Water Quality Analysis of the Mason Inlet Relocation Project

Final Project Report

by

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EXECUTIVE SUMMARY

A water quality sampling program was conducted by University of North Carolina at Wilmington researchers to assess potential impacts of the relocation of Mason Inlet. Five stations were sampled in and near Mason Inlet from December 2001 through February 2003. Common pollutant parameters such as fecal coliform bacteria counts, turbidity, chlorophyll *a*, and nutrients (nitrate and total phosphorus) were low both before and after inlet relocation. Dissolved oxygen concentrations stayed above the North Carolina state water quality standard at all times and at all stations. Total suspended solids approximately doubled at most stations following inlet relocation, and considerable sedimentation occurred in Banks Channel and Mason Creek. Sampling in nearby Howe Creek, across the Atlantic Intracoastal Waterway from Mason Creek, showed little change either way in fecal coliform abundance at the lower and middle creek stations before or after dredging. There was a 43% decrease in fecal coliform concentrations at the uppermost Howe Creek station following inlet relocation. However, salinities collected at the same time as fecal coliforms actually showed lower values in Howe Creek following the dredging of Mason Inlet. Additionally, statistical analysis showed a positive correlation between rainfall and fecal coliform counts in upper Howe Creek. Thus, the fecal coliform decrease in upper Howe Creek following inlet relocation appeared to be related to localized rainfall and runoff patterns rather than increased salinity resulting from inlet relocation.

BACKGROUND

During the period 1993 to 1996, Mason Inlet, which separates Figure Eight Island and Shell Island, underwent a period of active southerly migration. This migration took the inlet all the way to the base of the Shell Island Resort, where a geotextile revetment and sand bags were employed as a temporary measure to protect the resort and other nearby residences. Following lengthy negotiations among stakeholders and Federal and State regulatory groups, a long-term solution to the inlet migration was agreed upon. This involved dredging a new inlet 2,500 feet to the north of the old inlet at Shell Island, and dredging Mason Creek from Banks Channel to the Atlantic Intracoastal Waterway (ICW).

As a result of an agreement with the US Army Corps of Engineers and the North Carolina Division of Water Quality regarding a permit for construction work involved with the relocation of Mason Inlet, New Hanover County was expected to conduct a program to analyze water quality before and after dredging activities and channel relocation. The Aquatic Ecology Laboratory of the Center for Marine Science, University of North Carolina at Wilmington (UNCW), was contracted to perform the water quality assessment. However, UNCW was not brought into the project until mid-December 2001, leaving limited time to perform pre-project data collection. Thus, UNCW was able to sample twice in late December 2001 and once in January 2002 before dredging operations curtailed further pre-project sampling.

The following report analyzes water quality in the Mason Inlet vicinity from the period December 2001 through February 2003, before and after moving of the inlet. UNCW has also been monitoring the nearby tidal creek system since 1993 (Mallin et al. 2000a). Thus, we provide additional information on fecal coliform bacterial abundance in Howe Creek during that same period to assess the possibility of water quality improvement from increased water flows as a result of relocation of the inlet.

WATER SAMPLING FREQUENCY

Water sampling was conducted on three occasions between December 20, 2001 and January 10, 2002 prior to construction activities. Following completion of construction and beginning in April 2002, samples were collected at two-week intervals over a 12-week period for a total of six sampling occasions. Afterwards, samples were collected once a month for six months until early February 2003. Samples were collected at or near flood tide. Water samples in Howe Creek were collected on a monthly basis from August 2001 through February 2003, also at or near high tide.

SAMPLE LOCATIONS

Water samples were collected at five locations (Fig. 1). One station was located in the Atlantic Intracoastal Waterway near the entrance to Mason Creek, one was located along Mason Creek midway between the ICW and Banks Channel, one was located in Banks Channel near the south sedimentation basin, and a fourth was also in Banks Channel north of Mason Creek. The fifth was located in the inlet throat adjacent to the Shell Island Resort prior to dredging activities, and was moved to the mouth of the new inlet following completion of dredging and construction. GPS coordinates are provided in Table 1.

Table 1. Global Positioning System (GPS) coordinates and location descriptions of UNCW sampling stations in and near Mason Inlet, 2001-2003.

