

SPEAR FISHING SPAWNING LAKE TROUT; EVALUATION OF AN EXPERIMENTAL SUPPRESSION METHOD

by

Larry Lockard, Karen Nelson, and Wade Fredenberg



U.S. Fish and Wildlife Service

Ecological Services, Helena, Montana

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U.S. Fish and Wildlife Service, Montana Field Office, 585 Shepard Way, Suite 1, Helena, Montana 59601, USA

Abstract

Gillnetting for removal of invasive nonnative lake trout is being conducted in at least a half dozen regional lakes to help conserve native and ESA listed fishes. Gillnetting bycatch can result in loss of important non-target fish, such as bull trout, and gillnetting is also relatively expensive, nonselective, and sometimes causes negative publicity. Purposes of this study were to: 1) observe spawning lake trout behavior underwater, 2) determine the potential efficacy of utilizing spear fishing to selectively remove lake trout from spawning concentrations and 3) evaluate bycatch concerns. Prior to and during an eight week study period, five Scuba divers collectively conducted 104 day and night time dives in Lake McDonald, Glacier National Park. Divers utilizing artificial lights and 6 foot pole spears searched for lake trout along preset depth contours on previously delineated lake trout spawning sites. Lake trout behavioral response to diver disturbance, lights, pursuit, and spearing events was recorded. Spawning concentrations of lake trout were first observed and speared on September 26, 2013 and were consistently present through the end of the evaluation on November 7. During 15 days of diving when lake trout spawning concentrations were present (56 of 78 dives during the study period) over 200 spawning lake trout were observed and divers attempted to spear lake trout a total of 52 times. Of the 52 attempted spearing events, 30 hits and 22 misses were recorded; zero bycatch resulted. Preliminary conclusions reached were: 1) female lake trout size and behavior may make them more vulnerable than males to spearing, 2) spawning lake trout were neither attracted to artificial light nor did they actively avoid lights or diver disturbances, 3) at night, lake trout were most susceptible to spearing partially due to the spotlighting “deer in the headlights” effect, 4) seasonal spear fishing by agency or supervised recreational scuba divers may be a viable management option for suppression of spawning lake trout in delineated spawning areas (< 100’ in depth), and 5.) with basic training, bycatch concerns may be minimal.

INTRODUCTION

Invasive lake trout have established populations in at least a dozen Montana lakes as well as other waters of the Pacific Northwest and Yellowstone Lake, Wyoming, where their presence can cause near extirpation of native fishes, including bull trout listed as “threatened” under the Endangered Species Act (ESA) (Fredenberg 2002). Over the last twenty years, in response to this threat, fishery resource agencies throughout the region have conducted a number of studies on lake trout populations and the methods required to reduce their numbers to levels compatible with maintaining native and sport fish populations. At Swan Lake, Montana, a cooperative multi-agency effort to suppress invasive lake trout is being undertaken by the Swan Valley Bull Trout Working Group comprised of: Montana Fish, Wildlife and Parks, U.S. Forest Service, U.S. Fish and Wildlife Service, Montana

Department of Natural Resources and Conservation, the Confederated Salish and Kootenai Tribes, Montana Trout Unlimited, and Montana State University (Rosenthal et al. 2012). At nearby Glacier National Park, Montana, lake trout suppression research has been conducted on Lake McDonald and Quartz Lake (Dux et al. 2011 and D'Angelo et al. 2011) and a current proposal is being assessed to expand to Logging Lake (Downs and Secrest 2013).

At Swan Lake, population modeling results indicated that lake trout population growth was highly sensitive to survival rates of age-0 lake trout (starting as eggs) (Cox 2010). Thus, an effective method contributing to reduction of lake trout populations is to remove mature fish (i.e. their eggs) before spawning occurs (Syslo et al. 2013). A major advantage of this approach to fish population suppression is that most of the sexually mature lake trout in the assessment lakes are localized at specific spawning areas during a relatively short time frame which allows managers to focus removal efforts in time and space (Hansen et al. 2008, Cox 2010, Dux et al. 2011). Gillnetting has been the primary method utilized to accomplish removal of lake trout in these situations. However, gillnetting for spawning lake trout results in the unintended capture (bycatch) and mortality of other fish species. Because gillnetting operations result in bycatch of other fishes, managers have implemented modifications to gillnetting operations (seasonal timing, restricting length of time nets are allowed to fish, varying net mesh sizing, etc.) to reduce bycatch mortality of bull trout and other sensitive species. In spite of operational modifications, substantial bycatch mortality can be an inherent consequence of any gillnetting effort. The objective of this assessment was to determine if another fish removal method, spear fishing, could effectively remove lake trout (and lower their reproductive potential) while eliminating the unwanted bycatch of native fishes.

