Modeling the Influence of Lake Circulation Patterns, Upwelling Events, and Turbulence on Fish Recruitment Variability in Lake Michigan

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Overview

The transport, growth and settlement of larval yellow perch and alewife in Lake Michigan is studied with a 3D particle trajectory model coupled with an individual-based bioenergetics model. The physical model uses 3D currents generated by the Great Lakes version of the Princeton Ocean Model driven by observed momentum and heat fluxes in June-August 1998-2003. The model was tested with drifting buoys observations in southern Lake Michigan. Virtual larvae of yellow perch were released in the nearshore region north of Chicago, IL with the most abundant preferred substrate for yellow perch spawning, rocks. In case of alewife, larvae were released in the vicinity of Twin Rivers, WI where high concentration of alewife larvae was observed.

We investigated the potential for physical transport mechanisms to affect recruitment of Lake Michigan fishes by coupling hydrodynamic models with individual-based particle models of fish larvae to study variation in larval distributions, growth rates, and potential recruitment. Larval growth rates were simulated using a bioenergetics growth model with fixed consumption rates. Growth rates and time to settlement were predicted assuming two different food availability scenarios: maximum consumption and reduced consumption. Results indicate that lake circulation patterns are critical for understanding interannual variability in Great Lakes fish recruitment.

It appears that the hydrodynamic conditions may produce a “source and sink” recruitment dynamic for yellow perch. The rocky habitat, preferred for spawning and presumably for feeding is primarily on the western side of Lake Michigan, and is perhaps most extensive in Illinois. The present modeling effort suggests that larvae originating from this preferred habitat would be mostly transported to the sandier and generally unconsolidated substrate along the eastern side of Lake Michigan (Figure 1). Much of the habitat along eastern Lake Michigan is now depauperate of potential forage for newly settled juvenile perch which may impact survival in later life stages. Therefore, it becomes critical if circulation patterns transport larvae north along the east coast in a cyclonic circulation pattern, or transport them back to Illinois waters in an anticyclonic circulation pattern observed in some years. In case of larval alewife transport, circulation patterns are equally important. For example, for a Twin Rivers patch, we predict two distinct larval transport scenarios. In the first case, are transported deep south along the west coast eventually reaching Illinois and Indiana waters. In the second case, larvae are transported across the lake in a cyclonic fashion and circulate mostly in the northern Lake Michigan. valuate the accuracy of particle trajectory model predictions.

