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2014-15 Connectivity Indicators for the GHHP Gladstone Harbour Report Card

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CSIRO: Scott Condie, Mike Herzfeld, John Andrewartha, Rebecca Gorton

University of Queensland: Karlo Hock

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Summary

The ISP007 Report (Condie et al. 2015) described a methodology for calculating connectivity indicators for Gladstone Harbour and included definition of a baseline (4-year average) and numerical scores and associated grades for 2013-14. Here we report the connectivity scores and grades for 2014-15. The only significant changes in methodology from 2013-14 to 2014-15 were: (i) contaminant loads from the previous year (2013-14) were used to calculate the current year contaminant connectivity scores because 2014-15 contaminant loads do not become available until January 2016; and (ii) numerical ranges for connectivity indicator scores were aligned with those used for other indicators in the report card.

Compared to the baseline, 2014-15 connectivity scores were more favourable for flushing rates (B-average) and contaminant connectivity (B-average), but less favourable for ecological connectivity (D-average). The Narrows, Western Basin, Colosseum Inlet and Rodds Bay all achieved B-averages across the three connectivity indicators. Most other zones achieved C-averages, the one exception being Calliope Estuary where an unusual combination of poor flushing rate (D) and very poor ecological connectivity (E) contributed to a D-average. Deviations from the baseline during 2014-15 were largely associated with changes in flow rather than anomalies in either contaminant loads or habitat distributions.

1. Introduction

This report for the Gladstone Healthy Harbour Partnership (GHHP) provides connectivity indicator scores for the 2014-15 GHHP Gladstone Harbour Report Card. The 2014-15 reporting year is the first year that connectivity scores will be formally reported. The ISP007 Report (Condie et al. 2015) described a methodology for calculating connectivity indicators for Gladstone Harbour and included definition of a baseline (4-year average) and numerical scores and associated grades for 2013-14.

2. Methods

The complete methodology for calculating connectivity indicators for Gladstone Harbour was described in the ISP007 Report (Condie et al. 2015), which included numerical scores and associated grades for 2013-14. Calculation of scores and grades for 2014-15 differed in only two respects:

(i)   Contaminant loads from the previous year (2013-14), rather than the reporting year (2014-15), were used to calculate the contaminant connectivity scores. This was necessary because 2014-15 loads do not become available from the National Pollution Inventory (NPI) until January 2016, which is after release of the 2015 Report Card. Estimating the current year loads by averaging over a number of prior years was considered as a potential way of smoothing out year-to-year variability and reducing errors. However, when this strategy was tested using data from all years back to 2007-08, it was found that root mean square (rms) errors increased with each additional year included in the calculation (Figure 2.1). Hence all contaminant connectivity scores described in this report use 2013-14 contaminant load data.
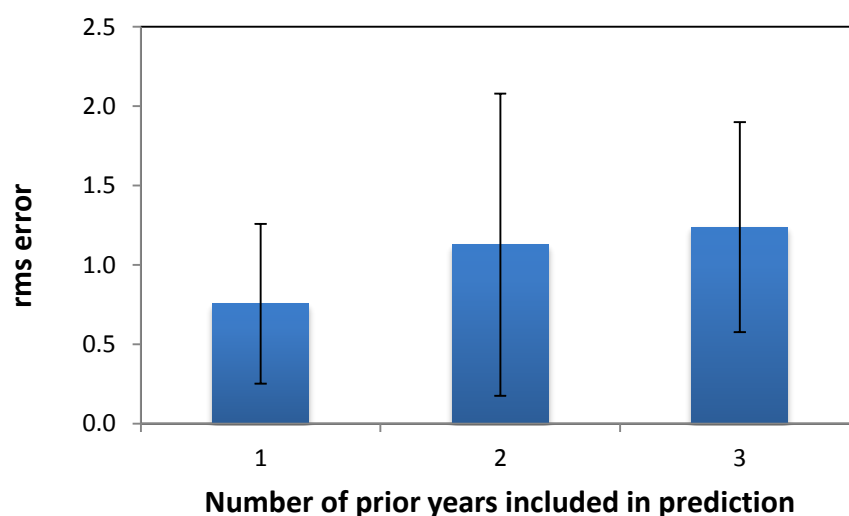
Figure 2.1. The rms error of predicted contaminant connectivity normalised by baseline values. These results are calculated using data from 2007-08 through 2013-14 and the error bars represent one standard deviation across these years.