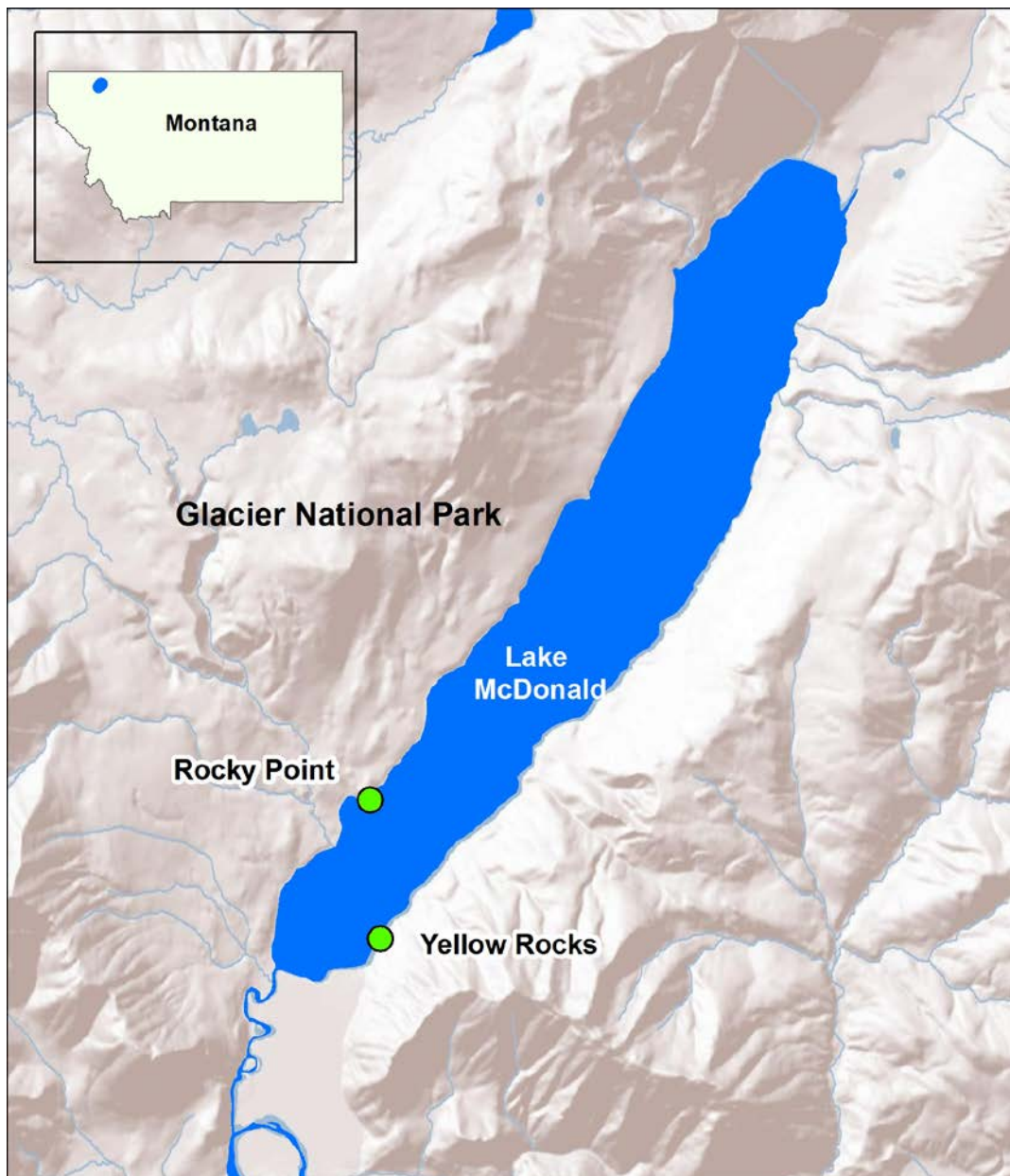
Spear fishing removal of invasive fish species is not a new concept. Scuba divers utilizing spear fishing techniques are currently being used by Atlantic coastal states, the Service, and the National Park Service (NPS) to suppress lionfish which are an invasive species causing severe impacts to rare and important sport fish associated with coral reefs (McCreedy et al. 2012). Regarding the “no bycatch” advantage of spear fishing, the Biscayne National Park “Lionfish Management Plan” (McDonough 2008) which calls for aggressive removal of the invasive lionfish using spear fishing techniques, concluded “...there is essentially no chance that native species would be collected”. The REEF organization (Reef Environmental Education Foundation) promotes spear fishing as a very selective method of removing the undesired lionfish from specific locations in Florida. Regarding the cost effectiveness of spear fishing, McCreedy et al. (2012) recommends that in addition to NPS staff, lionfish removal efforts could include: supervised volunteers, contractors, derbies, fishing clubs, dive clubs, researchers, NGO's, partner agencies, and unsupervised entities (not under park supervision or written agreements). Using the lionfish model for invasive fish suppression, local western Montana scuba professionals and spear fishing enthusiasts could potentially contribute to this “control action” providing a low cost supplemental method for reducing spawning lake trout.

