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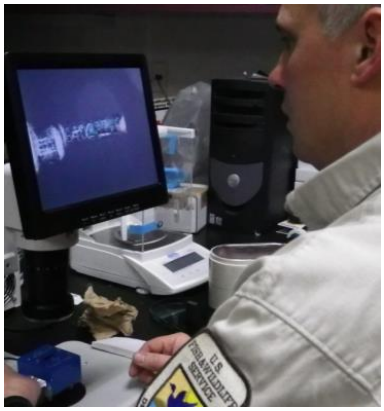

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Green Bay Fish and Wildlife Conservation Office
2661 Scott Tower Drive
New Franken, Wisconsin 54229
Phone: 920-866-1717; FAX 920-866-1761

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Results are from fish tagged and recovered through the cooperative Great Lakes Mass Marking Program

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Contribution of Lake Trout stocked at offshore and nearshore locations to the sport fishery in Lake Michigan

Matthew S. Kornis, Allen A. Lane, Kevin W. Pankow,

James L. Webster, and Charles R. Bronte

Introduction

Rehabilitation of Lake Trout (*Salvelinus namaycush*) in Lake Michigan has been a priority of federal, state, and tribal agencies since the species' collapse in the mid 1950's, with an ultimate objective of redeveloping self-sustaining populations to support recreational and commercial fisheries (Bronte et al. 2008). To achieve this objective, agencies have prioritized stocking Lake Trout at historically important offshore spawning reefs and designating such areas as fishery refuges to protect Lake Trout from exploitation (LMLTTC 1985; Holey et al. 1995; Bronte et al. 2008; Dexter et al. 2011). There is concern among stakeholders that Lake Trout stocked at offshore locations contribute to consumption of limited forage in Lake Michigan but have limited benefit to the recreational fishery, which largely occurs in nearshore waters.

All Lake Trout stocked into Lake Michigan from the 2010 year class through present have received a coded-wire tag (CWT) through the Great Lakes Mass Marking Program (Bronte et al. 2012). We can therefore determine the contribution of Lake Trout stocked at offshore and nearshore locations to the recreational fishery by examining return rates of Lake Trout from these year classes. Our objectives were to 1) determine the percentage of stocked Lake Trout originating from offshore and nearshore locations captured by open-water anglers, and 2) determine the return rate (catch corrected for number of fish stocked) of Lake Trout from these locations to assess return on investment and relative survival.

Methods

To examine how much offshore-stocked Lake Trout contributed to angler catch, we examined Lake Trout recoveries from open-water anglers (biotech, creel, and angler return sources) in the mass marking database. We focused on the recoveries of stocked Lake Trout from the 2010 – 2012 year classes because stocking location is known for all fish from these year classes from CWTs. Recoveries (n = 3,221) from 2012 – 2016 were analyzed, although 95% of samples were from 2015 (n = 1,075) and 2016 (n = 1,972). Lake Trout from earlier year classes often did not have CWTs enabling the identification of stocking location, while Lake Trout from later year classes (2013 – present) are still too young to be observed in the fishery in meaningful numbers (n = 24 fish recovered from the 2013 year class and later).

We compared recoveries from three offshore stocking locations (Northern Refuge, Southern Refuge, and Julian's Reef) to recoveries from three groups of nearshore stocking locations (fish stocked in Wisconsin waters, fish stocked in Michigan waters, and fish stocked in Indiana, MM7

and MM8; Table 1). Most CWT tag lots stocked in Indiana waters were also stocked at southern Michigan ports (e.g., Grand Haven, New Buffalo, South Haven), necessitating a multi-jurisdictional group.

Table 1: Stocking location groupings, with included sites and number of recoverable tags. Only sites and recoverable tags from the 2010 – 2012 year classes are included. The number of recoverable tags was calculated as the number of fish stocked multiplied by the tag retention percentage reported in the Great Lakes Fish Stocking Database (USFWS and GLFC 2016). The average tag retention value was used for tag lots where tag retention was not reported.

Stocking location	Included sites	Number of recoverable tags
Offshore stocking locations		
Northern Refuge	Boulder Reef, Gull Island Shoal, High Island Reef, Hog Island Reef, Middle Ground, Trout Island	1,856,454
Southern Refuge	Milwaukee Reef, Northeast Reef, Sheboygan Reef	1,685,232
Julian's Reef	Julian's Reef	360,038
Nearshore stocking locations		
Michigan waters	Big Reef, Dahlia Shoal, Elk Rapids, GTB Shoal, Old Mission, Torch Lake, Good Harbor, Point Betsie, Ile Aux Galets, Irishmen's Ground, Ludington, Manistee, Grand Haven, New Buffalo, Lake Macatawa	3,288,271
Wisconsin waters	Sturgeon Bay, Kewaunee, Wind Point, Manitowoc	689,153
Indiana waters plus MM7 and MM8	Michigan City, Grand Haven, South Haven, New Buffalo	631,417

We then summarized:

1) the percent of catch from each of the three offshore origin locations and from all nearshore locations, both lake-wide and within each jurisdiction, uncorrected for number of fish stocked to represent expected contribution to angler creels. This answers the question "Where were Lake Trout caught by anglers stocked?"

