Secchi and Sea-Run Alewives in Central Maine Lakes: Testing the 'Native-Invasive' Hypothesis

by Douglas H. Watts
Augusta, Maine
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Background:

The 'native-invasive' hypothesis holds that physical and ecological alterations to lakes on the coastal New England plain since the 18th century have led to internal bio-energetic changes which could cause the re-introduction and restoration of native anadromous alewives (*Alosa pseudoharengus*) to these lakes to have permanent and negative effects on lake water clarity. First-order propositions offered in support of this hypothesis are (a) native alewives in the lake *could* result in a net increase of phosphorus available for phytoplankton growth compared to baseline (no alewife) conditions; (b) juvenile alewives are highly effective grazers upon zooplankton species which keep 'nuisance' algae blooms in check and; (c) net export of phosphorus by juvenile alewives leaving the lake for the ocean in the fall is not sufficient to counteract the deleterious effects of (a) and (b).

Lake clarity as measured by Secchi disk is a primary tracking device for lake water quality and clarity on a decadal basis. Secchi monitoring in many central Maine lakes has been conducted since the early to mid 1970s, producing a fairly long (35-45 year) series of continuous datasets. These datasets are maintained by the Maine DEP and the Maine Volunteer Lake Monitoring Program (VLMP) at www.lakesofmaine.org. With these VLMP Secchi datasets one can make lake-to-lake, within-lake, nearest neighbor lakes and watershed-to-watershed comparisons over the available 35-45 year time-series.

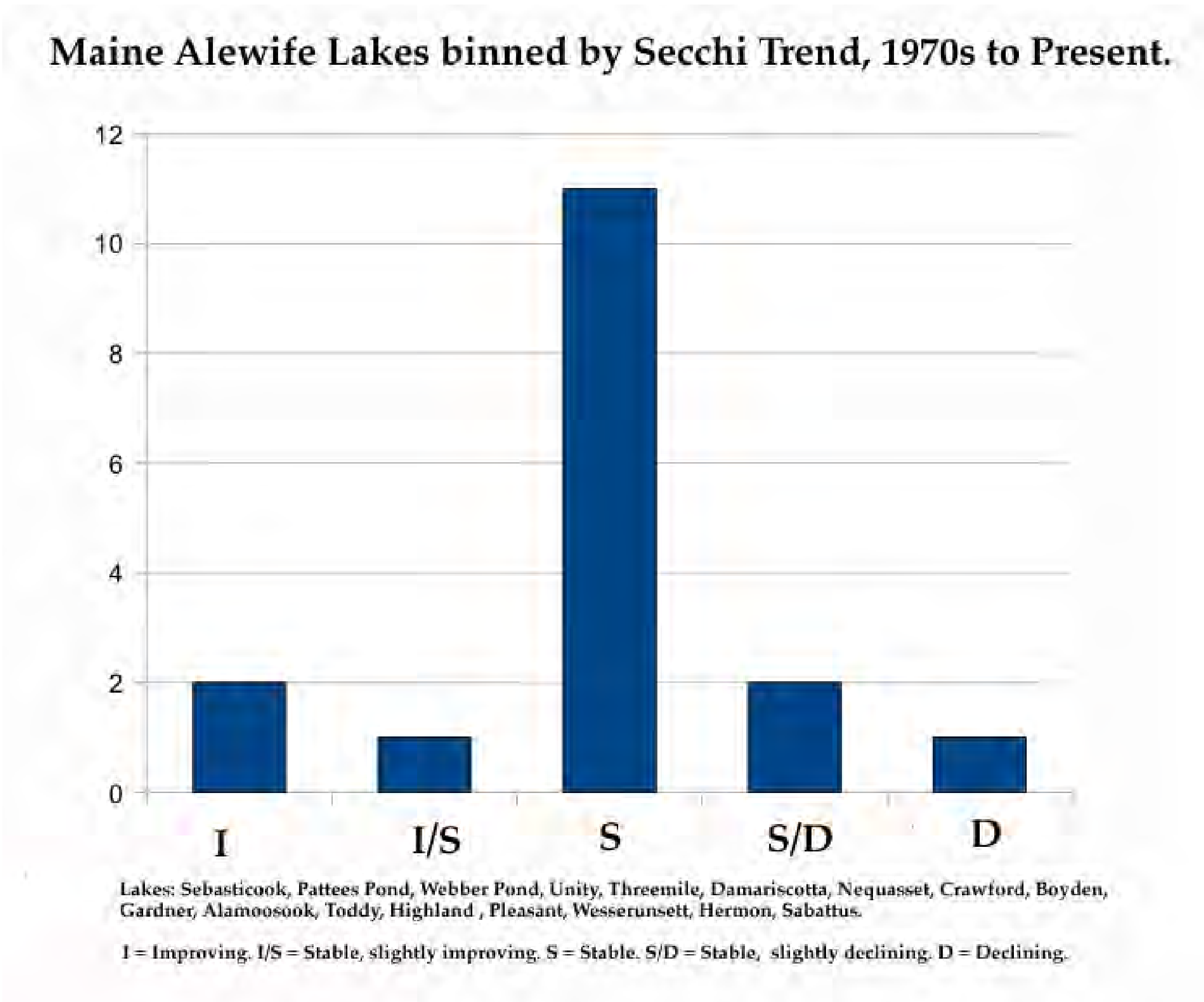
Testing the Native-Invasive Hypothesis with Secchi Clarity Data:

To be a true scientific hypothesis (and not a mere hunch or speculation), the 'native-invasive' hypothesis should be able to make predictions which are testable, ie. falsifiable. As such, the 'native-invasive' hypothesis should be able to predict *observable* effects in a waterbody which can be *measured*. Secchi clarity readings are an ideal testing method because (a) the technique is uniform from lake to lake and year to year and (b) the technique measures a physical characteristic (lake clarity) which is important for both aesthetic and ecological reasons. The 'native-invasive' hypothesis predicts that as a population, (a) lakes with alewives should show *declining* Secchi clarity over time; (b) lakes with alewives in them for the longest period should show the most decline; (c) lakes with large alewife populations should show more pronounced clarity declines than lakes with small populations (on a per surface-acre basis). These predictions arise because the native-invasive hypothesis holds that each year's migration of adult alewives into a lake creates a *new* input of phosphorus and each year's cohort of juvenile alewives creates a *new* predatory impact on zooplankton attempting to consume that year's phytoplankton 'crop' (which itself should be larger due to the new input of phosphorus by adult alewives). If the mechanisms predicted by the 'native-invasive' hypothesis are real, lakes with alewives should exhibit a cumulative and cascading effect of declining water quality over time. Such an effect should be observed as a measurable decline in *actual* Secchi clarity and a negative clarity *trend*, especially at 20 to 30 year time frames. To test the core predictions of the 'native-invasive' hypothesis, this study examined 17 alewife lakes across Maine which have long (35-45 year) periods of robust Secchi clarity data:

Maine Lakes with Sea-Run Alewives

Lake	Town	Date LYs introduced	Secchi Trend
Damariscotta	Newcastle	Before 1800s	S
Sebasticook	Newport	1987	I
Unity Pond	Unity	1987	S/D
Pattees Pond	Winslow	1987	I
Webber Pond	Vassalboro	1987	S/I
Threemile Pond	Vassalboro	1987	D
Wesserunsett Lake	Cornville	1987	S
Pleasant Pond	Gardiner	1997	S
Nequasset Lake	Woolwich	Pre-1970s	S
Duck Pond	Westbrook	1980s	S/D
Alamoosook	Orland	Native	S
Toddy	Orland	Native	S
Crawford	Union	Native	S
Sabattus	Sabattus	1980s	S
Hermon	Hermon	1980s	S
Gardner	E. Machias	1980s	S
Boyden	Perry	1980s	S

Code: S = Stable, S/I = Stable to slightly improving, S/D = Stable to slightly declining, D = Declining, I = Improving.



Discussion of Results:

In the 17-lake survey shown above, each lake was scored and binned for trend for its full Secchi time-series, ie. improving, stable to slightly improving, stable, stable to slightly declining and declining. Of the 17 lakes examined, 65 percent (n=11) had stable Secchi trends over their historic time-series. The other 35 percent (n=6) of the lakes had a scattering of improving or declining trends. These results fail to support the core predictions of the 'native-invasive' hypothesis. The 17-lake population appears to behave like a *randomly* selected group of 17 lakes in Maine which have 35-40 years of Secchi data. This is illustrated by the symmetrical form of the distribution curve with a strong dominance of lakes with *stable* Secchi trends (ie. no discernible trend toward improvement or decline). The 'native-invasive' hypothesis predicts that a population of lakes with alewives should show a distribution curve which is skewed toward *declining* Secchi clarity. The distribution curve of the 17 lakes studied does not show this.

