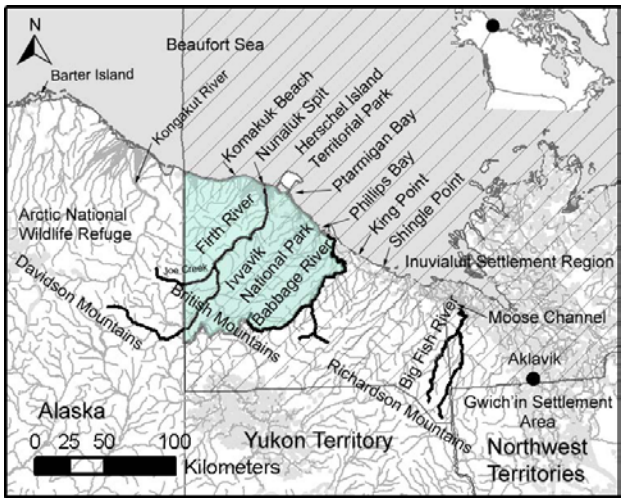

Fig. 1. Map of the North Slope area.

Summary

- Anadromous Dolly Varden spawn and overwinter in an area called "Fish Hole" in the Little Fish River, a tributary of the Big Fish River.
- These Dolly Varden are genetically distinct from other populations in neighbouring systems.
- Harvesters of Dolly Varden originating from this system are principally from the Inuvialuit land claim group, and most reside in Aklavik.
- The community of Aklavik agreed to stop harvesting directly from the river in 1987 because of their concerns with declining fish harvests.
- A limited fishery on the river was reopened in 1992.

- 50% of the Dolly Varden captured in the annual mixed stock fisheries on the coast of the Beaufort Sea in the Shingle Point area have been estimated to be from the Big Fish River Dolly Varden stock.

- Estimates of total annual exploitation rates for the Big Fish stock since 1990 have ranged between 3% and 9% of the adult anadromous population.

- The most recent estimate (1998) suggests there are approximately 4000 adult anadromous Dolly Varden in the population, down from the 20,000 estimated in 1972.

- Habitat alteration from natural causes has occurred on the Big Fish River, and may limit the potential size of the stock. The extent to which these changes may continue into the future is unknown.

- The stock may have reached a stable population size at a much lower level than that recorded historically.

- The total harvest from the river and the mixed stock fisheries on the coast must be taken into account when recommending harvest levels. Harvest should not exceed 5% of the adult anadromous population size.

- There is a need to determine the number of Dolly Varden harvested from the Big Fish River stock during the coastal fisheries in order to conserve this stock.

Species Biology

Dolly Varden (*Salvelinus malma*) are closely related to Arctic char (*S. alpinus*), lake trout (*S. namaycush*) and brook trout (*S. fontinalis*). Externally, all chars, including Dolly Varden, can be distinguished from salmon and true trouts by their light spots (yellow, orange or pink) on a darker background, as opposed to black spots or speckles on a lighter background. Dolly Varden can usually be distinguished from Arctic char by their more numerous and smaller spots with blue halos, more laterally compressed bodies and generally, less-forked tail fins. The anadromous form of Dolly Varden, when in non-breeding condition, is silvery with an olive-green to brown colour on the dorsal surface. Colours vary between stocks, fish size, and breeding condition (Armstrong and Morrow 1980).

In the Canadian Arctic, Dolly Varden inhabit North Slope rivers (Fig. 1) to the west of the Mackenzie River, including the Vittrekwa (Peel River drainage), Big Fish, Babbage, Firth and the Rat rivers. Dolly Varden are recognized as a distinct species (Reist *et al*. 1997), although earlier literature for this area either refers to them as the western Arctic form of Arctic char, or combines the information for the two species.

Many Dolly Varden stocks, including the Big Fish River stock, exhibit both an anadromous (sea-run) and a residual, non-migratory (solely freshwater) form (McCart 1980). A third form present in the Big Fish River system is an isolated stock of small fish that reside above the falls in the Little Fish River. The “isolates” are not discussed in this report. The anadromous form is most commonly observed. Eddy *et al.* (2001) summarize information known about

anadromous Big Fish River Dolly Varden. This form resides in headwater streams for approximately three years. At this stage, they are known as parr. After this time, these parr move downstream during the spring to the estuary where they become smolts, capable of entering the sea (Sandstrom 1995). At this stage, they are approximately 120 mm in length. The physiological changes that occur during smoltification allow the anadromous fish to migrate into marine waters during the summer to feed, (Armstrong and Morrow 1980) prior to returning to freshwater to overwinter. The returning smolts from the Big Fish River vary in length from 300 mm to 320 mm (Sandstrom 1995). They continue to make summer and fall migrations to and from the sea for the remainder of their lives. The residual form is comprised almost exclusively of males, which reside in the headwater areas for their entire lives and, therefore, do not go through the smoltification process. They mature at a smaller size and younger age than their anadromous counterparts and "sneak" into the redds to spawn with the anadromous females.