METHODS

Study Site

Three lakes in Montana which have been the subject of past or current lake trout removal research were identified as potential sites to conduct the spear fishing study (Swan, McDonald, and Quartz lakes). Due to logistical concerns and other considerations Lake McDonald in Glacier National Park was selected as the most suitable location for the study (Figure 1).

Figure 1. Location of lake trout spawning areas (Rocky Point, Yellow Rocks) at Lake McDonald, Glacier National Park, MT.



Previous work (Dux 2005) had identified significant spawning locations and there were no other ongoing or competing programs of lake trout removal. Dive safety investigations were conducted at Yellow Rocks and Rocky Point spawning sites (see Figure 1, Dux et al. 2011) in Lake McDonald in 2012; boat access was required at the Rocky Point spawning site.

Scuba Diving

The study required the use of scuba diving as a research tool. Five scuba diving members of a Fish and Wildlife Service Dive Team participated in the study. These divers undergo extensive training in scuba diving techniques and safety procedures applicable to the cold waters found in Lake McDonald during the lake trout spawning season (September into November). All diving operations were performed in accordance with safe diving practices and standards of the US Fish and Wildlife Service Dive Program, Part 241 FW 10 of the Service manual. All divers met Dive Program requirements for diving and safety certifications, training, medical examinations, equipment maintenance, and status as “active divers”. Procedures of the “Dive Safety Plan for Northwestern Montana” (Cullingford 2012) were followed.

The duration of each dive (observation time and potential disturbance time to fish) was recorded by a “Sherwood Scuba Insight” dive computer which automatically recorded “bottom time” (BT) when the diver descended below 1.5 meters in water depth and terminated recording when the diver ascended to 1.0 meters in depth. Divers slowly descended (1 to 3 minutes) to planned survey depths to allow ear pressure equalization. A three minute decompression stop at 6 meters of water depth was included in each dive before divers surfaced. Thus, the amount of time divers were in close proximity (potential disturbance) to spawning lake trout was less than the total bottom time. Water depth and water temperature were instantaneously reported on the dive computer.

Study Objective and Goals

A central objective of this assessment was to determine if a supplemental method (spear fishing) of capturing lake trout was feasible. Reduction of bull trout bycatch has been the desired result of modifications already made to lake trout gillnetting suppression activities (Rosenthal 2012). Modifications to the gillnetting operations have largely reached their maximum potential for reducing bull trout bycatch and mortality while still providing for capture of spawning lake trout. As an example, gillnetting on the Swan Lake lake trout spawning grounds, mostly during October in 2010-2013, captured roughly 200-400 mature lake trout annually, but also resulted in bycatch of roughly 80-120 bull trout, of which approximately one-third were direct mortalities (Rosenthal 2012 and W. Fredenberg, personal communication). The purpose of investigating the feasibility of removing lake trout during the spawning season by scuba divers utilizing spear fishing technologies is to provide a more selective method for removing lake trout, especially female lake trout, without associated bycatch and mortality of bull trout and other desirable species.