(ii)   The linear transformation of t-statistics to connectivity scores was changed to:

$$T = 0 \qquad\qquad t < -2.887 \qquad\text{(1a)}$$

$$T = 0.195t + 0.563 \qquad -2.887 < t < 2.887 \qquad\text{(1b)}$$

$$T = 1 \qquad\qquad t > 2.887 \qquad\text{(1c)}$$

This change was made to align our numerical scores with those used for other indicators in the report card (Figure 2.2). The ranges of scores defining the alphabetical grades were also changed so that the old and new approaches gave the same grades (with two exceptions where scores were very close to values separating two grades).

A	**Very good (≥ 0.85)**
B	**Good (≥ 0.65, < 0.85)**
C	**Satisfactory (≥ 0.5, < 0.65)**
D	**Poor (≥ 0.25, < 0.50)**
E	**Very poor (0, < 0.25)**

Figure 2.2. Definition of alphabetical grades based on the ranges of numerical scores and associated descriptors for each grade.

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3. Results

The connectivity indicators are shown as numerical scores in Table 3.1 and as alphabetical grades in Table 3.2. In 2014-15 flushing rates in most zones were higher than the 4-year baseline average with more than half scoring A's and a harbour average of B (Tables 3.2). The only low scoring zones were Calliope Estuary (D) and Middle Harbour (E).

Contaminant connectivity scores were also favourable (i.e. low export of contaminants to other zones) with all but two zones receiving an A or B, with a harbour average of B (Table 3.2). A very poor score in Graham Creek (E) was associated with anomalously high export (i.e. out-degree) into other zones compared to the baseline, rather than changes in contaminant loads.

Ecological connectivity was low relative to the baseline period with six of the eleven zones scoring an E and a harbour average of D (Table 3.2). The only zone to score above the baseline was Graham Creek (B), reflecting relatively high import (i.e. in-degree) from other zones.

Average connectivity (combining flushing rate, contaminant connectivity and ecological connectivity) was mostly higher than the baseline period with four zones scoring B (Table 3.2). The only zone below the baseline was Calliope Estuary (D), which was dragged down by a poor flushing rate (D) and very poor ecological connectivity (E). As expected the average across all indicators and all zones was similar to the baseline (C).

Table 3.1. Numerical connectivity scores for each zone and harbour-wide averages for 2014-15.

Zone		Connectivity indicator scores for 2014-15			
		Flushing rate	Contaminant connectivity	Ecological connectivity	Average connectivity
1	The Narrows	1.00	1.00	0.00	0.67
2	Graham Creek	1.00	0.00	0.81	0.60
3	Western Basin	0.95	0.81	0.27	0.68
4	Boat Creek	No data available			
5	Inner Harbour	0.78	1.00	0.14	0.64
6	Calliope Estuary	0.34	0.73	0.23	0.44
7	Auckland Inlet	No data available			
8	Middle Harbour	0.16	0.95	0.59	0.57
9	South Trees Inlet	1.00	0.59	0.11	0.57
10	Boyne Estuary	0.72	1.00	0.00	0.57
11	Outer Harbour	0.59	0.79	0.49	0.62
12	Colosseum Inlet	1.00	1.00	0.12	0.71
13	Rodds Bay	1.00	0.66	0.41	0.69
	Harbour average	0.78	0.78	0.29	0.61

Table 3.2. Connectivity grades for each zone and harbour-wide averages for 2014-15. Definitions and descriptors of each grade are provided in Figure 2.2.

