Framework for the Evaluation of New York's Sand Resource Needs

Prepared for

NYS DOS

Prepared by

Henry Bokuniewicz
School of Marine and Atmospheric Sciences
Stony Brook University
Stony Brook, NY 11794-5000

June 2018

Stony Brook University's COAST Institute

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RECOMMENDATIONS

- Recreating an inventory of past sand borrow activity is both difficult and time-consuming. Accurate data in project reports and permits are not routinely compiled or summarized in one place. Going forward, it would be helpful to develop an active database of projects in a standard format as they are completed. This should include a rolling inventory of the location of designated borrow areas, the specific location within the borrow area from which sand was extracted, quantity extracted, location of beach placement. quantity placed at each beach location and dates of placement.

- Establish a mechanism for improved agency coordination among NYS DOS to include appropriate representatives for the New York District Army Corps of Engineers, NYS DEC, BOEM, NYC DEP, Nassau and Suffolk County. The purpose is to meet annually to assess sand demand and the current state of the resource, create a table of beach nourishment accomplished in the previous year and report on new designations or changes in borrow areas and the anticipated schedule for upcoming nourishment projects.

- Precise locations of dredging within the identified borrow areas should be monitored in near-real time during the period of active dredging and used to assess both physical and biological impacts (Bokuniewicz and Jang, 2018). A high-resolution measure of dredging intensity can be derived from AIS data on grid cells fifty or one hundred meters on a side. Although uncertainties abound, both dredging and assessments can be done to minimize disruptions to physical processes and morphological features, like sand ridges which may serve as natural conduits for sand transport from offshore to onshore environments and naturally replenish beaches.

- High resolution habitat maps need to be produced offshore of New York's ocean shoreline, covering areas out to eight nautical miles. Offshore habitats mapping has come to rely on the use of abiotic proxies to provide high-resolution habitat maps to resource managers (Brown and Blondel 2009; Buhl-Mortensen et al. 2015). Multibeam echo sounders in particular have revolutionized mapping of benthic habitats (Brown and Blondel 2009), because their products can discriminate differences in habitat value using bathymetric information, such as slope, and topographic roughness, resolved to one-square-meter areas over large parts of the sea floor (Calvert et al. 2015). Discrimination of habitats over distances of as little as 200 meters has been found to capture important changes over distances of tens of meters among the clutter of very small-scale variation (Calvert et al. 2015).

INTRODUCTION

This document is a consideration of the management and sustainability of offshore sand resources needed by coastal communities along New York's ocean shoreline to address routine beach erosion and recover from severe storms and increased development that has reduced the natural ability of beaches to sustain erosional forces. Management of these sand resources is intended to sustain resilient coastal communities as well as to maintain important beach and coastal habitats, both at the shore and offshore benthic habitats.

The sustainability of offshore sand resources depends on three conditions (Hilton 1994). First, the volume removed by dredging should be insignificant compared with the total volume of the resource or, second, dredging should occur at a rate that is commensurate with the rate of natural recovery of the resource. Third, adverse impacts on morphological features and sand habitats should be avoided. The three conditions require adequate knowledge of the volume of available sand, the total demand, the rate of removal, the rate of natural replenishment and recovery and the area of benthic disturbance.

If the total volume of sand excavated from offshore borrow sites is, and continues to be, small compared to the total volume of the resources, it may be possible to sustain demands in the near-term. Evaluating this condition requires a reasonable estimate of future demand. The history of past demand can serve as a guide augmented by the professional judgement of, notably, the U.S. Army Corps of Engineers. The volume of the resource has been variously estimated, however, only a fraction of offshore sand is a suitable resource for beach nourishment. This fraction is estimated by overfill factors, requiring the grain-size characteristics not only of the borrow sand but also of the native beach. As suitable sand resources are depleted, sustainability depends on the rate of recovery of borrow areas or the expansion of the new sources.

