Time-periods for Plankton Index reference envelopes

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Introduction

The UK assessment of the environmental status of its shelf seas under the MSFD will be reported to the EC in 2018. As a preliminary to this, UK monitoring results are to be submitted to the UK HBDSEG. This includes results from the use of the Plankton Index (PI) tool, which the HBDSEG Pelagics sub-group has applied to fixed-station and CPR-line monitoring. The sub-group had previously identified the 5 year period from 2004 through 2008 as the reference period for the tool. However, not all sites had data for the full period. The main purpose of this note is to examine the effect on PI values of using a shorter reference period. A second purpose is to consider whether all data should be month-averaged before PI statistics are calculated.

Methods

Elieen Bresnan provided weekly data for diatom and dinoflagellate cells/L at the MSS monitoring station at Stonehaven. Mike Best provided data on the same lifeform pair at stations in the EA East region, which comprises a large number of sites that are sampled monthly. These time-series of abundances were analysed with a version of the PI tool implemented in the Matlab script `PI2B`. The control parameter `mf` was set either to 0 (directing use of all data-pairs) or 1 (directing averageing of data for each lifeform over all samples within a calender month). Minimum abundance (z in the transformation $\log_{10}(x + z)$) was set to 50 cells/L, half the smallest observed non-zero estimate, for the Stonehaven data, or 10 cells/L for the EA data.

Results

Use of weekly data from Stonehaven resulted in a larger envelope (figure 1(a)) than use of monthly-averaged data (1(b)). One reason for this

was the presence in the weekly time-series of zero values, mostly lost from the monthly data. Neither treatment, however, showed significant temporal change in the diatom-dinoflagellate pair (figures 1(a),(b) and 2(a),(b); tables 1 and 2). In these analyses, the reference period included 5 years of data (2004-8). When it was reduced to 2 years, however, the temporal comparisons (figure 1(c),(d); table 1) and trends (figure 2(c),(d); table 2) were all significant.

Similarly to the Stonehaven case, use of the individual site data from the EA East region resulted in a larger envelope (figure 3(a)) than that fitted to the month-averaged data (3(b)). In both cases, the resulting comparisons (figure 3(c),(d); table 1)and trends (figure 4(c),(d); table 2) were significant.

Table 1: Summary of results: PI comparison

site/region	mf	reference	comparison	PI	probability
Stonehaven	0	2004-8	2009-14	0.88	0.22
	1	2004-8	2009-14	0.86	0.18
	1	2007-8	2009-14	**0.64**	0.00
	1	2008-9	2010-14	**0.60**	0.00
EA East	0	2007-8	2009-14	**0.76**	0.00
	1	2007-8	2009-14	**0.35**	0.00

Table 2: Summary of results: PI trends

site/region	mf	reference	comparison	trend (τ)	probability
Stonehaven	0	2004-8	2009-14	–	> 0.05
	1	2004-8	2009-14	–	> 0.05
	1	2007-8	2009-14	**-0.68**	0.03
	1	2008-9	2010-14	**-0.68**	0.03
EA East	0	2007-8	2009-14	**-0.79**	0.01
	1	2007-8	2009-14	**-0.67**	0.02

Discussion

Monthly averaging

Monthly averaging is the recommended procedure when applying the PI tool to fixed station and CPR data. It has the practical benefit of reducing the number of zeros in the plotted data, and it should remove some of the week-to-week temporal variation that is usually evident in single-site data.

Such variation might result from (atmospheric) weather or from short-term changes in water flows past the site. Neither of these need be taken into account in calculating PI reference envelopes or time-series, because the tool is being used to track multi-year trends in the lifeform state-space locations of the annual cycles of the planktonic lifeforms.

In the case of CPR data, month-averaging acts on spatial variation within an ecohydrodynamically defined region, as well as on temporal variation; according to the theory of ecohydrodynamic determination, spatial variation within a region can be treated as noise. It is less clear that this is the case for the EA regions, where the sampling sites are distributed through a number of WFD water bodies that might belong to different water-body types (i.e. potentially have different type-specific reference conditions). Thus in the case of the EA data, there might be an argument for using the un-averaged abundances. And the use of unaveraged data has not given rise to any zeros (figure 3(a)).

Length of the reference period

The aim of the reference envelope is to define a 'plankton climate' in state-space, with which subsequent observations can be compared. Plankton seasonal cycles vary from year to year under the influence of weather, internal dynamics, and boundary conditions. Clearly, one year would not be enough to include all the variability that is part of climate. However, we expect long-term changes in PI values because of the effects of exogenous pressures (such as global atmospheric and oceanic climate change) and endogenous pressures (such as nutrient enrichment and fisheries) on marine pelagic ecosystems. Trends due to such pressures begin to become apparent on decadal time-scales, so any reference period should be less than this. We have agreed on 5 years as an empirically reasonable period, and it seems clear that the two-year periods used for figures 1(c),(d) and 2(c),(d) were too short, leading to the deduction of significant changes in the plankton that should probably be seen as part of inter-year variability within a given climate.