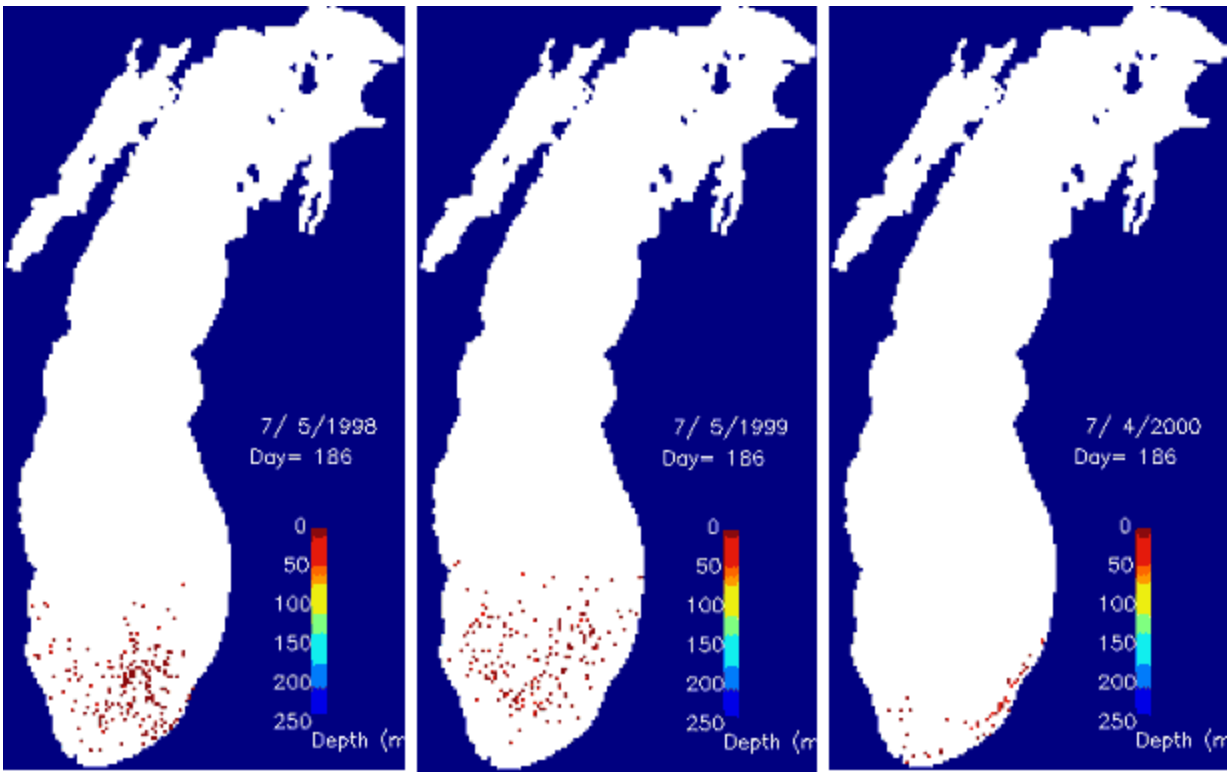

***Figure 1**: Positions of larval fishes on day 35 when they reach 30 mm in 1998, 1999, and 2000*.

Products

Papers

Beletsky, D., D.M. Mason, D.J. Schwab, E. Rutherford, and J. Janssen. 2006. Biophysical model of larval yellow perch advection and settlement in Lake Michigan. *J. Great Lakes Res*. (to be submitted).

Beletsky,D., D.J. Schwab, and M.J. McCormick. 2006. Modeling 1998-2003 summer circulation and thermal structure in Lake Michigan. *J. Geophys. Res*. (Accepted).

Beletsky, D., D.J. Schwab, D.M. Mason, E. Rutherford, M.J. McCormick, H.A.Vanderploeg, and J. Janssen. 2004. Modeling the transport of larval yellow perch in Lake Michigan. *Estuarine and Coastal Modeling, the 8th International Conference*, November 3 5, 2003, Monterey, CA, p.439-454.

Presentations

Beletsky D., D. Schwab , D. Mason, E. Rutherford , M. McCormick, and J. Janssen. 2005. *Modeling the transport, growth, and settlement of larval yellow perch in Lake Michigan*. IAGLR-2005, 23-27 May, Ann Arbor, MI.

HööK, T.O., Beletsky, D., Rutherford, E.S., and Mason, D.M. *A Linked Hydrodynamic and Individual-based Model of Early-life Alewife Dynamics in Lake Michigan*. IAGLR-2005, 23-27 May, Ann Arbor, MI.

Beletsky, D. 2005. *Modeling larval transport and growth in Lake Michigan*. GLERL Seminar Series, April 21, Ann Arbor, MI.

Beletsky, D. 2005. *Modeling thermal structure, circulation and larval transport in Lake Michigan*. SNRE Seminar Series, University of Michigan, March 11, Ann Arbor, MI.

Beletsky D., D. Schwab , D. Mason, E. Rutherford , M. McCormick, H. Vanderploeg. and J. Janssen. 2003. *Modeling the transport of larval yellow perch in Lake Michigan*. Estuarine and Coastal Modeling, the 8th International Conference, November 3-5, 2003, Monterey, CA.

Rutherford, E., D. Beletsky, D. Schwab, D. Mason, M. McCormick, H. Vanderploeg, and J. Janssen. 2003. *Modeling the influence of lake circulation on recruitment variability of Lake Michigan Yellow Perch*. 27th Annual Meeting of the Early Life History Chapter of American Fisheries Society, 20-24 August, 2003 Santa Cruz, California.

Rutherford, E., D. Beletsky, D. Schwab, D. Mason, M. McCormick, H. Vanderploeg, and J. Janssen. 2003. *Modeling the influence of lake circulation on recruitment variability of Lake Michigan Yellow Perch*. PERCIS 3 Symposium: International meeting of percid fish biologists, 17 July, 2003, Madison, Wisconsin.

Rutherford, E., D. Beletsky, D. Schwab, D. Mason, M. McCormick, H. Vanderploeg, and J. Janssen. 2003. *Modeling the influence of lake circulation on recruitment variability of Lake Michigan Yellow Perch.* The 46 th Conf. of IAGLR, 22-26 June, Chicago, IL.

Beletsky, D. 2003. *Modeling thermal structure, circulation and larval transport in Lake Michigan*. Great Lakes WATER Institute Seminar Series, University of Wisconsin-Milwaukee, 4 June, Milwaukee, WI.

Rutherford, E., D. Beletsky, D. Schwab, D. Mason, M. McCormick, H. Vanderploeg, J. Dettmers, and J. Janssen.2003. *Modeling the influence of lake circulation on recruitment variability of Lake Michigan Yellow Perch*. Great Lakes Fisheries Commission, Annual Meeting, 4 June, Thunder Bay, Ontario.

Beletsky D., D. Schwab , D. Mason, E. Rutherford , M. McCormick, H. Vanderploeg. and J. Janssen. 2003. *Modeling the influence of lake circulation on recruitment variability of Lake Michigan Yellow Perch*. Lake Michigan Technical Committee Meeting, March 18, Milwaukee, WI.