The impact on sand habitats and morphological features depends on frequency of dredging events, type of dredge, and locations among other things. The number of benthic species in a borrow area might be reduced by more than 50% after dredging (Desprez 2000; Boyd and Rees, 2003; Newell et al. 1998, 2004; ICES 2009; Krause et al. 2010). Recovery of abundance and biomass and diversity may occur within a few months after recruitment (Byrnes et al. 2004; Michel et al. 2013), but community-structure recovery time can take up to 15 years following dredging at high intensity (Turbeville and Marsh. 1982; Boyd et al. 2003, 2004; Thrush et al. 2008; Birchenough et al. 2010; Wan Hussin et al. 2012; Waye-Barber et al. 2015).

Consistent use of a quantitative parameter of dredging intensity as a proxy for volume/area/time of dredging would be an important step in the comparison of the environmental impact of aggregate extraction.

DREDGING FUNDAMENTALS

Excavation of marine sand for beach restoration is usually done using ocean-going trailing suction hopper dredges. These self-propelled vessels have two, long suction pipes, called dragarms, attached, one on each side. The mouths of the dragarms, called dragheads, are dragged over the seabed to extract sand. The other end of the dragarm is attached through pumps to the ship's hopper. Offshore dredging is undertaken in designated "borrow" areas. There are 44 borrow areas in New Your State waters along the ocean shoreline that have been used in the past or are proposed for use now or in the future When the dredge arrives at the designated borrow area, its speed is reduced to two or three knots (Vlasblom 2007, p13). The suction pipes' dragheads are lowered to the sea floor. Sand is pumped through the dragheads and suction pipes into the ship's hopper, later to be transported to the beach nourishment site and discharged. Trailer-section dredging results in tracks across the sea floors that are usually less than 22 inches deep (van Moorsel & Waardenberg, 1990; Kenny & Rees, 1994; Boyd et al., 2003: Davies & Hitchcock, 1992). Removal of the surface 20 inches of the seabed is sufficient to eliminate the benthos from the deposits. So, as will be discussed later, benthic habitats can be impacted in places where the changes in bathymetry are unresolved by bathymetric surveys.

To nourish a beach, the rule of thumb is "one cubic yard per foot of beach width per foot of shoreline" (e.g. Waldner 2004). Because of the mix of grain sizes both on the beach and at the borrow area, however, only part of the sand excavated from a borrow area will end up being suitable for nourishing the beach. The overfill factor accounts for the mismatch. For instance, if the borrow sand has an overfill factor of, say, 1.3 and you need 100,000 CY of sand on the beach, you will need to excavate 130,000 CY of sand from the borrow area.

DEMAND FOR BEACH NOURISHMENT

The demand for beach nourishment had been compiled from available inventories from 1950 to 2017. BOEM had provided an undocumented GIS inventory of "Large Beach" projects nationwide, and an independent inventory for New York had been compiled by Kana (1995). While the broad outline of New York's demand was probably well-represented, accounts lacked precision and various attempts at an inventory did not agree in detail. There were gaps in the records, especially in the early years, and there was some uncertainty whether the reported volumes were contracted amounts (as opposed to a summation of hopper-loads, or based on pre-and-post-surveys at the borrow site), or whether the reporting period was a calendar year or fiscal year. In addition to the abovementioned inventories, since 2001, records for the New York ocean coast have been compiled by the International Council for the Exploration of the Seas' Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem:

http://www.ices.dk/community/groups/Pages/WGEXT.aspx

This is compiled by the author annually from personal request to the relevant managers in the US Army Corps Districts of New England, New York, Philadelphia, Baltimore and Norfolk.

Although the record is flawed, in previous years, the annual demand averaged 1,242,202 cubic yards (CY) per year ranging from a high value of 2,109,098 CY per year in the interval from 1975 to 1979, to a low value of 200,000 CY per year between 1950 and 1954 (Bokuniewicz and Huang 2015). The location of the demand is important because the grain size of the native beach at the particular location determines what offshore sand bodies would be a suitable resource.