MI-1	N 34 14.215	W 77 46.512	Throat of inlet
MI-2	N 34 14.637	W 77 46.233	Banks Channel 500 ft north of Mason Creek mouth
MI-3	N 34 14.895	W 77 46.079	Banks Channel outside of the south sedimentation basin
MI-4	N 34 14.827	W 77 46.535	In Mason Creek 1000 ft east of ICW
MI-5	N 34 15.196	W 77 46.755	In ICW at Channel Marker 122

METHODS

Water column vertical profiles were collected on-site by measuring water temperature, turbidity, pH, salinity, and dissolved oxygen at the surface, mid-depth, and one foot from the bottom. These measurements were taken using a YSI Model 6920 multiparameter water quality sonde and Model 610 display unit. Calibration and checks of the YSI instrument were performed using North Carolina Division of Water Quality (DWQ) approved calibration, sampling, and record keeping protocols. Current velocities were taken at surface, mid-depth and one foot from the bottom using a Marsh-McBirney Flo-Mate flow meter.

Surface water samples were analyzed for nitrate+nitrite nitrogen, total phosphorus (TP), total suspended solids (TSS), fecal coliform bacteria and chlorophyll *a*. Chemical samples, fecal coliform bacteria, and suspended solids analyses were performed by a State-certified contract laboratory, except for February 2003, when all samples were analyzed at the UNC Wilmington Center for Marine Science. Chlorophyll *a* was analyzed on all occasions at UNCW using an EPA-approved fluorometric method.

RESULTS

Mason Inlet Environs

Salinity

Salinity at the five sampling stations ranged from 33 - 37 psu. There were slightly higher salinities at the inlet and Banks Channel stations than in Masons Creek and the ICW (Table 2). The only evident seasonality was slightly lower salinities November 2002 - February 2003, probably a result of increased rainfall.

pH

During the study pH ranged from 7.6 to 8.2 among the stations (Table 2), normal for euhaline and nearshore marine salinities. There were no seasonal or spatial patterns evident.

Dissolved oxygen

Dissolved oxygen ranged from 5.8 mg/L to 10.7 mg/L, with a normal seasonal pattern of lowest concentrations in summer and highest in winter. There were no occasions when dissolved oxygen fell below the North Carolina State Standard of 5.0 mg/L.

Turbidity

Turbidity concentrations were generally low at all stations (Table 2), and there was no evident seasonal pattern. The North Carolina brackish water turbidity standard of 25 NTU was exceeded on three occasions; on May 13, 2002 at MI-1 and MI-2, and on August 15, 2002 at MI-3. May 13, 2002 was the only sampling period that yielded generally elevated turbidity levels.

Total suspended solids (TSS)

Total suspended solids concentrations increased at all sites following dredging (Table 2). Although only three collections were made previous to dredging, these collections occurred over a three-week period, and the standard deviation among the three collections was generally quite low. The post-dredging TSS concentrations were approximately twice as high at all stations except MI-5 in the ICW, and the standard deviation of the twelve collections was relatively low. Thus, the increase was likely real and a result of inlet relocation (Fig. 1).

Total phosphorus (TP)

Total phosphorus data at first appearance shows apparently larger post-dredging values compared with pre-dredging (Table 2). However, standard deviations are very large, affected by unusually high TP levels on July 8, 2002. When comparing median values, the concentrations are much closer and show no real difference. Median TP values at MI-1 were 0.017 for pre-dredging versus 0.017 for post-dredging, for MI-2 they were 0.029 for pre versus 0.024 for post, for MI-3 they were 0.023 for pre versus 0.018 for post, for MI-4 they were 0.010 for pre versus 0.014 for post, and for MI-5 they were 0.019 for pre versus 0.025 mg/L for post. Thus, there was no consistent pattern among stations for TP values.

Nitrate-N

Nitrate concentrations were characterized by high variability among sample dates (Table 2) with no clear pattern. Values were generally low throughout, with the exception of a maximum of 0.5 mg/L at MI-3 on August 15, 2002, and a maximum of 0.2 mg/L on that same date at MI-1.

Chlorophyll *a*

Chlorophyll *a* concentrations, (a measure of algal biomass), ranged from 0.6 to 5.2 μg/L, with highest concentrations summer through fall 2002, and lowest during winter months. There was little difference among stations (Table 2), and these concentrations can be considered typical of

nearshore ocean waters in this region. The North Carolina State standard of 40 μg/L was not violated at any time.