Anadromous males and females from North Slope populations begin to mature at age 4 at about 340 mm in length. However, most mature at an age of 5-6 years, after having spent two or three summers feeding at sea. Plots of length-at-age data are very similar for anadromous male and female Dolly Varden in the Big Fish River (Fig. 2).

On average, males constitute only 14% of all the spawning anadromous Dolly Varden sampled in the Big Fish River. The female:male ratio is, therefore, about 6:1 (Sandstrom and Harwood 2002). Large numbers of residual

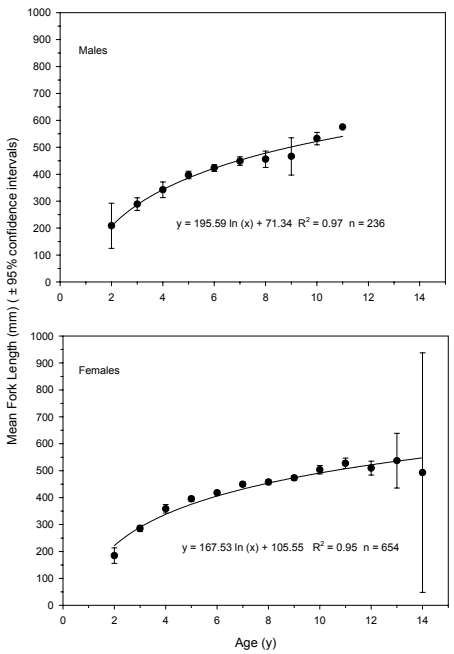

Fig. 2. Length-at-age data for male and female anadromous Dolly Varden from the Big Fish River. Data are combined for all years and were collected as part of various studies indicated in brackets. Data from 1982 (Souter et al. 1986), 1984 (Gillman et al. 1985), 1986 (Sparling and Stewart 1986), 1987 (MacDonell 1987), 1988 (Reist et al. 1997), 1991 (P. Lemieux unpublished data), 1993 (females only) and 1994 (L. Harwood unpublished data), 1997 and 1998 (S. Stephenson unpublished data).

males are also found at the spawning site. The relative absence of large anadromous males may be due to a high rate of precocious maturation in the stock (Sandstrom and Harwood 2002). Upon reaching maturity, many female Dolly Varden in the Big Fish River appear to spawn every year (Sandstrom and Harwood 2002). In other North Slope populations, spawning generally occurs every second year. Spawning in the Big Fish River drainage basin occurs at the Fish Hole on the Little Fish River (referred to as Cache Creek in many scientific reports)(Fig. 3) from late September to early October. Egg size was larger for females from the Big Fish

River than the Babbage River, and was correlated with fish length (Sandstrom 1995). Larger eggs had much higher survival rates than smaller eggs (S. Sandstrom, pers. comm.). Hatching times in the Big Fish River can vary by several months depending on the water temperature at the site (S. Sandstrom, unpublished data).