The Navigation Data Center of the U.S. Army Corps of Engineers, Institute for Water Resources (7701 Telegraph Rd, Alexandria, VA 22315) maintains the U.S. Waterway Data, which is a collection of data related to the navigable waters in the U.S., including an annual compilation of dredging in all Corps Districts. The tabulation contains information on each awarded dredging contract advertised by the Corps of Engineers from FY 1990 to Present. For each record, the file contains fiscal year, Corps of Engineers District, and name of dredging location, representative latitude and longitude of the dredging area, units of contract measurement, the estimated number of units, the quantity of dredged material in CY(the equivalent CY if the units were not cubic yards, i.e. hours), type of dredge used, class of work, type of material disposal, dates of bid advertisement, opening and contract award, small business set aside restrictions, government estimate, number of bidders, winning bid, winning bidder, city, state and small business status of winner. For our purposes, the data can be extracted and filtered as follows:

Go to <http://www.navigationdatacenter.us/db/dredging/xls/ > [1] called the "Index of/db/dredging/xls". In that index, look for the directory named "dredging.xlsx" (it should have been modified on a recent date). Selecting "dredging.xlsx" will download an EXCEL table. The legend can be found at http://www.navigationdatacenter.us/dredge/drgadv.htm (Appendix 1). You'll need to winnow out the New York data. Select the entire page and sort on Column B "DISTNAME". Delete all rows except NEW YORK. To simplify further processing, the following columns may be deleted:

J	UNITMATR	Material units
K	EST_QUAN	Estimated quantity
L	EQ_CU_YD	Estimated CY (if the "quantity" is not CY already)
M	PRDRTYPE	Project dredge type
N	CLASSWRK	
P	ADV-DATE	
Q	BOPENDAT	Date bids opened
R	AWARDDAT	Award Date
S	ESTSTART	Estimated start date
T	ESTEND	Estimated end date
U	SET_ASIDE	
V	TOT-EST	
W	NUM_BID	Number of bidders
X	TOT_BID	Total bids
Y	CONTRNAM	Contractor's name
Z	CITY	Contractor's City
AA	STATE	Contractor's State
AB	SMALLBUS	Is this a "small business"?
AC	ACT_ARR	Actual arrival date
AD	ACT_DEP	Actual departure date
AF	ACTUAL_CST	Actual cost

…keeping:

D	JLATDEG	DEGREES OF LATITUDE OF THE PROJECT SITE
E	JLATMIN	MINUTES OF LATITUDE OF THE PROJECT SITE
F	JLATSEC	SECONDS LATITUDE OF THE PROJECT SITE
G	JLONDEG	DEGREES OF LONGITUDE OF THE PROJECT SITE
H	JLONMIN	MINUTES OF LONGITUDE OF THE PROJECT SITE
I	JLONSEC	SECONDS LONGITUDE OF THE PROJECT SITE
O	DISPTYPE	DISPOSAL TYPE (e.g. "beach nourishment")
AE	ACTUALCY	ACTUAL VOLUMN IN CUBIC YARDS

[1] You can also reach this site from: http://www.navigationdatacenter.us/db/dredging/ This is the INDEX OF DATA BASE dredging in the index look for the directory named "xls/" in the list. Select "xls/" to bring you to http://www.navigationdatacenter.us/db/dredging/xls/

An example of the resultant product is shown in Appendix 2. There are several issues with the NDC tabulation that need to be resolved. The latitudes and longitudes that are intended to show the borrow area locations were incomplete and seemed to contain some errors. Out of 72 entries between 1990 and 2015, 17 had locations of the borrow area used and, at least some locations were not correct. The annual totals do not seem to agree with the ICES/WGET inventories, but this likely to be an issue of the difference in reporting calendar years and fiscal years and, finally, the tabulation is only for Corps projects. State and local projects would have to be compiled separately.