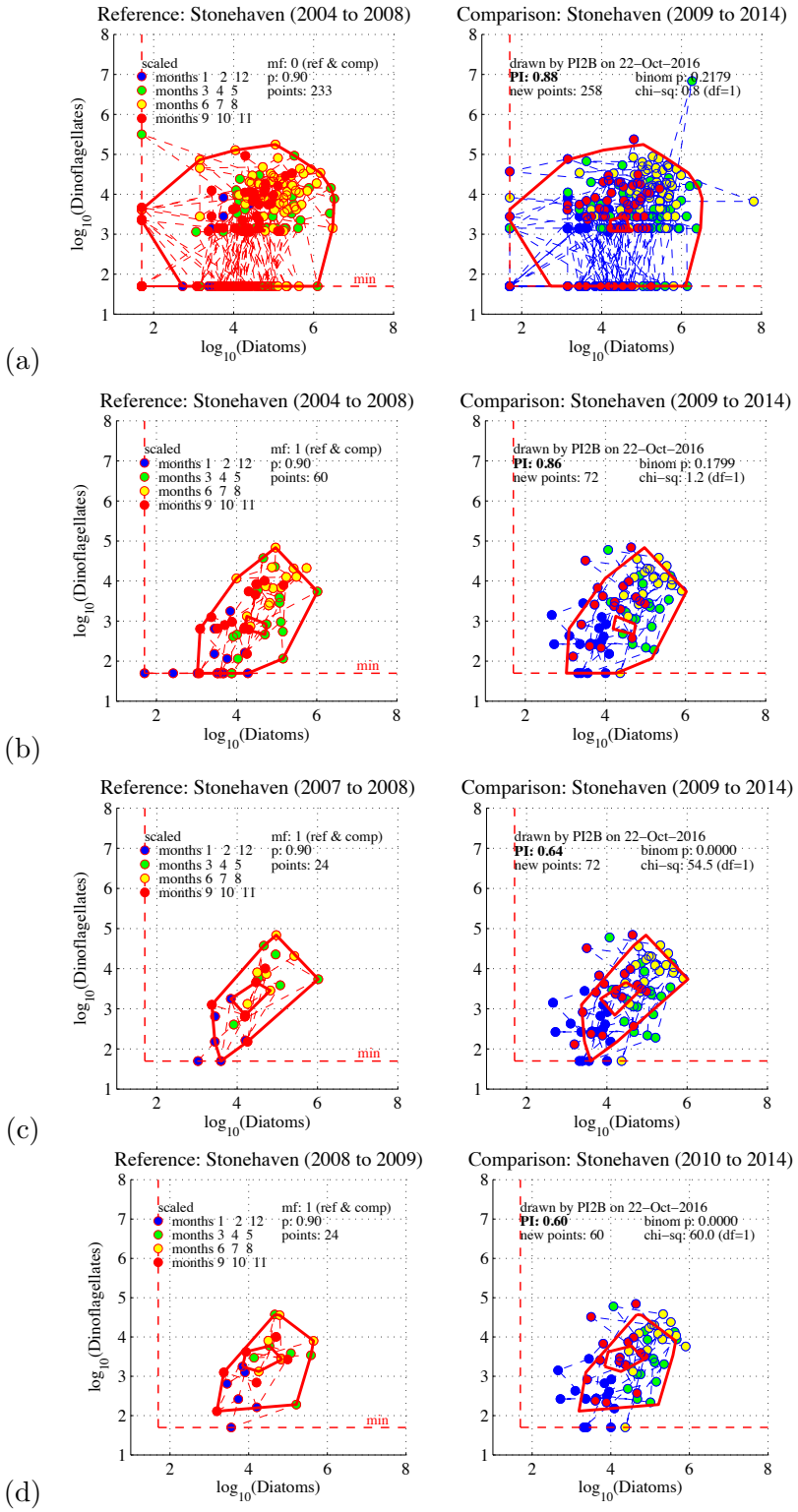


Figure 1: PI reference envelopes (left) and comparisons (right) for the life-form pair diatoms and dinoflagellates at the MSS Stonehaven site. Parts (a) and (b) used a 5-year reference period (2004-2008), and the comparison period showed no significant change. Parts (c) 2007-8 and (d) 2008-9, used 2-year reference periods, and the comparison periods showed significant change.