The goals for an assessment of experimental spear-fishing of lake trout included:

1. Observe and document (photos and video) lake trout behavioral response to scuba divers (diver presence, bubble disturbance, active pursuit, etc.) and spear fishing activities (response of lake trout in the near vicinity of a speared lake trout) during daylight and hours of darkness time periods.
2. During night diving, observe and document lake trout response (attraction, “flight/freeze” reactions, etc.) to artificial lights (stationary and mobile).
3. Determine effectiveness of pole spears (and various terminal points) for collecting lake trout, especially gravid female lake trout.
4. Develop an efficient fish collection and short-term underwater storage technique for lake trout taken by spearing.

Data Collection

Prior to the study period (data collection and spearing, Hall 2013), a biologist experienced in fish identification trained all divers by the comparative use of pictures and specimens of lake trout and bull trout. Also prior to the study period, at the Yellow Rocks dive entry and exit point, divers placed white colored depth markers at 10 foot depth intervals from 10 feet to 60 feet of depth. These markers were used as the starting point for depth contour searches through the spawning area, and as end point and exit markers for divers during night dives. Typically, two to three person dive teams entered the water at spawning sites during daylight hours to assess goals 1, 3, and 4. Following the dive during daylight hours, a night dive was conducted to assess goals 1, 2, 3, and 4. At the Lake McDonald “Rocky Point” spawning site (a secondary priority site), scuba divers and equipment were transported to the dive site by boat. Field notes recorded immediately following each dive documented routine dive statistics (water depths, air supply used, water temperature, bottom times, etc.) and observations pertaining to each goal. All lake trout collected were brought to the surface, measured and spawning condition determined before carcasses were returned to the lake.

Observations to assess Goal 1 were based on divers searching for and/or observing lake trout when confronted by or speared by scuba divers. Goal 2 was assessed during night dives by placing a fixed light with its beam aimed parallel to the substrate contour (or other configurations such as shining the light toward the water surface) at variable depths (for example 20’, 30’, 40’ and 50’); divers remained for a time (5 – 10 minutes) in stationary positions within good visibility range of the light (for observation and spearing purposes). If no lake trout were attracted to the light after a time interval, then divers used mobile handheld lights to search the spawning area along a set contour depth for a distance of about 50 m in either direction, then return to the stationary light for a further observation period. Following the swimming search and return to the stationary light, and following another observation period at the stationary light, divers made another swimming search along the contour depth in the opposite direction as the first search, and then returned to the stationary light for another observation period before surfacing. This typical protocol was dependent upon air supply, lake trout spearing events, and other factors. Goal 3 was assessed by

documenting all attempted spearing events which necessarily occurred on an opportunistic basis during all dives. Type of spear and terminal point (pole spear with single or multiple points) was noted in the dive report as well as the result of the spearing event (for example: hit/escape, hit/capture, miss, etc.). All lake trout observed during the dive by all divers were counted and reported. Goal 4 was assessed by documenting the fish storage method used (fixed or mobile stringer, other method). Following return to the surface with the fish storage device, all fish were placed in a cooler for later data collection (length, sex, etc.).