Based on personal communication with the New York District, Army Corps of Engineers, 5,927,951 CY of sand was extracted in 2016 for beach renourishment projects at four sites in New York and 4.8 million CY was placed on Rockaway Beach in 2017:

2016	Smith Point County Park	2,211,000 CY
2016	Kismet to Seaview	1,640,000 CY
2016	Robert Moses State Park	1,556,952 CY
2016	Sea Gate, Staten Island	480,762 CY
2017	Rockaway Beach	4,804,680 CY

Beach nourishment projects by the Corps of Engineers require, not only the volume of an initial fill but also periodic renourishment needed to sustain the project for 50 years. An inventory of 15 projects provided (https://www.boem.gov/Mid-Atlantic-Sand-Management-Working-Group-Webinar-12-14-2017/) a demand for 120,118,170CY to the year 2063 and estimated a shortage in identified resources of 17,200,000 CY.

AVAILABLE SAND RESOURCES

Estimates of undifferentiated sand volumes in designated borrow areas in State water range from 52,000,000 to 75,000,000 CY (Table 1).

Table 1. Estimates of sand volumes in designated borrow areas

Borrow area	Volume of Holocene sand, Cubic Meter	Sand volume assuming a one-meter layer	Differential*
1994 Saltaire/Fair Harbor/Dunewood Borrow Area	1,460,364	567,446	892,918
1997 Fire Island Pines Borrow Area	544,651	1,187,308	-642,656
1A	308,613	249,157	59,456
2A	1,633,180	1,148,402	484,778
2B	6,633,995	2,246,345	4,387,650
2C+2C expanded	11,262,288	5,405,601	5,856,687
2D	1,900,445	914,458	985,988
2F	660,410	248,832	411,577
2G	321,713	251,275	70,438

2H	73,941	244,080	-170,139
3A	1,994,471	3,692,438	-1,697,968
3B	194,501	247,584	-53,083
4A	39,270	283,204	-243,934
4B	805	343,103	-342,298
4C	176,938	253,897	-76,959
5A	101,768	618,995	-517,227
5B	711,655	2,339,261	-1,627,607
5B expanded	1,298,039	2,935,936	-1,637,897
6A	27,996	309,726	-281,730
6B	313,512	99,672	213,841
6C	60,272	442,859	-382,587
6E	226,759	258,038	-31,279
6F	68,017	242,587	-174,570
6G	66,153	239,456	-173,303
6H	71,640	239,343	-167,704
6I	17,314	248,177	-230,863
7A	51,123	852,131	-801,008
7B	4,333	246,105	-241,772
7C	924	252,848	-251,923
7D	92,460	251,230	-158,770
8A	293,810	2,428,643	-2,134,833
8B	373,698	252,415	121,283
8C	1,043,304	585,252	458,052
8D	21	242,668	-242,647
CI	0	1,555,587	-1,555,587
P&E Western Borrow Area	847,084	845,740	1,344
PE&E Eastern Borrow Area	1,995,657	629,864	1,365,793
Long Beach	0	6,417,025	-6,417,025
Shinnecock	4,802,941	13,327,953	-8,525,012
Westhampton Eastern Borrow Area	143,181	400,900	-257,719
Westhampton Western Borrow Area	35,794	422,232	-386,438
A-West	0	1,570,753	-1,570,753
A-East	0	1,599,536	-1,599,536
B-West	0	131,607	-131,607

* Values greater than zero indicate that more sand is found in the Holocene cover than would be recovered in the excavation of a uniform layer one-meter thick. A value less than zero means that the excavation of a uniform layer one-meter thick would provide more sand than is to be found in the Holocene layer alone.