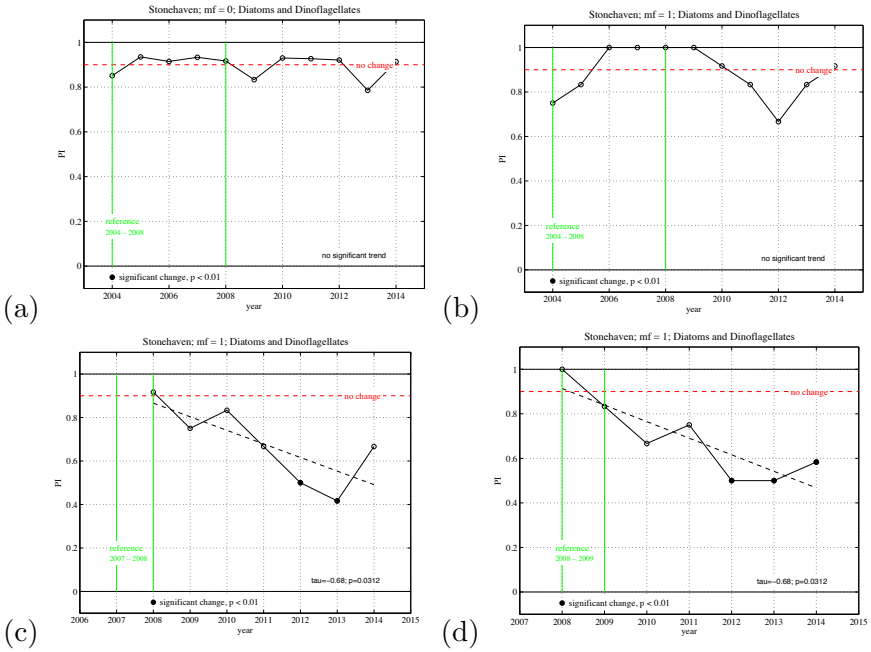
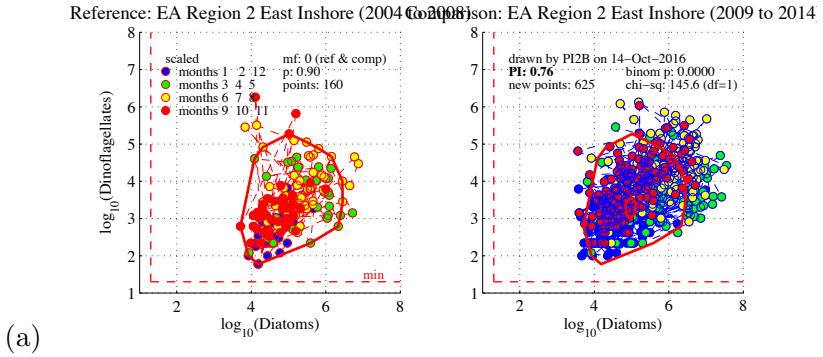
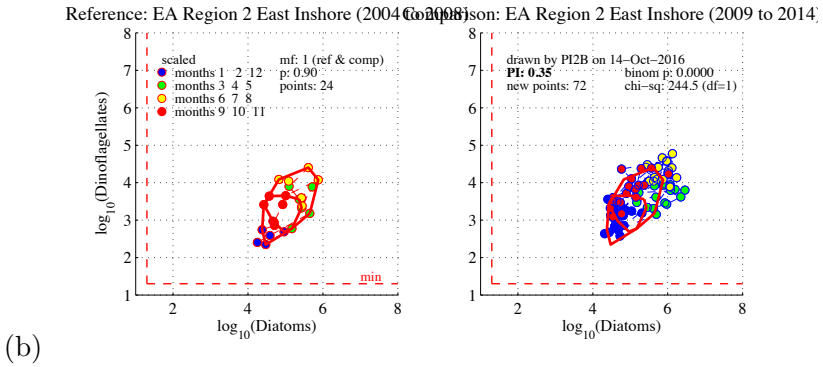


Figure 2: PI time-series for the life-form pair diatoms and dinoflagellates at the MSS Stonehaven site. In parts (a) and (b) the reference period was 2004 through 2008; in (c) it was 2007-8 and in (d) 2008-9. The shorter reference periods resulted in significant trends in annual PI values, the longer periods didn't, irrespective of whether all data ((a), mf=0) or monthly-averaged data ((b), mf=1) were used.

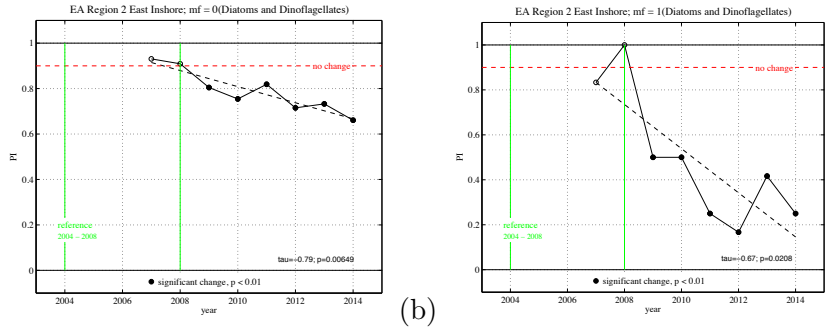


(a)



(b)

Figure 3: PI reference envelopes (left) and comparisons (right) for the life-form pair diatoms and dinoflagellates at sites in the EA East region. Although the reference period is shown as 2004-8, there were data only for 2007-8. The comparison shows significant changes (in the distribution of points in diatom-dinoflagellate lifeform space), irrespective of whether all data ((a), mf=0) or monthly-averaged data ((b), mf=1) were used.



(a) (b)

Figure 4: PI time-series for the life-form pair diatoms and dinoflagellates at sites in the EA East region. Although the reference period is shown as 2004-8, there were data only for 2007-8. There were significant trends in the PI whether data were month-averaged (mf=1) or not (mf=0).