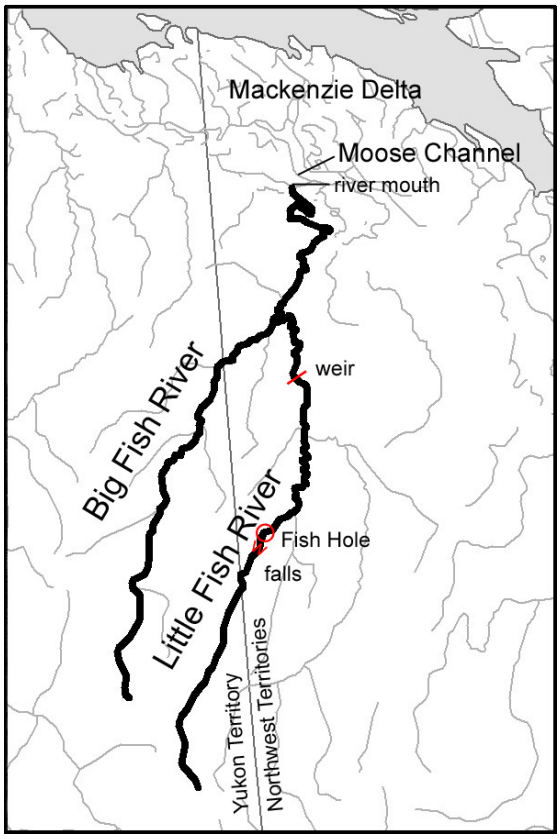

Fig. 3. The Big Fish River system with fishing sites marked. Little Fish River is usually referred to as Cache Creek in the scientific literature.

Description of Habitat

The Big Fish River originates in the Richardson Mountains and flows north to Moose Channel of the Mackenzie River (Fig. 1). Its upper reaches are composed of numerous small feeder streams with swift flowing waters and gravel and cobble substrates. Tributaries are typically 1-5 m wide, 0.5-2 m deep, and have moderate flows and gravel substrates (Gillman *et al.* 1985). Little Fish River contains thermal mineral springs at and above a 3 m waterfall that is impassable to fish moving upstream (Fig. 3) (McCart and Bain 1974).

The foothills section of the Big Fish River flows rapidly through a steep-sided gorge. Gravel bars and large boulders are common in this section, and depths are generally 0.5-1 m. Slow flows, mud banks and substrates, and depths of 1-4 m characterize the lower reaches of the river (Gillman *et al.* 1985).

All Big Fish River Dolly Varden overwinter and spawn in a single location, called “Fish Hole” (68°18’08”N, 136° 20’32.7”W) (Fig. 3). This area contains a thermal spring that has high levels of dissolved solids, relative to over-wintering sites of other North Slope rivers. Water temperature at the orifice of the thermal spring can be as high as 15.5°C, and the majority of the upper areas of Fish Hole remain ice-free throughout the winter (McCart and Bain 1974). There is a temperature gradient from the falls to about 4 km below the falls, where the temperature can be as low as 0°C. Below the Fish Hole, tunnels form in the core of the aufeis, or “overflow ice” fields, that are about 2 m in diameter and contain water about 0.5 m deep. These tunnels appear to be a unique feature of Little Fish River that results from the much warmer than average temperature of its thermal spring (Sandstrom 1995).

Estuary environments are important for most juvenile anadromous fish undergoing smoltification. They provide a salinity gradient that fish can use to gradually increase their tolerance to

marine waters, and they also provide important feeding habitat.

The Fishery

Historical harvest

Dolly Varden were harvested from the mixed stock fishery at Shingle Point in the summer. The Big Fish River was fished at the mouth (Fig. 3), where it joins Moose Channel, during the fall upstream migration, using 2" to 4" gill nets. Fish were also caught with seine or smaller mesh gill nets at Fish Hole, usually in October and November after freeze-up (Fehr and Archie 1989). The pools were typically swept with a 3" mesh net (Byers 1993).

Annual harvests at Fish Hole have declined from about 10000 to less than 100 fish since the 1970s (Table 1), as has the catch-per-unit-effort (CPUE) (D. C. Gordon, Aklavik, pers. comm.). Exploitation rates during the 1972 harvest were estimated to be as high as 38% at Fish Hole and 19% in the lower Big Fish River (Fehr and Archie 1989).

The Big Fish River was closed to all fishing in 1987 (Baker 1987), and re-opened to limited subsistence harvests in 1992 (Stephenson 1999), although the mixed stock fishery on the coast continued during this time. The Traditional Ecological Knowledge Fishing Study (TEKFS) (Papik *et al.* 2003) confirms that harvests began to decline at Fish Hole in the 1980s, prompting the 1987 closure.

Current harvest

Current reported harvests of Big Fish River Dolly Varden from coastal and river fisheries combined are less than 50 Dolly Varden annually (Table 1).

Length-frequency histograms, comparing the length classes of fish captured during subsistence harvests and sampled in population surveys (sampling included electrofishing in 1993) indicate that the subsistence fishery removes large fish (300–550 mm in length) from the population (Fig. 4). Few smaller fish (e.g. near 200 mm) appear to be kept during subsistence harvests.