BOEM conducted detailed surveys at three locations in federal waters along the south shore of Long Island (Figure 1). In these, two proven sand reserves were identified and two other potential reserves (Flood et al. 2018). In all, these were estimated to contain 17.8 million cubic yards of sand as follows:

Fire Island Inlet	1.5 Million CY
Fire Island	10.0 Million CY
Fire Island	4.2 Million CY
Moriches Inlet	2.1 Million CY

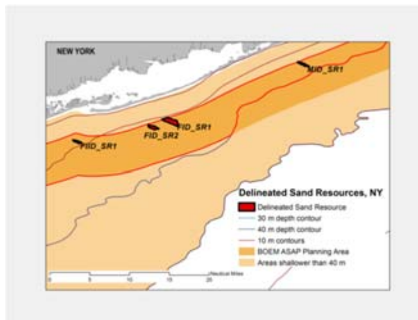

Figure 1. Sand resources identified in Federal water (Flood et al. 2018).

Off the south shore of Long Island, unconsolidated sediments reach a maximum thickness of about 1.9 miles (3 kilometers) essentially giving a volume of material approaching eighty trillion CY. Of course, not all this is sand, and only a fraction of the sand is both within the reach of dredging technology and of suitable quality for beach nourishment.

Bliss et al. (2009a) used existing sedimentological data and probability statistics to model the amount of undiscovered Holocene-aged sand, presumably suitable for beach nourishment, contained in an area extending from a water depth of 33 feet to a depth of 131 feet off the south shore of Long Island between Long Beach and Montauk Point. Bliss et al. (2009a) believed offshore sand resources should only be considered if the borrow area is seaward of the active zone of significant nearshore sediment transport which they put at about 33 to 39 feet water depth, and in sufficiently shallow water so that sand can be extracted within the depth limits of U.S. dredging equipment limits, estimated to be 130 feet (Bliss et al. 2009b). They estimated the mean volume of undiscovered Holocene sand in this 867,000 acres tract was 2.2 billion CY or about 2,500 CY per acre, although not all this sand would necessarily be suitable and available for extraction due to political, environmental, geographical, geological or other factors (Bliss et al., 2009a).

Based on an analysis of core samples and (widely spaced and relatively low resolution) seismic records taken along the stretch of coast between Tobay Beach and Montauk Point, Williams (1976) estimated that between 5.3 and 7.3 billion CY) of sand was available for recovery with the dredging techniques available at that time in the area between the beach and a depth of 32 m. This area is approximately 369,000 acres giving an average of between 14,400 and 19,800 CY per acre. These estimates include both the modern Holocene-aged and Pleistocene-aged sands. However, more specific estimates based on high-resolution mapping of the sea floor and shallow stratigraphy (Foster et al., 1999) indicated that the study area between Tobay Beach and Montauk covered 290,000 acres to a water depth of about 83 feet and a distance of about 6.2 miles from shore; this area was estimated to contain approximately 1.3 billion CY or 4483 CY/acre of Holocene-age sand (Williams, electronic communication, 2007).

The Corps estimated the proposed "Fire Island Inlet to Montauk Point Storm Damage Reduction" (FIMP) project will require about 55 million CY of sand for beach nourishment over its lifetime, or 1.1 million CY per year. Estimates of the volume of beach compatible sand found on the shelf less than 130 feet deep range from about 1.3 billion CY to 7.3 billion CY (depending on the geographic area considered and the data used (Foster et al., 1999; Williams, 1976).

One way to estimate the volume of sand available in each borrow area is to multiply the area by one meter (Table 2). This accounting gives a total of about 75 million CY. Alternatively, the USGS isopach map of the Holocene sand (Foster et al. 1999) can be used to calculate the total volume of Holocene sand in each borrow area. For each borrow site, the average thickness of the Holocene sand can be calculated and multiplied by the area of the site. Holocene sand quantity estimates, do not include potential non-Holocene deposits in the area that may include suitable sand for beach nourishment. This accounting gives a total of about 52 million CY, but does not take into account the suitability of the sand for any particular beach, as discussed in the next section.