Fecal coliform bacteria

Fecal coliform bacteria concentrations were generally low at all stations (Table 2), ranging from 0 to 51 CFU/100 mL. There was no apparent seasonality among coliform counts (Fig. 2). The shellfishing water standard of 14 CFU/100 mL was exceeded on several occasions: December 27, 2001 at MI-1 and MI-3, April 25, 2002 at MI-2, May 13, 2002 at MI-2, May 28, 2002 at MI-4, and September 26, 2002 at MI-1 and MI-3. The human contact standard of 200 CFU/100 mL was not exceeded at any time during the study.

Flow data

The flow data presented here should be considered limited as it represents only snapshots in a strongly tidally influenced system. The surface, middle, and bottom measurements were averaged to obtain the data on Table 2. Additionally, since there was an equipment malfunction only two data points are available for pre-dredging results. Due to the large variability, and the fact that during the latter part of the study some stations were boat accessible only at high tide, few comparisons can be made. However, the data for Mason Creek (Station MI-4) does show much greater flow following inlet relocation than before, as one would expect.

Qualitative observations

The physical attributes of the area around Mason Inlet and Mason Creek changed slowly over time, but some patterns became evident. Shortly after dredging, the inlet and creek stations were all deep enough for boat passage at high tide. Station MI-1, located in the inlet, was measured to be 3-4 meters deep at or near high tide. MI-2, located north of the inlet and closer to the marsh, varied in depth but was usually approximately 1.5 meters deep. MI-3, located in the sedimentation basin south of the inlet, was generally shallower, about 1 to 1.5 meters deep. The station located within the creek, MI-4, was about 3 meters deep after dredging. MI-5 was located within the Intracoastal Waterway and was not visibly affected by the dredging, though some sedimentation may have occurred.

In the months following dredging, it was observed that the inlet itself seemed narrower, with waves breaking closer to the sound area. The sand on the north end of Wrightsville Beach began to form a spit extending outward in a northwest direction. Also, it was noted that the area between the inlet and MI-2 became shallower with shoaling occurring between the back of the barrier island and marsh area. In February 2003, we were only able to get within 500 feet of MI-2, due to shallow waters. The sedimentation basin filled in gradually, but eventually made it impossible to sample the original site of MI-3. In February 2003, we were able to get within 1000 feet of the site, sampling in less than 0.5 meters of water. Mason Creek also became shallower in the months following the dredging. MI-4 had a depth of 1.5-2.0 meters from November 2002 to February 2003.

Table 2. Parameter concentrations before and after Mason Inlet relocation, presented as mean ± standard deviation (fecal coliform bacteria presented as geometric mean). Pre-n=3, Post-n=12

Station	MI-1	MI-2	MI-3	MI-4	MI-5
Salinity (psu)					
Pre	36.6±0.3	36.6±0.3	36.6±0.3	36.3±0.7	35.7±1.2
Post	36.0±0.7	36.6±0.7	36.0±0.7	35.4±1.2	35.4±1.2
pH					
Pre	8.0±0.2	8.0±0.1	8.0±0.1	7.9±0.2	8.0±0.1
Post	7.9±0.2	8.1±0.1	8.1±0.1	8.0±0.1	8.0±0.1
DO (mg/L)					
Pre	8.5±0.8	8.2±0.2	8.2±0.2	8.3±0.1	8.5±0.5
Post	7.8±1.1	7.7±1.2	7.7±1.1	7.3±1.4	7.3±1.5
Turbidity (NTU)					
Pre	3±2	3±2	3±2	5±7	2±2
Post	7±7	5±8	10±11	5±5	5±3
TSS (mg/L)					
Pre	23.1±0.3	26.3±3.4	23.1±2.2	25.0±2.1	29.4±13.4
Post	47.3±9.9	51.7±8.2	50.4±7.7	50.8±6.4	49.9±8.0
TP (μg/L)					
Pre	16±4	41±27	29±12	17±16	16±7
Post	61±137	32±32	65±108	34±45	39±42
Nitrate-N (μg/L)					
Pre	45±13	28±8	44±9	64±33	70±40
Post	38±55	15±11	63±146	20±13	43±55
Chlorophyll *a* (μg/L)					
Pre	1.3±0.3	1.3±0.3	1.3±0.7	1.1±0.7	0.9±0.3
Post	2.0±1.2	1.7±0.9	1.8±1.0	2.3±1.6	2.5±1.6
Fecal coliforms (CFU/100 ml)					
Pre	4	4	5	2	2
Post	2	2	2	3	2
Flow (m/s)					
Pre	0.74±0.40	0.39±0.08	0.32±0.04	0.08±0.07	0.39±0.00
Post	0.51±0.44	0.28±0.17	0.18±0.23	0.47±0.23	0.20±0.10