A second prediction of the hypothesis is that lakes with the *most* alewives (ie. the largest runs) should show the highest magnitude of negative water quality effects as measured by Secchi. This is not supported by the data. Three of the lakes with the largest number of alewives (Sebasticook Lake, Pattees Pond, Webber Pond) have improving to slightly improving trends in Secchi clarity. Two of the lakes with slight to noticeable declines in Secchi clarity (Unity Pond, Threemile Pond) have alewife runs of similar size to Sebasticook Lake, Pattees and Webber Pond. Other lakes with large runs (Damariscotta, Alamoosook, Toddy, Gardner, Hermon Pond) have stable Secchi trends.

The third prediction of the hypothesis is that lakes which have had alewife runs for the longest time should show the most pronounced negative water quality effects. This is not supported by the data. The lakes with the longest history of alewife presence (ie. Damariscotta Lake, Boyden Lake, Crawford Pond, Gardner Lake, Alamoosook Lake), have very stable Secchi trends.

A fourth prediction of the hypothesis is that alewife introduction and presence should have the most observable negative effect on those lakes which already suffer from high levels of cultural eutrophication (ie. water quality is already so negatively impacted by human effects that they are super-sensitive to additional negative effects by alewives). The data do not support this. Results for the most human-impacted lakes (Sabattus Pond, Sebasticook Lake, Webber Pond, Threemile Pond, Unity Pond) show no clustering or pattern. Sebasticook Lake has been the most negatively impacted by human activities but also shows the strongest improving trend of the 17-lake population.

<u>Testing Against the Null Hypothesis:</u>

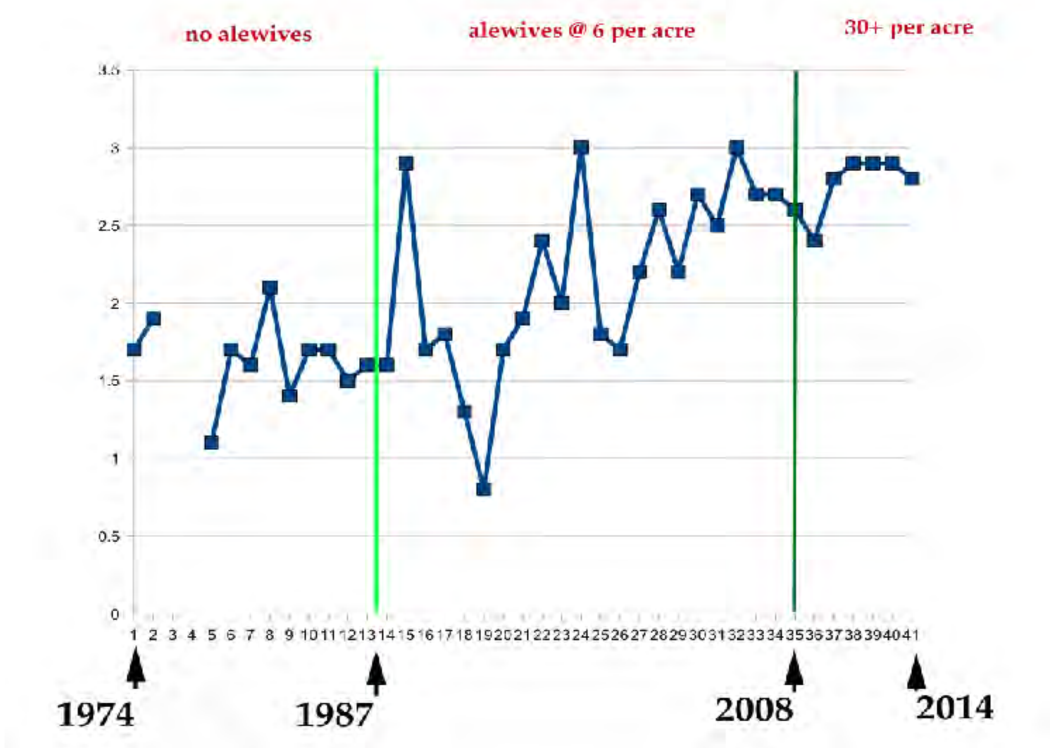
For this study, the null hypothesis can be stated in several complementary ways. The first is that the presence or absence of alewives has no *measurable* effect on Secchi clarity (ie. flipping a penny vs. a nickel; or flipping a coin on Monday vs. Tuesday). A second is that a person looking at the above distribution curve for lakes-with-alewives could not guess it was from 'alewife lakes' as opposed to a *random* collection of 17 Maine lakes at a rate better than chance. A third is that a person could not look at the Secchi trend for an individual lake in the 17-lake sample and determine whether it has alewives or not at a rate better than chance.