COMPATIBILITY

Any mismatch between the sand excavated at the borrow site and the native sand at the beach nourishment site is accounted for by an "overfill factor". The overfill factor is calculated by comparing the grain-size distribution of the borrow-area sand to that of the native sand on the beach. Two commonly used methods of calculating the suitability of sand for the renourishment of a particular beach are "Shore Protection Manual" (SPM) method (USACE 1984) developed by Krumbein and James (1965, James 1974, 1975), and the Dean method (Dean 1974, 2000, 2002). The SPM method tends to give more conservative, that is larger, values of the overfill factor, because it assumes that both the fraction of borrow sand that is coarser than the native beach sand and the fraction of borrow sand that is finer than the native beach sand will be removed from the beach fill and ultimately will not contribute to the nourishment. On the other hand, the Dean method assumes that only the finer fraction will be lost. As a result, the Dean method tends to give less conservative (smaller) overfill factors.

As a screening tool, however, the Dean (2000) method is recommended because it depends on only three parameters. These are the mean phi-size of the beach (native) sand M_n, the mean phi-size of the borrow sand, M_b, and the standard deviation of the borrow area sand, σ_b. These can be combined into a single parameter (Bodge 2006):

$$(M_b - M_n)/\ \sigma_b \qquad [2]$$

The ideal material would have a Dean overfill factor, K, less than or equal to 1.05, corresponding to a standard deviation at least nine times greater than the difference between the mean grain sizes, that is $(M_b\text{-}Mn)/\sigma_b = 0.11$. An overfill factor of 1.3 could be acceptable however; this corresponds to $(M_b\text{-}M_n)/\sigma_b < 0.4$ (Bodge 2006). From these rules-of thumb we can define a "suitability index" for screening purposes only. The most suitable material would have $(M_b\text{-}0.11\ \sigma_b) < Mn$. Adequate material would have (M_b-0.4 σ_b) < Mn and unsuitable material would have (M_b-0.4 σ_b)> M_n (Table 3).

Table 2. Screening criteria for the suitability of renourishment sands*.

Borrow sand	Suitability Index
Suitable	(M_b-0.11σ_b) < M_n
Adequate	(M_b-0.4σ_b) < M_n
Unsuitable	(M_b-0.4σ_b)> M_n

***the subscript "b" refers to the sand at the borrow site. "n" refers to the native material or, in other words, the sand at the beach site to be renourished.**

Mean grain size and the standard deviation of bed samples were compiled in usSEABED (Reid et al. 2005; http://pubs.usgs.gov/ds/2005/118/accessed 2015). In the study area shallower than 30 m, 891 samples were tabulated in usSEABED. The criteria used here is only a preliminary screening tool, but it suggests that only 30% of the area could provide adequate replacement for any of the beaches between Fire Island inlet and Montauk Point (Figure 2). About 22% were suitable for beach nourishment for at least one beach location and an additional 9% were adequate for at least one beach location. Only 4% were adequate for all locations, but about 9% were suitable for almost all beach locations and an additional 7% were adequate for almost all stations.

