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Experimental Manipulation of Habitat Capacity in Inland Lakes

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The *Fisheries Act* protects fish habitat from any work or undertaking resulting in its harmful alteration, disruption, or destruction (HADD) through a policy of No Net Loss of the productive capacity of fish habitat. To achieve the goal of this policy when a HADD is authorized, habitat enhancement or creation must be used to compensate the loss of habitat productive capacity. Woody material (e.g. brush bundles, root wads, tree drops) and other fish habitat structures (e.g. reefs, wetlands) have been placed in lakes and streams, often with the explicit goal of increasing fish production, or to compensate for a HADD. However, the success of habitat enhancements is rarely assessed from a biological perspective (i.e. by measuring changes in fish biomass or production resulting from designed changes in habitat). One assumption underlying these compensation decisions is that habitat availability and quality are directly related to fish production. To test this assumption, a whole-lake habitat manipulation (wood removal and habitat additions) experiment was conducted to determine the effect of nearshore habitat perturbation or enhancement on the fish communities in a suite of small aquatic systems.

In three experimental lakes « 25 ha each) in the Algoma region of Ontario, we decreased nearshore habitat diversity (2 in 1999, 1 in 2000), and referenced the changes in biological metrics to an unperturbed system and to pre-manipulation conditions in each experimental system. Habitat manipulations mimicked the effects of human encroachment into aquatic habitat (e.g. cottage development) by reducing the complexity of physical habitat available to fish in the nearshore areas. At a workshop attended by managers and scientists, it was determined that a 50% alteration of the shoreline within a lake would be considered a HADD. Consequently, coarse woody debris was removed from 50% of the nearshore area (50% of total shoreline distance, to a depth of2 m or 10 m from shore) in the three systems. Additionally, in one of the lakes a portion of the same nearshore bottom substrate was covered with a water/gas permeable geotextile cover (1999). In three other experimental systems (2 gravel pit ponds and 1 quarry pond - considered to have sparse natural habitat variability) in Southern Ontario, we increased habitat diversity (2 in 2000, 1 in 2001) and referenced changes to an unperturbed system and to pre-manipulation conditions in each experimental system. Habitat enhancements were designed to represent typical Habitat Management compensation for a HADD, and included re-grading littoral slope and planting wetland vegetation, creating a rock-rubble reef, and adding tree-brush bundles.

While fish response was the main indicator of interest, an ecosystem approach was adopted to help clarify the mechanism(s) behind any observed change in fish parameters. Consequently, water chemistry, phytoplankton chlorophyll a, zooplankton, invertebrates on wood, and chlorophyll a in periphyton on wood, as well as fish catch-per-unit-effort, mark-recapture abundance, biomass, production, and habitat-specific distribution were monitored. A modified BACI ANOVA design was used in the analysis whereby each system in each year was assigned to a category of either 'Before or After' (time) and 'Control or Impact' (treatment) with the resulting 'treatment x time' interaction as the statistic of interest. A significant interaction would indicate that the experimental systems responded differently over time than unperturbed control systems and that our habitat manipulations affected the Impact systems. Due to an unrelated fish kill in our "habitat addition" control system, we used the lake control systems as our control in the BACI.ANOVA. As this analysis provided a coarse measure of impact, we also conducted analyses that might allow detection of more subtle effects within an impact system.

By the 6th year of our experiment, any changes that were appearing to emerge in earlier analyses disappeared, and all parameters tested under the BACI design were not significant. At no time in our analyses over the years did we detect an effect on water chemistry, chlorophyll a, or invertebrates on wood. Earlier analyses indicated that fish community shifts were occurring in the wood removal lakes, whereby catch of smaller fish decreased, and catch of larger fish increased, supporting the hypotheses that habitat complexity serves as cover from predation. This effect is no longer significant. In addition. it appeared that some minnow species known to be more sensitive to perturbation (e.g. *Notropis* sp.) disappeared from our lakes, but in 2003 one of the species was again captured in our impact lakes. In the habitat addition systems, it appeared that the wetland creation was having a significant and positive effect on the fish community (biomass and production), but in 2003 total biomass decreased to below pre-manipulation conditions. While it now appears that the rock-rubble reef addition is having a positive influence on fish catch and biomass, this effect is currently not significant relative to controls. At no time did we detect a change in total fish biomass resulting from habitat manipulations; supporting the theory that total fish community biomass is one of the more stable parameters in aquatic systems.

These results do not provide support for the assumption that habitat supply is directly related to productive capacity, nor do they support the perception that a 50% habitat perturbation constitutes a HADD. Our design was not conducive to detecting a functional relationship between habitat alteration and fish response. Our results also do not provide insight into what type of physical habitat creation is more effective than another in enhancing productive capacity. The level of effort required to obtain a reliable abundance estimate from mark-recapture is large even in our relatively small and manageable systems. The resulting one-number-per-system-per-year also reduces the power to detect an effect from such a measure. Fish catch per unit effort in most cases was a reasonable surrogate for abundance, so the recommendation is that a standardized netting program used in conjunction with measures of biomass would be adequate for monitoring purposes. The transient and ephemeral results provide support for the need of long-term monitoring to avoid adopting erroneous conclusions. In fact, the results presented here could change with additional years of data since we included a maximum of only four years post-treatment monitoring to date. If financing long-term monitoring is an issue, we recommend conducting a focused, standardized effort in alternate years to extend the timeframe of monitoring at a similar overall cost.