Because of its very strong central tendency at a stable Secchi trend, the 17-lake collection shows no features which might distinguish it from a random population of 17 Maine lakes. The only thing which can be confidently said about this population is that most of its members show no significant improvement or decline in Secchi clarity during the past 35-40 years. The 'native-invasive' hypothesis predicts a negative effect by alewives on the clarity of their spawning lakes which can be observed and measured with a Secchi disk over time. In this case, two thirds of the lakes studied show *no trend* in Secchi over time. This means there is no correlation which can be tested for causation except perhaps, "Does the presence of alewives *cause* lakes to have stable Secchi trends?"

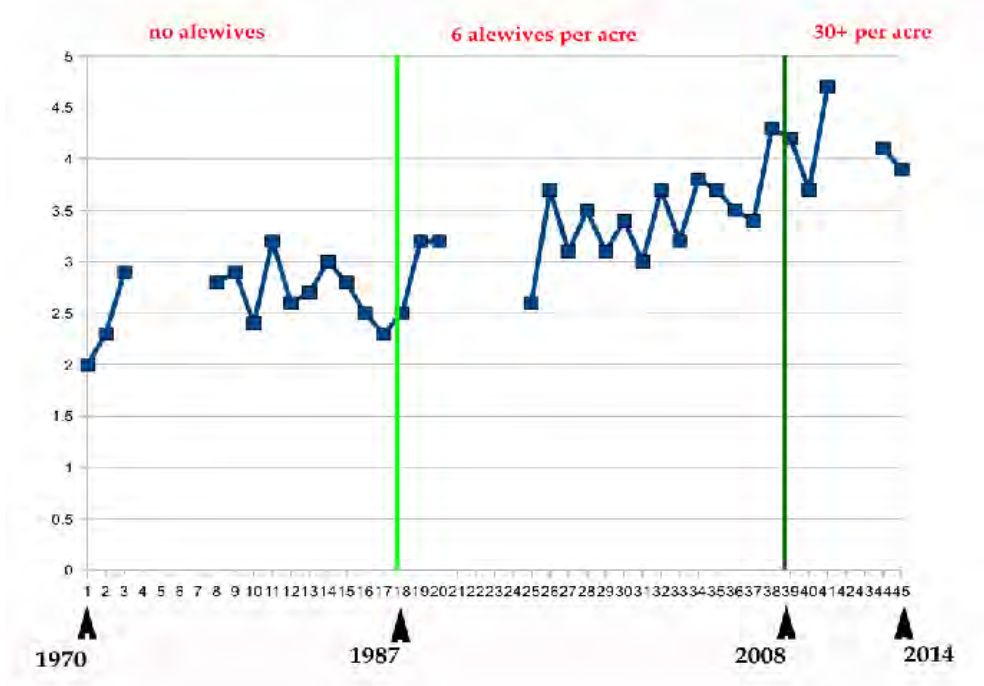
Reductio ad absurdum.

Examples of Lakes with Improving Secchi Trends.