Howe Creek

Howe Creek data were examined to see if the relocation of Mason Inlet had any effect on tidal creek water quality. We used fecal coliform counts as the measure because fecal coliform counts are typically inversely related to salinity (Mallin et al. 2000a), and we used measured salinity and rainfall data to help explain the results. Dredging the mouth of Futch Creek had led to both increased salinity and decreased fecal coliform counts in that nearby tidal creek (Mallin et al. 2000b). Fecal coliform bacterial counts had been collected from August 2001, before dredging, through the dredging and are scheduled to continue until at least July 2003, over a year following dredging. In this report we examine the six months of pre-dredging data collected from August 2001 though January 2002 and compare it with six months of post-dredging data collected from August 2002 through February 2003 (October 2002 was not sampled). Salinity data were collected on station during the fecal coliform collections.

The data show that fecal coliform counts for the lower four stations in the creek showed little change in either direction following dredging (Table 3). The lower two stations continued to show low coliform counts and the middle two stations moderate coliform pollution. However, the uppermost station (essentially as far upstream as one can safely take a boat on high tide) showed a distinct decrease in terms of the geometric mean of the six months from 325 to 185 CFU/100 mL.

Table 3. Fecal coliform bacterial concentrations in Howe Creek before and after Mason Inlet relocation, presented as geometric mean. Pre-August 2001-January 2002, n=6, Post-August 2002-February 2003, n=6. Sampling date salinity data are presented as mean ± standard deviation.

Station	HW-M	HW-FP	HW-GC	HW-GP	HW-DT
Fecal coliforms (CFU/100 ml)					
Pre	2	2	11	87	325
Post	4	4	14	74	185
Salinity					
Pre	35.7±0.9	35.5±1.0	34.8±1.8	27.5±9.5	15.4±13.5
Post	31.2±3.8	33.0±2.3	29.4±5.2	20.0±10.3	2.5±1.9

Salinity data collected at the time fecal coliforms were sampled in Howe Creek showed that lower salinities prevailed following the dredging of the new Mason Inlet channel (Table 3). Thus, the reduction in fecal coliform bacterial counts in upper Howe Creek is not likely associated with salinity increases associated with the moving of Masons Inlet. It is more likely that fecal coliform counts in upper Howe Creek are associated with local runoff factors, especially rainfall variability. To test this we performed correlation analyses among untransformed fecal coliform counts, salinity, and total rainfall for the 72-hour period preceding fecal coliform collections at HW-DT. There was no significant correlation between fecal coliforms and salinity. However, there was a significant correlation ($r = 0.644$, $p = 0.024$) between fecal coliform abundance and rainfall. Thus, rainfall-

driven runoff variability was the factor most likely responsible for the decrease in fecal coliforms in upper Howe Creek following inlet relocation. Extensive water quality data for Howe Creek can be found at our Tidal Creeks website:
http://www.uncwil.edu/cmsr/aquaticecology/TidalCreeks/Index.htm

DISCUSSION

With the exception of total suspended solids, the relocation of Mason Inlet has not led to any adverse water quality impacts in Mason Creek or other nearby locations. State-regulated water quality parameters including turbidity, chlorophyll *a*, and fecal coliform bacteria counts showed few violations of North Carolina State standards either before or after inlet relocation, and dissolved oxygen remained well within required limits at all times. Total suspended solids concentrations doubled at four out of the five stations following project completion. We suspect that this was due to the higher energy entering the system from the new inlet having greater ability to move the sand particles around. Since turbidity and chlorophyll *a* remained low after dredging, the TSS measurements consisted primarily of sand particles that are individually large but do not unduly cloud the upper water column. Observations of the rapid filling in of Banks Channel and Mason Creek following dredging tend to support this speculation.

The water quality of Howe Creek has likewise not had any ill effects from the Mason Inlet project. In fact, the uppermost station has demonstrated a decrease in fecal coliform counts. Since salinity during the coliform collections was actually lower following inlet relocation, the decrease in the upper watershed was likely not related to the dredging project, but to rainfall variability and localized runoff patterns. UNCW is continuing its sampling program in Howe Creek to follow water quality fluctuations, especially in light of the new development activity along Military Cutoff and its potential effect on upper Howe Creek.

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