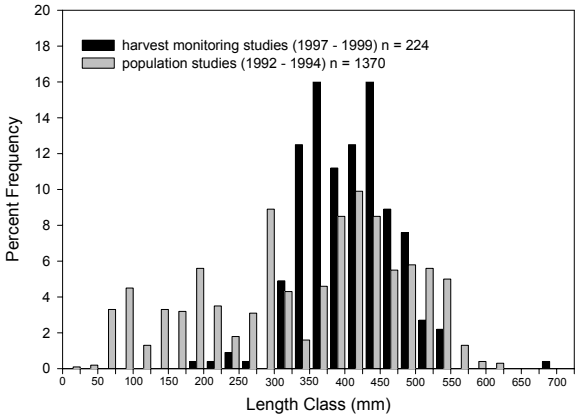

Fig. 4. Comparison of lengths of Dolly Varden captured during population studies and subsistence harvest monitoring studies from 1992 to 1999 (Eddy et al. 2001).

View of Fishers

The Inuvialuit have long depended on the Dolly Varden (*iqaluqpiq)* of the Yukon North Slope for winter sustenance. Inuvialuit fishers have changed their fishing locations and practices over the decades because a number of circumstances have changed. Prior to the 1930s, people fished where they lived, in places like Herschel Island, Kay Point, King Point and Shingle Point. The entire coastline was used for fishing, from the Canada/Alaska border to the Mackenzie

River. In the 1930s and 1940s, RCMP posts, stores and schools began closing as people moved to the Mackenzie Delta and Aklavik to take advantage of good muskrat trapping opportunities. In the 1960s, most people used Aklavik as a base and went to the coastline for shorter trips. The Big Fish River Fish Hole was heavily fished, because it was accessible from Aklavik.

In the mid 1980s, fishers became concerned about declining fish harvests from the Big Fish River and apparent changes in abundance of over-wintering fish in the Fish Hole. These concerns led to closure of the fishery in 1987. The fishers have continued to support restrictions of harvests, even though the period of time originally projected for stock recovery has long passed.

The Aklavik Hunters and Trappers Committee have supported traditional knowledge and scientific studies to assess the causes of the problem with the fish stock. Studies have included the assessment of local knowledge of fishers and elders (Byers 1993; Papik *et al.* 2003), amongst others. Elders and fishers have long believed that environmental changes in the spawning and over-wintering areas in the Fish Hole are critical factors in the decline of the Big Fish River Dolly Varden population. They believe that this is responsible for failure to recover, despite significantly reduced fishing pressure. They consider that a holistic approach is essential to ensure the future survival and possible recovery of the population. The fishers have supported the establishment of the West Side Working Group by the FJMC, DFO, the Aklavik HTC and Parks Canada (PC) to develop a long-term, objectives-based Fisheries Management Plan for all fish stocks west of the Mackenzie River to the Canada/Alaska border.

Resource Status

Stock Delineation

Dolly Varden that spawn and over-winter in Fish Hole appear to be a discrete genetic stock. This conclusion is based on genetic structuring (Reist 1989; Bajno and Reist in prep; Rhydderch 2001), tag returns (Sandstrom and Harwood 2002), and comparison of morphometric variables with those of other North Slope stocks (Reist *et al.* 1997; Johnson 2002). Preliminary analysis of strontium levels in otoliths also supports this view (Babaluk and Reist in prep.). The TEKFS (Papik *et al.* 2002) indicates that fish size is larger in rivers near Herschel Island than it is in rivers near Aklavik, also suggesting separation of fish from the different river systems.

Residual males in the Big Fish River have been shown to belong to the same genetic population as the anadromous Dolly Varden (Reist 1989). The isolated population of Dolly Varden above the falls in the Little Fish River is significantly different from the downstream anadromous population (Bajno and Reist in prep.).

Stock Size

The Big Fish River Dolly Varden stock over 150 mm was estimated (Petersen method) to number approximately 20,700 fish in 1972 (Table 2), with 95 % Confidence Limits of 15,800 to 27,600 fish (Kristofferson and Baker 1988). By 1985, Petersen estimates indicated that abundance had dropped (Table 2) to

approximately 9300 fish (95 % CI 6300 – 14,300) (Kristofferson and Baker 1988). Data from weir counts and Petersen estimates between 1987 and 1991 show that the stock continued to decline over that period (Table 2) (Sandstrom and Harwood 2002). Data from Petersen estimates, conducted in 1993 and again in 1998, show that the stock size of anadromous fish was about 4000 during that period (Table 2) (Stephenson 1999).