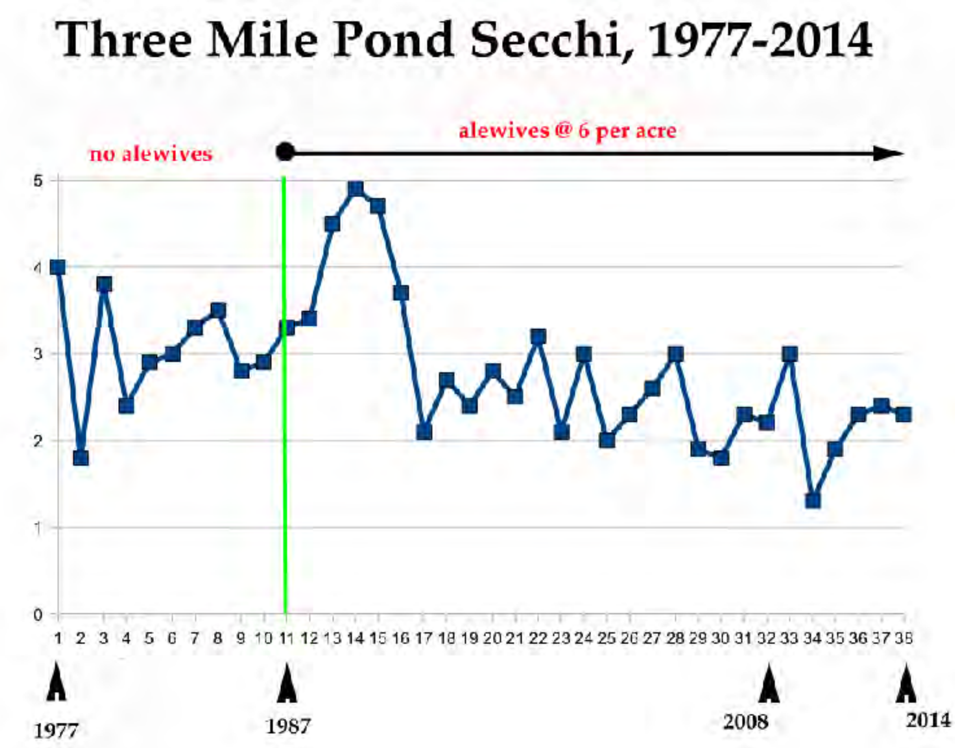
Sebasticook Lake Secchi, 1974-2014

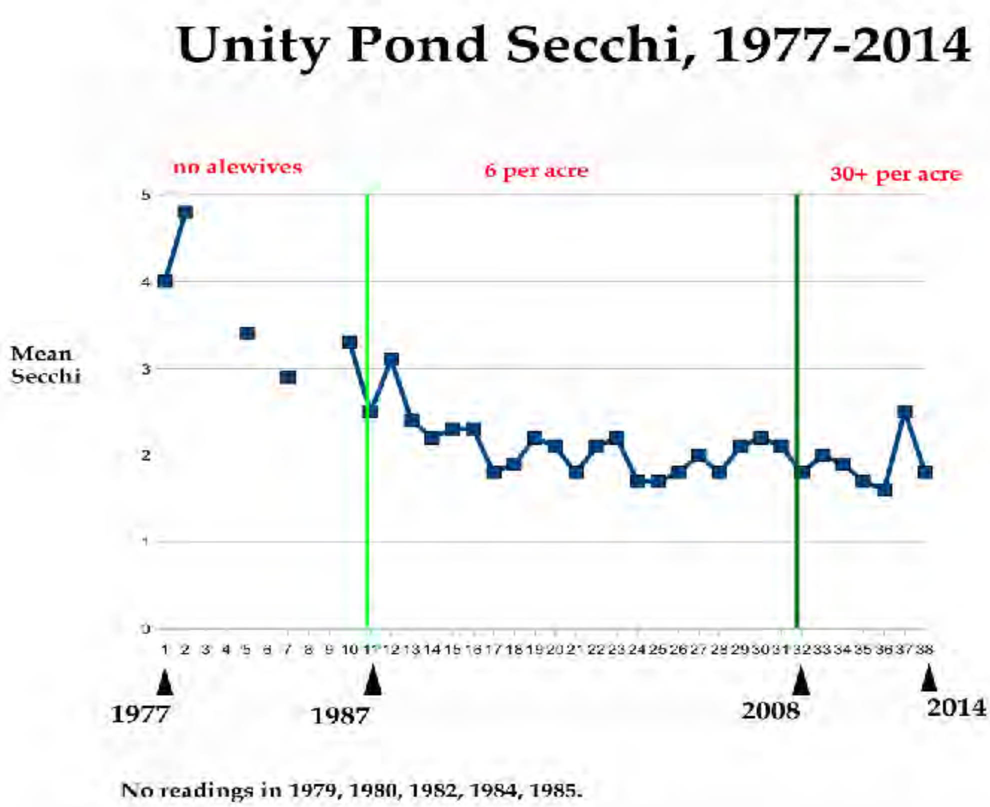


Pattees Pond Secchi, 1970-2014



Examples of Lakes with Not-Improving Secchi Trends.





Examples of Lakes with Stable Secchi Trends.