2) the return rate (catch per 100,000 fish stocked), both lake wide and from each jurisdiction, from each of the six locations to help inform the potential effects of shifts in stocking numbers/allocations on angler catch. Return rate from each of the three nearshore locations are provided only for the corresponding state waters in which recoveries occurred, because few nearshore-stocked Lake Trout were recovered outside of the state waters in which they were stocked. This procedure provides an accurate picture of the performance of nearshore stocked fish, because the alternative of including fish stocked on the opposite shoreline would add to the denominator (number of fish stocked) and not the numerator (number of fish recovered) in a given state's waters. This answers the question "What was the performance/return on investment of Lake Trout stocked at different locations?"

"Catch per 100,000 fish stocked" is defined as the catch per 100,000 recoverable tags throughout this report. The number of recoverable tags was calculated as the number of fish stocked multiplied by the tag retention percentage reported in the Great Lakes Fish Stocking Database (USFWS and GLFC 2016). The average tag retention value was used for tag lots where tag retention was not reported.

Limitations

The main limitation of this analysis is that fish from the 2010 – 2012 year classes and later were young at recovery (Age 6 at most) and still have many more years of vulnerability to the fishery. However, the patterns shown below are backed from a large enough sample size (3,221 angler-caught fish) to be meaningful and informative. Future analyses will incorporate older fish from these year classes, as well as fish from other year classes as they enter the fishery.

Results

Where were Lake Trout caught by anglers stocked?

Of the catch of stocked Lake Trout lake wide, 62% originated from offshore stocking locations (Table 2). Anglers in Wisconsin, Illinois and Indiana waters predominantly caught offshore-stocked Lake Trout (70-96%; Table 2). There was a greater contribution of nearshore stocked Lake Trout in Michigan waters (52%; Table 2). Note that percent of catch values do not include any wild fish or any fish stocked prior to the 2010 year class.

Of the offshore stocking locations, fish stocked in the Southern Refuge had the most consistent contribution to state anglers' catch (33 – 46%; Fig. 1). Julian's Reef contributed substantially to Illinois (53%), Indiana (29%) and Wisconsin (18%) waters, but not to Michigan waters (5%) (Fig.1). Northern refuge fish contributed $\leq$10% to catch in all state waters except Wisconsin (24%) (Fig.1).

Nearshore stocking events that occurred in the state of Michigan contributed the most to catch in that state's waters (51%; Fig. 1). Returns of nearshore-stocked fish were slightly greater from

in-state than out-of-state stocking events for recoveries in Wisconsin and Indiana waters (Fig. 1). Illinois did not have nearshore stocking events from the 2010-2012 year classes, and thus did not return nearshore fish from in-state stocking.

Table 2: Percent of total catch of Lake Trout stocked at offshore and nearshore locations. Percentages are based on raw catch values (i.e., not corrected for number of fish stocked) and represent the contribution of Lake Trout by source to angler creels (n = sample size). Recoveries were from 2012-2016, but primarily from 2015 and 2016. Percentages were consistent between 2015 and 2016 when those years were analyzed separately.

Spatial Area	% Offshore	% Nearshore	n
Lake Michigan	62%	38%	3,221
Wisconsin Waters	87%	13%	441
Illinois Waters	96%	4%	116
Indiana Waters	70%	30%	981
Michigan Waters	48%	52%	1,683