Stock Trends

Population estimates (Table 2) and observations of local fishers indicate that the stock declined in size from the 1970s to the mid-1980s. Although population estimates from various years are not directly comparable, they do indicate that numbers have declined in the Big Fish River stock. Estimates from 1998 indicate that the Big Fish River Dolly Varden stock has not recovered since the 1987 closure of the fishery. Additionally, stock abundance appears to have remained relatively stable at approximately 4000 fish for a period of at least five years (Stephenson 1999).

The average size of Dolly Varden in this stock increased between 1984 and 1994 (Sandstrom and Harwood 2002). This may reflect reduced fishing pressure on the stock in recent years.

Age-frequency histograms (Fig. 5) indicate that, in some years, the stock may be dominated by strong cohorts. In 1984, age 6 was dominant, and in 1986, age 8 was dominant (Fig. 5).

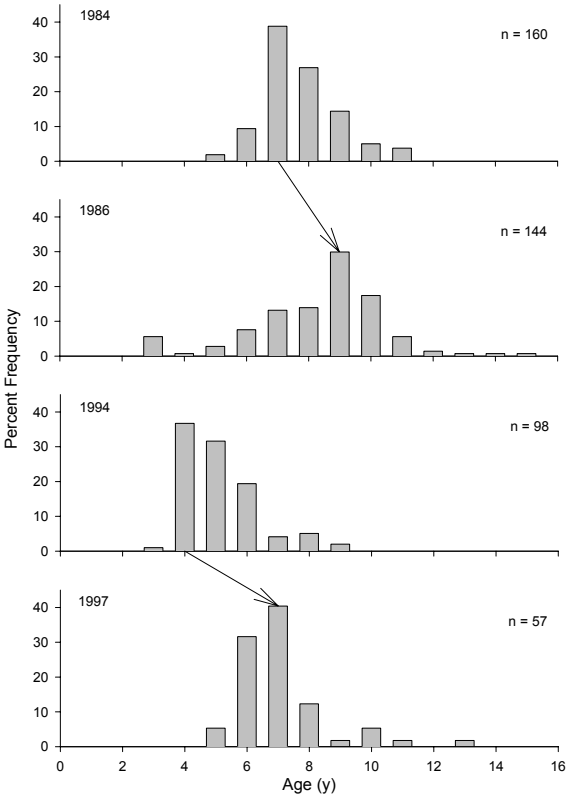

Fig. 5. Age-frequency distributions for Big Fish River anadromous Dolly Varden (Eddy et al. 2001). Arrows indicate dominant cohorts.

Habitat Trends

Present day water levels are much lower than they were during the 1960s and 1970s (Sandstrom and Harwood 2002; Papik et al. 2003). Salinity at the Fish Hole has also reportedly declined (Papik et al. 2003).

Long term records of area temperature (Fig. 6A) indicate a slight trend to higher mean temperatures since the early 1960s. Precipitation records for the same period (Fig. 6B) are variable with the 1960s and 1990s having above average precipitation, the 1970s average precipitation, and the 1980s having below average precipitation.

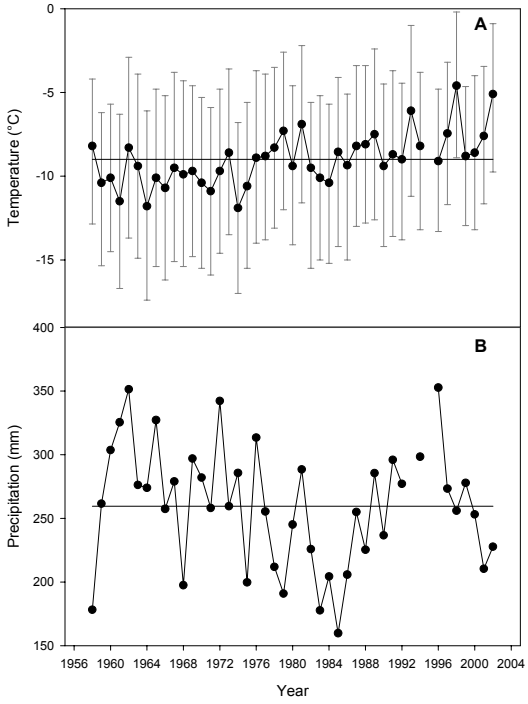

*Fig. 6. Mean annual temperature (**A**) (± range) and total precipitation (**B**) (snow and rain) for Inuvik and Aklavik combined, for the years 1958-2002 (data from Environment Canada). There are no precipitation data for 1993, temperature or precipitation data for 1995 and both temperature and precipitation data for 2002 are from January to August only. The long-term averages are indicated by horizontal lines.*