Zone		Connectivity indicator scores for 2014-15			
		Flushing rate	Contaminant connectivity	Ecological connectivity	Average connectivity
1	The Narrows	A	A	E	B
2	Graham Creek	A	E	B	C
3	Western Basin	A	B	D	B
4	Boat Creek	No data available			
5	Inner Harbour	B	A	E	C
6	Calliope Estuary	D	B	E	D
7	Auckland Inlet	No data available			
8	Middle Harbour	E	A	C	C
9	South Trees Inlet	A	C	E	C
10	Boyne Estuary	B	A	E	C
11	Outer Harbour	C	B	D	C
12	Colosseum Inlet	A	A	E	B
13	Rodds Bay	A	B	D	B
	Harbour average	B	B	D	C

4. Discussion

Changes in methodology

The methodology was the same as that described in the ISP007 Report (Condie et al. 2015) apart from two aspects. First, contaminant loads from the previous year (2013-14), rather than the reporting year (2014-15), were used to calculate contaminant connectivity scores. This was necessary because 2014-15 loads are not scheduled to become available from the NPI until January 2016 (after release of the 2015 Report Card). The same limitation is expected to apply in future years.

Second, the transformation of t-statistics to connectivity scores was modified so that the ranges of numerical scores corresponding to each grade aligned with those used for other indicators in the report card (Figure 2.2).

Comparison to previous years

The 2014-15 reporting period is the first to extend beyond the 4-year baseline and it was therefore not too surprising to find a greater range of scores than was typical of years within the baseline period. For example, six zones achieved an A for flushing rate in 2014-15 (Table 3.2) compared to one in 2013-14 (Table 4.1) and a total of two over the three years of the baseline period. The corresponding harbour average was B in 2014-15 compared to C's in all the baseline years. Similarly, contaminant connectivity achieved four A's and a harbour average of B (Table 3.2) compared to a single A and harbour averages of C in 2013-14 (Table 4.1). Ecological connectivity scored lower than previous years with six E's compared to just one throughout the baseline period. This may be seen as a continuation of a general downward trend in ecological connectivity with harbour average scores falling from B to D over the baseline and then holding D for 2014-15.

The wide range of scores achieved in 2014-15 compared to the baseline was largely driven by changes in water circulation rather than changes in contaminant loads or habitat distributions. These circulation changes were not a simple response to rainfall, with annual rainfall in 2014-15 (968 mm) close to the baseline average (1027 mm). However, more consistent rainfall across months in 2014-15 likely contributed to enhanced flushing rates and reduced transport from spawning areas to nursery habitats. Factors such as wind and offshore conditions may also have played a significant role.

Table 4.1. Connectivity grades for each harbour zone and harbour-wide averages from 2013-14. Descriptors for each grade are provided in Figure 2.2

Zone		Connectivity indicator scores for 2013-14			
		Flushing rate	Contaminant connectivity	Ecological connectivity	Average connectivity
1	The Narrows	C	A	E	C
2	Graham Creek	C	C	C	C
3	Western Basin	A	C	D	D
4	Boat Creek	No data available			
5	Inner Harbour	B	B	C	C
6	Calliope Estuary	B	C	C	C
7	Auckland Inlet	No data available			
8	Middle Harbour	C	B	C	C
9	South Trees Inlet	B	E	C	D
10	Boyne Estuary	E	B	D	B
11	Outer Harbour	C	C	C	C
12	Colosseum Inlet	C	B	D	C
13	Rodds Bay	C	C	D	C
	Harbour average	C	C	D	C

Strategies for migrating systems to GHHP

The workflow for generating connectivity indicator scores for Gladstone Harbour has been modified from July 2015 by calculating particle tracks inside the hydrodynamic model in near-real time (Figure 4.1). Hence the particle tracking has been subsumed into the hydrodynamic model, eliminating the need for a separate particle-tracking model.

The following steps are required to further automate the process and migrate the remaining processing to GHHP:

1. Integrate the *flushing rate algorithm* and *network analysis algorithm* into the *connectivity indicator score algorithm* now being run within DIMS.
2. Automate a stream of particle trajectory data from the hydrodynamic model to DIMS.
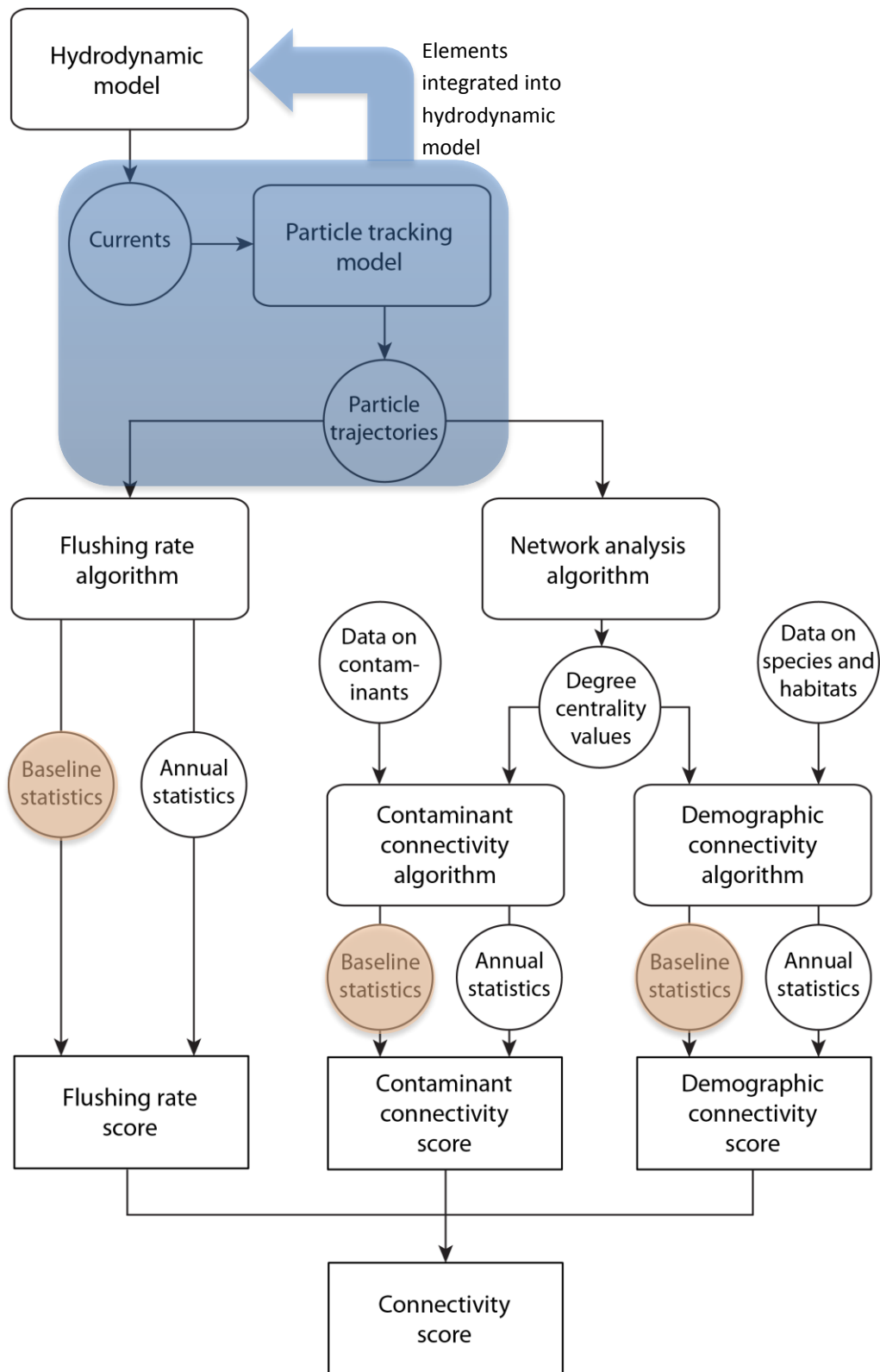3. Explore the feasibility of migrating the complete hydrodynamic model into DIMS.

Figure 4.1. Flowchart outlining the steps involved in calculating the connectivity indicators and report card scores (Condie et al. 2015). Modifications implemented from July 2015 are shown in blue and the fixed baseline statistics that do not need to be updated are shown in orange.

References

Condie S, M Herzfeld, J Andrewartha, R Gorton, K Hock (2015) Project ISP007: Development of Connectivity Indicators for the GHHP Gladstone Harbour Report Card. CSIRO Oceans and Atmosphere (Hobart) 54pp.