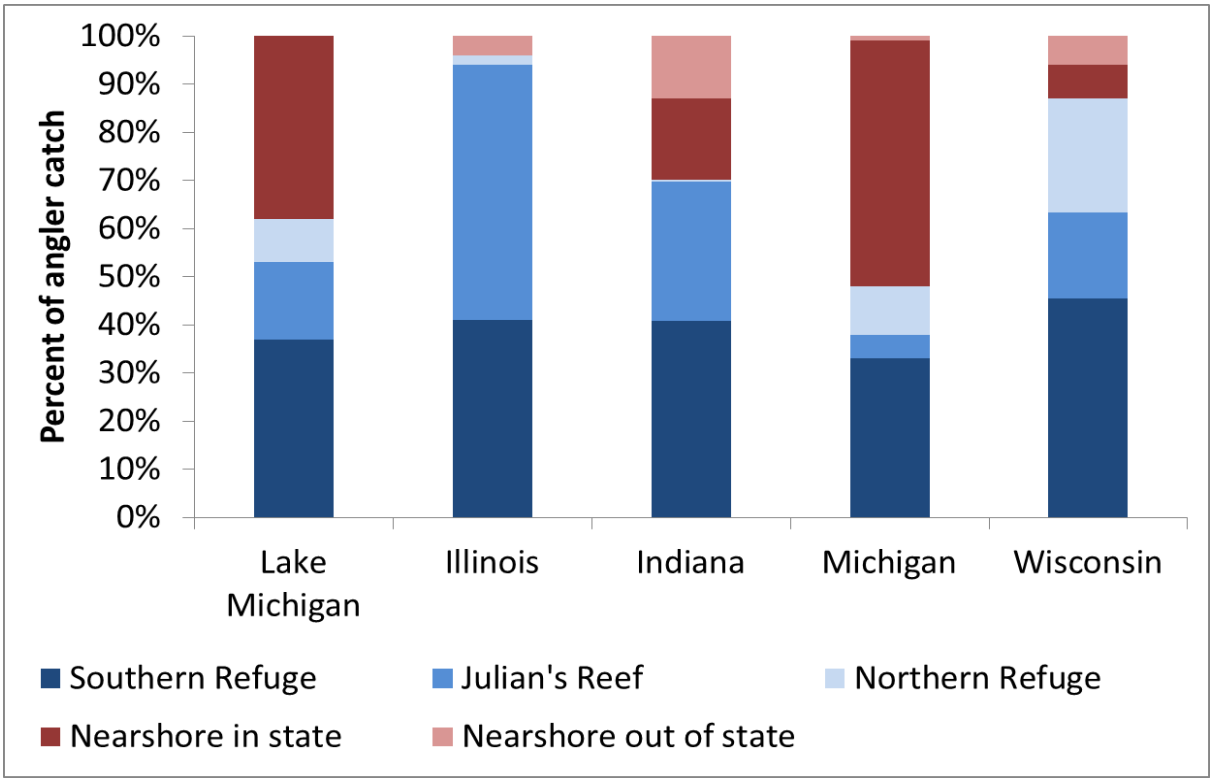

Figure 1: Percent of total catch of Lake Trout stocked at offshore (blue) and nearshore (locations), broken up by origin. Percentages are based on raw catch values (i.e., not corrected for number of fish stocked) and represent the contribution of lake trout by source to angler creels. "Nearshore in state" percentages assumed that all fish recovered in a state's waters from a multi-state CWT were stocked in the state of recovery. Illinois had no in-state nearshore stocking.

How did the return rates of Lake Trout stocked at offshore locations compare with nearshore locations?

Return rates of offshore-stocked fish were double those of nearshore-stocked fish lakewide (50.9 vs. 23.9). For state-specific waters, return rates of nearshore-stocked fish from outside state waters were much lower than those from fish stocked within state waters. This may be because Lake Trout in Lake Michigan generally do not move more than 120 km from their stocking locations (Smith and Van Oosten 1939; Rybicki and Keller 1978; Rybicki 1990; Schmalz et al. 2002; Bronte et al. 2007; FWS unpublished data).

Therefore, we compared return rates of in-state stocked nearshore fish to return rates from each of the three offshore stocking locations to give a comparison return on investment (Table 3, Fig. 2). An offshore stocking location had the highest return rate in the waters of each state: Julian's reef in Indiana, Illinois and Wisconsin waters and Southern Refuge in Michigan waters (Table 3, Fig. 2). Lake Trout stocked nearshore in Michigan and Indiana had relatively high return rates, while Lake Trout stocked nearshore in Wisconsin had the lowest return rates of each origin within Wisconsin waters (Table 3, Fig. 2).

Table 3: Return rates (catch per 100,000 fish stocked) of Lake Trout from the three offshore stocking locations and from fish stocked nearshore in each state's waters.

Spatial Area	Julian's Reef	Southern Refuge	Northern Refuge	Nearshore (in-state stocking only)
Lake Michigan	141.9	70.8	15.2	23.9[1]
Wisconsin Waters	21.4	11.9	5.7	4.5
Illinois Waters	16.9	2.8	0.1	n/a
Indiana Waters	79.2	23.6	0.2	45.6[2]
Michigan Waters	24.4	32.4	9.2	19.0

[1] value from all of Lake Michigan (all states combined).

[2]Includes recoveries of tag lots stocked in IND, MM7 and MM8 due to multiple tag lots co-stocked in those districts.