Geological Survey of Canada records indicate that seismic activity in the northern portion of the Richardson Mountains in 1981, 1983 and 1986 was higher than usual (Sandstrom and Harwood 2002). Seismic events also occurred within 20 km of the Fish Hole in 1970 (Sandstrom and Harwood 2002). Geological changes in the region could have reduced the volume of groundwater flow into the site, reducing the amount of over-wintering habitat. Temperatures on the spawning beds may also be less stable as a result of the decline in water level.

Sustainable Harvesting Rate

Although some stocks, such as the Rat River, are thought to be able to sustain harvest levels as high as 13 to 17.7% (DFO 2001), it is thought that Big Fish River Dolly Varden cannot tolerate such levels. Rather, a rate of 5.0% of the anadromous population of harvestable sized fish may be sustainable (Cosens et al. 1998). A small subsistence fishery of about 150 fish annually at Fish Hole would represent about 2.5-5.0% of the estimated 1998 stock size, and would not at first appear to exceed sustainable harvest rates. However, the number of Big Fish River Dolly Varden that are harvested as a portion of the Shingle Point fishery represents approximately 3.5-6.6% of the estimated 1998 stock size (Stephenson 1999). The total take of these two fisheries combined would, therefore, range between 6-11.6%.

Additional factors that must be taken into account when attempting to determine the sustainable harvesting level for this stock. These include the possibility that recent habitat changes may have altered or reduced the amount of critical over-wintering habitat, and the fact that the stock has not shown any sign of recovery since the 1987 closure (Stephenson 1999).

Sources of Uncertainty

There is no estimate of current stock size or current harvest since 2000, although both are expected to be lower than previous estimates. The present day contribution of the Big Fish River stock to the Shingle Point harvest is unknown.

The mechanisms by which changes in water level, temperature and salinity

might limit stock recovery are not known. High levels of sedimentation have also been observed at the spawning beds, but it is not known whether sedimentation rates have increased in recent years or whether there has been an impact on egg survival. The extent to which habitat changes may continue into the future is unknown.

Outlook

Despite traditional fishery management practices (closure of the fishery at the spawning/over-wintering areas to reduce exploitation rate, reopening with a limited quota, monitoring harvest levels and biological parameters of the harvested fish), the stock has not recovered. Although empirical evidence is lacking, both fishers and scientists agree that habitat change is likely limiting the size of the stock.

Management Considerations

The Big Fish River Dolly Varden fisheries are co-managed by DFO and FJMC as established under the Inuvialuit Final Agreement (IFA 1984). The FJMC, DFO, Aklavik HTC and Parks Canada have established the WSWG to develop a long-term, objectives-based Fisheries Management Plan for the Big Fish River and other rivers between the Mackenzie River and the Canada/Alaska border. The WSWG is currently made up of fishers from Aklavik, community elders, biologists and managers.

The WSWG has initiated a process to:
- assemble scientific and traditional knowledge and information on fish stocks and habitats, implemented through the DFO Science Regional Advisory Process (RAP),
- establish conservation limits for the stock,
- set fisheries management objectives and strategies for the stock, and
- develop the fisheries management operational plan.

The Aklavik Inuvialuit Community Conservation Plan (Community of Aklavik *et al.* 2000) was prepared by the community of Aklavik, the Wildlife Management Advisory Council (NWT) and the Joint Secretariat (2002). This plan has designated the Fish Hole and riparian areas of the Big Fish River as Management Category E, which indicates that the lands and waters where renewable resources are located are of extreme significance and sensitivity. No development is allowed in these areas, and the lands and waters are to be managed to eliminate (as far as possible) potential damage and disruption. The remainder of the watershed is designated as Management Category D, which indicates lands and waters where renewable resources are of particular significance and sensitivity throughout the year. Management should also eliminate, where possible, potential damage and disruption.

The Environmental Impact Screening Committee and the Environmental Impact Review Board, established under the IFA (1984), are responsible for screening and review of any development activity on crown lands within the ISR that may have detrimental effects on the resources or their habitat.