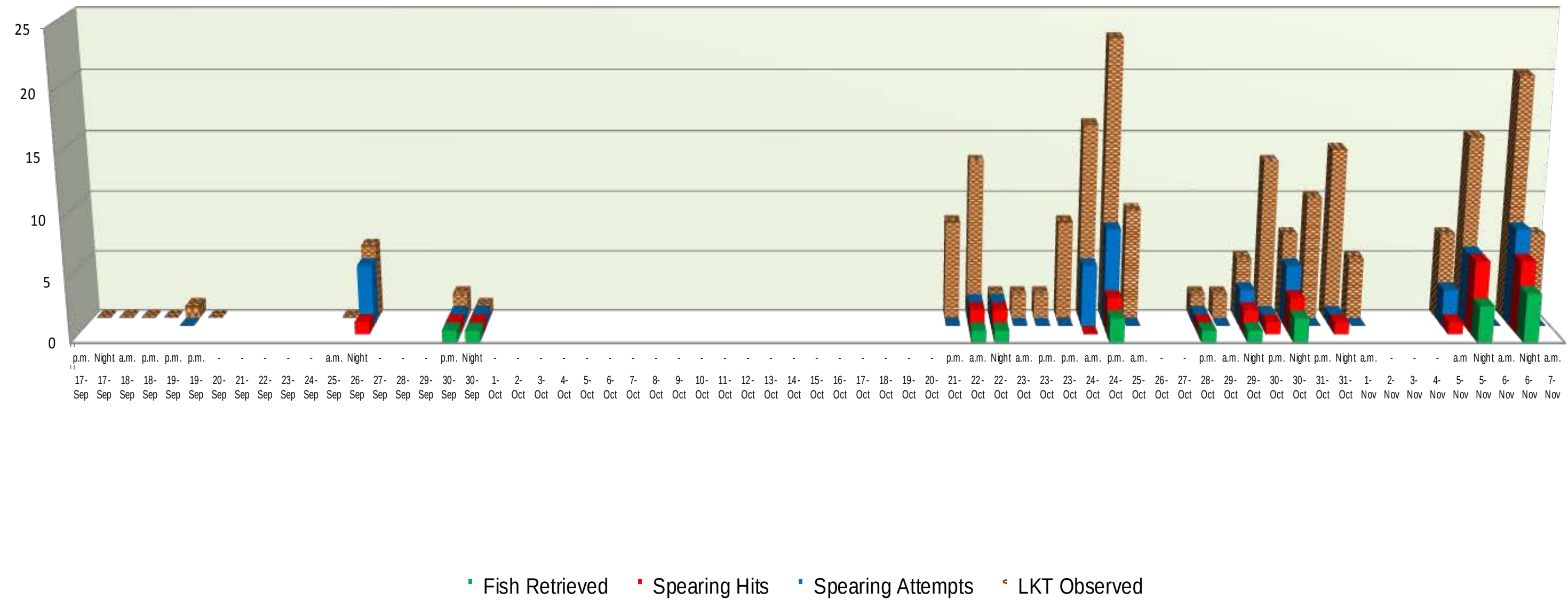
Timeframe

Prior to initiation of the study period, a number of dives (n = 26) were conducted on July 23, August 14 and 15 and September 4 in order: to familiarize divers with the study sites, and camera, underwater lighting and spearing equipment; to assess underwater safety hazards; to practice spearing techniques; and to place depth contour markers at the Yellow Rocks dive site. The range of dates that spear fishing activities (study period) were permitted by the National Park Service to occur in Lake McDonald was September 16 to November 8, 2013, encompassing an eight week time period (Hall 2013). During the study period, diving was scheduled on Lake McDonald on a weekly basis, however, the government shutdown in 2013 (October 1 – October 17) resulted in the loss of weeks 3-4-5 diving observations.

RESULTS

During the study period (between September 17 and November 7, 2013), a total of 32 dive events were conducted at two known lake trout spawning sites (Yellow Rocks, 28 dive events; Rocky Point, 4 dive events) in Lake McDonald (Figure 2). Each dive event was conducted by either two individual divers (n = 18) or three individual divers (n = 14) for a total of 78 individual dives during the study period (an additional 26 individual dives were conducted in preparation for the study period). Total dive time (Bottom Time) during the study period ranged from 18 to 52 minutes per dive and averaged 35.6 minutes per dive. Through the study period, water temperatures at depths greater than 20 feet ranged from 42° F to 62° F; during the October 21 to November 7 time period water temperatures ranged from 42° F to 49° F. Spearing attempts were made at depths ranging from 5 to 70 feet with most (44 of 52 attempts, 85%) attempts made in the 30 to 70 feet depth range.

Figure 2. Summary of evaluation observations; date, time of day (morning, afternoon or night), number of lake trout observed, number of spearing attempts, number of spearing hits, and umber of fish retrieved.



Concentrations of lake trout and lake trout exhibiting spawning behavior were first observed at Yellow Rocks spawning site on September 26 and were consistently present from then on through the last dive on November 7 (see Figure 2). Over 200 lake trout were observed during the 32 dive events on 19 different days. Of the 32 dive events, 11 were conducted in the a.m. (on or before 13:00 hours), 12 were conducted in the p.m. (from 13:00 hours to sunset), and 9 were conducted at night (after sunset) Table 1.

Table 1. Scuba diving event time periods (when lake trout were observed during the study period) with numbers of lake trout observed, number of spearing attempts, and number of spearing hits in total and per dive event.