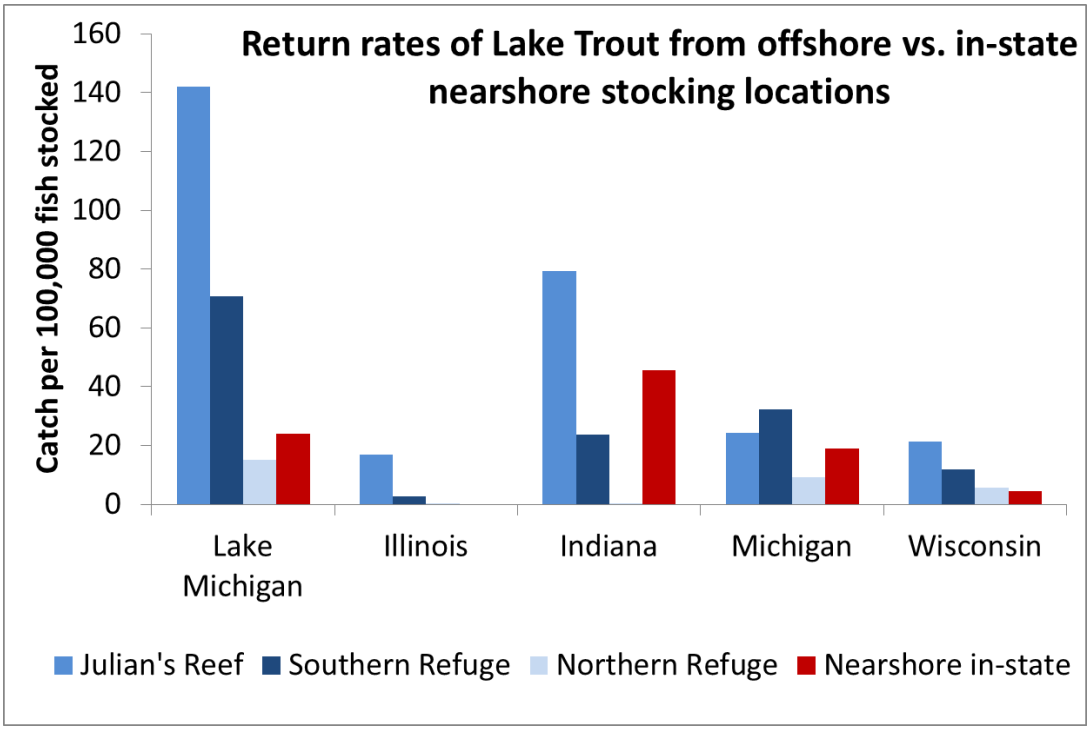

Figure 2: Return rates (catch per 100,000 fish stocked) of lake trout from three offshore stocking locations (blue) compared to return rates of fish stocked nearshore in each state's waters (red). Return rates of nearshore stocked fish from outside state waters were much lower, consistent with multiple studies that have shown lake trout generally do not move more than 120 km from their stocking location (e.g., Bronte et al. 2007). Evaluating return rates of in-state stocked nearshore fish only therefore gives a better sense of the return on investment of nearshore-stocked fish.

Summary

Offshore stocking locations produced the majority of stocked Lake Trout that returned to angler creels, and these findings therefore dispel the perception that Lake Trout must be stocked nearshore to benefit anglers. Although our analysis was based on relatively recent year classes, the percentage data strongly indicate that offshore-stocked Lake Trout contribute substantially more to angler creels than nearshore-stocked Lake Trout. Moreover, return rates (catch corrected for numbers stocked) indicate that the high level of contributions from offshore-stocked Lake Trout is not simply due to high stocking numbers offshore, as the return rate from offshore sources was double the average return rate from nearshore sources lake wide. Although there was some variation in the strength of returns from nearshore-stocked fish, an offshore location had the greatest return rate in the waters of each state.

These findings are consistent with an ongoing study of legacy CWTs returned to fishery-independent surveys (LWAP and FIWS; Kornis et al. *in prep*). That study showed that about

50% of recoveries of offshore-stocked fish occurred in nearshore areas accessible to anglers. The legacy CWT study also suggested that nearshore recoveries of offshore-stocked fish increased until about Age 13; therefore the strong return rates of offshore-stocked fish noted by this report, which reflect fish captured at Age 6 or less, could actually increase over coming years as older CWT Lake Trout enter the fishery.

Higher survival of offshore-stocked Lake Trout seems to be the most plausible explanation for the pattern in return rates. It makes ecological sense that fish stocked in offshore locations, which provide excellent habitat and are shielded from exploitation, would have high survival. It would appear that any survival advantage enjoyed by offshore-stocked fish is more sizeable than the distance barrier that must be overcome for offshore-stocked fish to move inshore and become accessible to the recreational fishery.

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