Management of this stock is complicated by the fact that fish are caught in a mixed stock fishery at Shingle Point, and that habitat change

has occurred in the spawning and over-wintering area. This stock also has some distinctive biological characteristics that may constrain reproductive potential. These include the sex ratio of anadromous adults, egg size, etc., and need to be considered.

Timing of Harvests

Fish that are concentrated in over-wintering sites are highly vulnerable to capture, and large numbers can often be harvested in a short period of time. Harvest in these areas following spawning also has the potential to increase egg mortality. This can occur if seining activities disturb or destroy redds (Stephenson 1999).

Other Considerations

Habitat alteration and/or degradation of the spawning and over-wintering sites on the Big Fish River system are the major threats faced by this stock of Dolly Varden. Any development activity (e.g., roads, right-of-way, etc.), which would diminish the integrity or physical characteristics (water level, oxygen level, silt loads, temperature, pH) of the spawning and over-wintering area, could pose a threat to developing embryos, rearing juveniles, and/or spawning and over-wintering adults found there. The integrity of the watershed must be maintained. More pervasive threats, such as climate change and/or increased incident ultraviolet radiation resulting from ozone depletion, may affect the fish and their habitat, but the details are not understood at the present time.

For More Information

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ISSN 1480-4913

La version française est disponible à l'adresse ci-dessus.

Correct citation for this publication

DFO. 2003. Big Fish River Dolly Varden. DFO Sci. Stock Status Report D5-60 (2002).

Table 1. Number of fish harvested from the Big Fish River stock, 1972-2002. Samples came from the subsistence fishery (Sb), Scientific sampling (Sc) or Scientific sampling of the subsistence fishery (Sc/Sb). The Big Fish contribution to the Shingle Point mixed stock fishery is assumed to be 50% (Harwood pers. comm.). Exploitation Rate is determined using the harvest and the average population estimate from Table 2 for the same year when it is available or the following year when it is not. Q = quota issued for the waterbody.

Year	Harvest Location					Total Harvest (number)	Exploitation Rate	Source
	Shingle Point	River Mouth	Weir Site	Fish Hole	River			
1972		3000-5000(Sb)[1]		5000-7000(Sb)[2]		8000-12000	0.48	Low unpubl. data[1]; Stein *et al.* 1973[2]
1973		2500(Sb)		1500(Sb)		4000		Low unpubl. Data
1980		94(Sc/Sb)				94		Kristofferson 1988
1981				60(Sc)		60		Souter et al. 1986
1982				10(Sc)		10		Souter et al. 1986
1983				18(Sc)		18		Souter et al. 1986
1984	7(Sc)[4]	192(Sc/Sb)[3], 151(Sb)[3]		67(Sc)[4]		417	0.06	Gillman, Sparling and Gillis 1985[3]; Souter et al. 1986[4]
1985		489(Sb)[5]		8(Sc)[6], 500(Sb)[5]		997		Kristofferson 1988[5]; Souter et al. 1986[6]
1986	18 (37)(Sb)[9]	105(Sc/Sb)[9], 92(Sb)[9]	74(Sc)[7]	72(Sc)[8], 1660(Sb)[9]		2021	0.22	MacDonell 1987[7], Reist 1989[8], Sparling and Stewart 1986[9]
1988	73(147)(Sb)[12]		81(Sc)[10]	17(Sc)[10]	120(Sc)[11]	291	0.04	Fehr and Archie 1989[10], Reist unpubl. data[11], Sandstrom and Harwood 2002[12]
1989	15(30)(Sb)[13]				no Sb[14]	15		Sandstrom and Harwood 2002[13], Stephenson pers. comm.[14]
1990	107(214)(Sb)[15]				no Sb[16]	107	0.04	Sandstrom and Harwood 2002[15], Stephenson pers. comm.[16]
1991	3(7)(Sb)[17]		115(Sc)[17]		no Sb[18]	118	0.05	Sandstrom and Harwood 2002[17], Stephenson pers. comm.[18]
1992	9 (17)(Sb)[19]	1(Sb)[20], 23(Sc/Sb)[19]		83(Sc)[19]		116	0.03	Sandstrom and Harwood 2002[19], Stephenson pers. comm. [20]
1993	60 (119)(Sb)[22]			40(Sb Q=400)[22], 177(Sc)[21]		277	0.06	Sandstrom and Harwood unpubl. data[21], Stephenson pers. comm.[22]
1994	17(33)(Sb)[24]			36 (Sb Q=200)[24], 171(Sc)[23]		224		Sandstrom and Harwood 2002[23], Stephenson pers. comm.[24]
1995	32(63)(Sb)			40(Sb Q=200)		72		Stephenson pers. comm.
1996	402(805)(Sb)	19(Sb Q=200)				19		Stephenson pers. comm.
1997	61(124)(Sb)			100(Sb Q=150)		161	0.04	Stephenson pers. comm.
1998	260(521)(Sb)			89(Sb Q=150)		349	0.09	Stephenson pers. comm.
1999	125(250)(Sb)			196(Sb Q=200)		321		Stephenson pers. comm.
2000	7(15)(Sb)			32(Sb Q=400)		39		Stephenson pers. comm.
2001	low				no Sb			Stephenson pers. comm.
2002	low				no Sb			Stephenson pers. comm.