Dive events (n) by time period	No. Lake Trout Observed (per dive)	No. Spearing Attempts (per dive)	No. Spearing Hits (per dive)
a.m. (n = 11)	62 (5.6 per dive)	10 (0.9 per dive)	3 (0.3 per dive)
p.m. (n = 12)	69 (5.8 per dive)	11 (0.9 per dive)	6 (0.5 per dive)
Night (n = 9)	70+ (7.8 per dive)	31 (3.4 per dive)	21 (2.3 per dive)

Divers attempted to spear lake trout a total of 52 times when fish were within two meters of the divers. Of the 52 attempted spearing events, 30 hits and 22 misses were recorded (Figure 3). Of the 30 spearing hits on a target fish, 17 lake trout were retrieved and removed from the lake for data collection while 13 fish escaped (one fish escaped but was later found dead, it was counted as retrieved). The number of lake trout observed was approximately the same for morning, afternoon and night dives, however, the number of spearing attempts and number of spearing hits was higher during night dives (see Table 1). Spearing accuracy (spearing hits/spearing attempts, see Figure 2) and retrieval efficiency (number of fish captured after being hit with a spear) was noted to increase through the study period.

DISCUSSION

Attainment of Goals

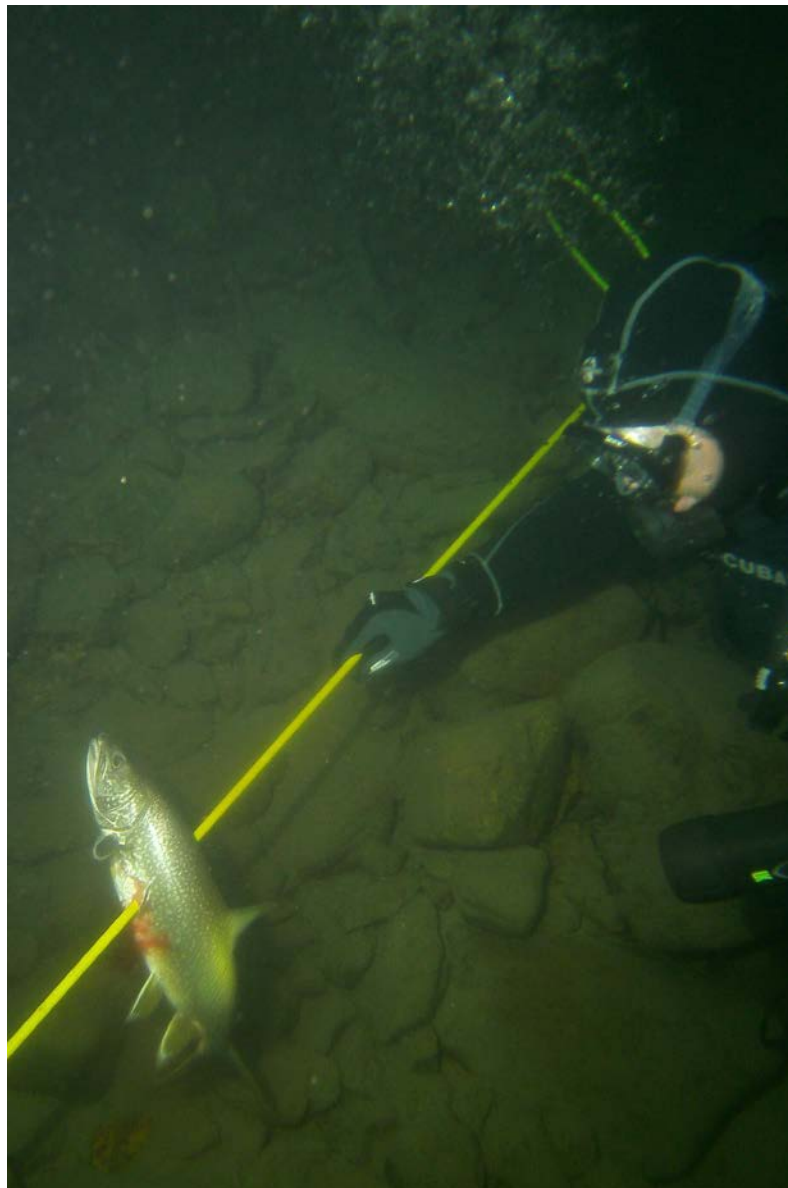
The first goal of the study was to document lake trout behavior in response to scuba divers (diver presence, bubble disturbance, active pursuit, etc.) and spear fishing activities (response of lake trout in the near vicinity of a speared lake trout) during daylight and hours of darkness time periods. Only one lake trout was observed through the first seven dive events between September 17 and September 25 and that fish did not exhibit spawning behavior and left the area after it observed the divers. On September 26 and 30 lake trout exhibiting spawning behavior were first observed. Then, after the 3-week hiatus, such behavior was consistently observed between October 21 and the last dive on November 7.

Gender specific behavior included male lake trout swimming more actively and interacting with other males, while females seemed to posture by swimming slowly and exposing their broadside to divers and other fish (something we termed “display” behavior). Most lake trout we observed did not flee from divers, bubble disturbance, or active pursuit, nor did they

respond (either attracted or fleeing) from the near vicinity of a recently speared lake trout. Spawning and “display” behaviors were more pronounced during hours of darkness.

The second goal of the study was to observe and document lake trout response (attraction, “flight/freeze” reactions, etc.) to artificial lights (stationary and mobile). Night time observations made near stationary lights left at various depths (20’ to 50’) for the duration of a dive did not indicate that lake trout were attracted to lights. Likewise, mobile lights carried by the divers did not appear to either attract or repel lake trout. On several occasions focused high power dive lights seemed to “freeze” a fish or distract it while divers approached to within spearing range (similar to the spotlight effect on deer).

Figure 3. Photo of scuba diver spearing a lake trout at the Yellow Rocks spawning site in Lake McDonald, Glacier National Park.



Observations among the three time frames when dive events occurred indicated that night time dive events had more spearing attempts and more spearing “hits” than either the morning (a.m.) or afternoon (p.m.) dive events (see Table 1).

The third goal of the study was to determine the effectiveness of pole spears for collecting lake trout. Pole spears with a three prong “paralyzer tip” did not have adequate barbs to hold a struggling fish after it had been speared (speared fish struggled free and escaped). Pole spears equipped with a single tip (JBL “Rotating Tricut Long Wing”, 6 mm) were more effective at penetrating and holding lake trout after spearing (Figure 4). The effective range of the 6’ spear pole was limited. Lake trout within a range of 1-2 meters could be hit by the spear, but many escaped because the spear did not penetrate past the barbs. Lake trout inside one meter were much more effectively speared and held.

Figure 4. Photo of lake trout speared by a pole spear with a JBL “Rotating Tricut Long Wing” tip.



The fourth goal of the study was to develop an efficient fish collection and short-term underwater storage technique for lake trout taken by spearing. A metal fish stringer with large “safety snaps” attached to a diver proved efficient for transporting speared lake trout; it was best to rapidly dispatch captured lake trout immediately by piercing the heart with a knife for humanitarian reasons and to limit entanglement with other fish on the stringer or with diver equipment (Figure 5).

Figure 5. Photo of metal stringer with lake trout attached, stringer is attached to the scuba diver.



Lake Trout Sex Ratio

The interrupted data collection period and the limited sample size of speared and retrieved lake trout ($n = 17$) precluded any meaningful statistical comparisons. Anecdotally, divers with fisheries experience could easily identify and differentiate male and female lake trout during daylight or night dives (lake trout were reflective in dive lights at night and were visible at the limits of water visibility, usually 20' – 30'). Of the 17 lake trout retrieved, 13 were males and 4 were females (this likely reflects relative abundance of the genders, as spearing attempts were made on most fish in spearing range). Prior to the diving shutdown, October 1 through October 20, two lake trout were speared and retrieved and both were gravid females; females may have been more vulnerable to spearing during the early pre-spawning season which likely extended for several more weeks when no diving was conducted.

Bycatch Observations

Though no inadvertent spearing of nontarget species occurred, we did collect observational information. Based on our observations, it is considered highly unlikely that nonsalmonids (e.g., suckers, northern pikeminnow) would be accidentally speared by trained observers, even though they were approachable, especially by divers using lights during night dives. Both lake and mountain whitefish and other salmonids were commonly observed foraging lake trout eggs or swimming among or in the vicinity of spawning lake trout. Because of the smaller size of other salmonids (westslope cutthroat trout and kokanee) and the distinctive body shapes of the whitefish species, it is unlikely these fish would be mistaken for mature lake trout and accidentally speared.