Table 2. Abundance estimates for Big Fish River anadromous Dolly Varden. Some estimates are for current year spawners or for non-spawners (silvers) and some are for both (combined). The abundance estimates are limited to the subset of the population described by 'portion of the population' and the notes provided.

Year	Estimate Method	Abundance Estimate (95% C.I.)	portion of population	Notes	Source
1972	Petersen	20,700 (15,800-27,600)	≥150 mm	August estimate at river mouth, assuming catch of 4000, tagged same year as recaptured	Kristofferson and Baker 1988
1972	Petersen	13,500 (11,300-16,000)	≥150 mm	fall estimate at Fish Hole, assuming catch of 6000, tagged same year as recaptured	Kristofferson and Baker 1988
1984	Petersen	9300(6300-14,300)	≥350 mm	assuming no mortality of tagged fish, tagged 1984 and recaptured 1985	Kristofferson 1988, Kristofferson and Baker 1988
1984	Petersen	4600 (3100-7100)	≥350 mm	adjusted for mortality=0.5, tagged 1984 and recaptured 1985	Kristofferson 1988, Kristofferson and Baker 1988
1987	Petersen	7572 (5551-10,623)	>200 mm	estimate of silvers, tagged same year as recaptured	MacDonell 1987
1987	Petersen	1504 (781-3167)	>200 mm	estimates the current year spawners, tagged same year as recaptured	MacDonell 1987
1987	combined	9076	>200 mm	combined, marked and recaptured the same year	MacDonell 1987
1987	weir count	3107	>200 mm	partial weir count (8.5 days)	MacDonell 1987
1987	Petersen	7379 (5479-9279)	>200 mm	marked 1987 and recaptured 1988, adjusted for tag loss 11.3%	Sandstrom and Harwood 2002
1988	Petersen	5827 (4293-8122)	>200 mm	marked and captured Sept 16-18 in Fish Hole, tagged same year as recaptured	Fehr and Archie 1989
1988	Petersen	8499 (5846-12,848)	>200 mm	all fish marked and recaptured in 1988, tagged same year as recaptured	Fehr and Archie 1989
1988	weir count	1244	>200 mm	partial weir count (12.5 days)	Fehr and Archie 1989
1988	Bailey	6766 (1845-11,687)	>200 mm	tagged in 1987 and 1988 and recaptured in fall 1988, triple-mark-recapture estimate	Sandstrom and Harwood 2002
1991	weir count	1617	anadromous, few smolts	weir operated 53 days but underwater 28 days	Sandstrom and Harwood 2002
1991	Petersen	2840 (2014-3666)	anadromous, few smolts	applied at the weir and recaptured at Fish Hole	Sandstrom and Harwood 2002
1991	Petersen	2232 (1716-2748)	anadromous, >400 mm	based on visual count of tagged	Sandstrom and Harwood 2002
1993	Petersen	4477(2305-6649)	≥370 mm, anadromous, few smolts	tagged in 1993 recaptured 1994, adjusted for tag loss and immigration	Sandstrom and Harwood 2002
1998	Petersen	1856 (1237-2917)	≥320 mm anadromous	current year spawners, marked and recaptured the same year	Stephenson 1999
1998	Petersen	2094 (1383-3333)	≥320 mm anadromous	silvers, marked and recaptured the same year	Stephenson 1999
1998	Petersen	4026 (2988-5563)	≥320 mm anadromous	combined, marked and recaptured the same year	Stephenson 1999