Of greatest concern are Threatened bull trout, which have a similar body profile and are known to occupy the same habitat as spawning lake trout in Swan Lake and many of the others where spearing could potentially be employed. We did not observe any bull trout in Lake McDonald, where their presence is considered rare. However, we anticipate bull trout would behave similarly to nonspawning lake trout and even if attempts were made to spear them (considered unlikely by trained observers) they would be unlikely to present a close broadside silhouette to allow spear fishing contact.

Response to Disturbance

It had been speculated that diver presence or possibly even other disturbance such as gillnetting on a spawning area may cause lake trout to abandon that particular spawning site. Although some individuals may have exhibited this behavior, in general, lake trout did not move away from the diver disturbed spawning areas for long periods of time. During a typical dive, divers would observe lake trout and after spearing attempts or pursuit, the fish would move out of observation range. Three following examples illustrate how diver disturbances did not appear to affect lake trout abundance on anything more than a short-term basis at the Yellow Rocks spawning area. On October 24, divers observed 16 lake trout during a dive that began at 11:09 a.m. and lasted 38 minutes; a little more than two hours later (2 hours, 17 minutes) divers conducted another dive at the same location and observed 23 lake trout. On October 31, divers observed 10 lake trout during a dive that began at 1:45 p.m. and lasted 30 minutes; about 2 ½ hours later divers conducted a second dive (night dive) at the same location and observed 14 lake trout. On November 5, a night dive was conducted after sunset and 15+ lake trout were observed (6 were speared) during the 25 minute dive; on the next day (November 6) another night dive at the same location was conducted and 20+ lake trout were observed (8 were speared). In conclusion, it appears lake trout maintain some fidelity to spawning site locations and only move away from disturbances for short periods of time before returning.

Spawning and Spearing depths

Dux et al. (2011) reported lake trout spawning aggregations at two sites on Lake McDonald, “Yellow Rocks” on the east shore and “Rocky Point” on the west shore. After review of lake trout scientific literature, he concluded that lake trout most commonly spawn at water depths of less than 12 m, but he observed that mean depth of spawning lake trout in Lake McDonald

was somewhat deeper at 18 m. As stated earlier, most spearing attempts in Lake McDonald occurred at depths between 30 and 70 feet (10-23 m). This confirms Dux' observations of lake trout spawning depths of 18 m at the Yellow Rocks spawning site.

Cost Effectiveness and Bycatch Reduction

Syslo et al. (2013), utilizing data from the experimental gillnetting lake trout removal program at Swan Lake, developed a density-dependent lake trout population model to assess the cost effectiveness of 41 management scenarios. They concluded that management scenarios including harvest of spawning adults resulted in the greatest decline in lake trout abundance after 10 years. They also concluded that some less intensive management options (still including harvest of spawning adults) could achieve biological results similar to the most intensive and expensive scenario (gillnetting subadults and spawning adults annually) over time. Managers have several options for the long-term suppression of lake trout in Swan Lake depending on goals and funding.

In the face of limited resources, McCreedy et al. (2012) suggested that National Park Service (NPS) managers consider using the public and other cooperators to achieve the most cost effective spear fishing removal program for invasive lionfish in Florida. They concluded that NPS should pursue partnerships to accomplish lionfish control with volunteers and other sources. Based on our current findings from Lake McDonald, it appears that recreational scuba divers could accomplish spawning lake trout removal from well defined spawning areas on lakes in the range of bull trout.

Conclusions

Preliminary conclusions reached were: 1) female lake trout size and behavior may make them more vulnerable than males to spearing, 2) spawning lake trout were neither attracted to artificial light nor did they actively avoid lights or diver disturbances, 3) at night, lake trout were most susceptible to spearing due in part to the spotlighting "deer in the headlights" effect, 4) seasonal spear fishing by agency or supervised recreational scuba divers may be a viable management option for suppression of spawning lake trout in delineated spawning areas (< 100' in depth) (Figure 6 and 5). With basic training, bycatch concerns may be minimal. Implementation of a supervised recreational spear fishery by the public or an agency spear fishing effort could be quite cost effective and contribute substantially to the goal of lake trout suppression by selective removal of spawners. Such a program would very likely greatly reduce bycatch of desirable fish species when compared to current gillnetting techniques.

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Figure 6. Photo of speared lake trout and scuba diver.



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