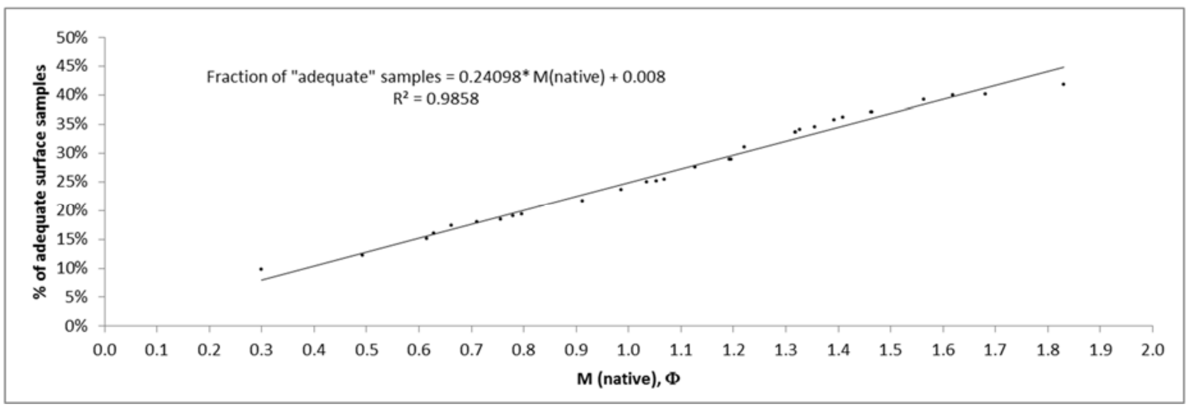

Figure 2. Percentage of USGS offshore sand samples providing adequate sand for native beaches.

NATIVE (BEACH) SAND CHARACTERISTICS

In 1982, sand was collected along 34 cross-shore transects between Fire Island Inlet and Montauk Point. Samples were taken from (1) the base of the dune, (2) the berm crest, (3) mean high water, (4) mean low water, and at water depths of (5) two meters, (6) four meters, (7) six meters, (8) eight meters and (9) ten meters (Tsien, 1986). Sampling was repeated in 1995 along 59 transects in the same stretch of shoreline. A beach grain size model was developed by the USACE from the latest data set in 11 sections of the coast between Fire Island Inlet and Montauk Point. These were chosen based on pumping distance, similarity of grain-size distribution, and other factors (Table 2).

In terms of the entire set of USGS surficial sand samples, without regard to location relative to the beach, about one-third of the offshore sand would be deemed "adequate" (overfill factor of 1.3 or less). Alternatively, the Corps of Engineers has done a preliminary estimate of the volumes of

Table 3. Native Beach Sands in FIMP.

Model	Location	Mean Grain Size Φ	Percentage of USGS surficial samples deemed "adequate"
GSB-D1	Robert Moses State Park to Fire Island Lighthouse	1.34	33%
GSB-D2	Kismet to Cherry Grove	1.33	33%
GSB-D3	Cherry Grove to Watch Hill	1.26	31%
GSB-D4	Fire Island Wilderness Area	1.25	31%
MB-D1	Smith Point County Park	1.25	31%
MD-D2	Moriches Inlet to Westhampton Groin field	1.15	29%
SB-D1	East of Westhampton Groins to Tiana Beach	1.33	33%
SB-D2	Vicinity of Shinnecock Inlet	1.14	28%
SB-D3	Southampton Beach	1.26	31%
P-D1	Agawan Lake to Amagansett	1.15	29%
M-D1	Amagansett to Montauk Point	1.05	26%

sands deemed "adequate" for the FIMP study area using vibracore samples and taking into account proximity to the receiving beach (Table 3). With these targeted adjustments, 75% of the designated sand reserves were deemed adequate.

Table 6 from:
http://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/ny/coast/fimp/FIMP%20GRR/HSGRRAppendix%20B%20-%20Borrow%20Area.pdf?ver=2016-07-19-184707-047

Beach Model	Vicinity	Borrow Area ID	Suitable Cores	Average Dredging Cut Depth in ft	Area in acres	Assumed % Unusable	Average Ra	Environmental Analysis Status	Available Volume in cy	Subtotal Available Volume in cy
GSB-D1		no suitable borrow areas							0	
GSB-D1										0
GSB-D2	F15	1A	97-6	10.5	90	25%	1.02	Not Done	1,140,000	
GSB-D2	F32	2C	ICONS 71, 79-2-9, FII 2, 97-2	12.7	522	25%	1.03	Complete	8,010,000	
GSB-D2										9,150,000
GSB-D3	F38	2B	79-2-12, 98-3	5	500	25%	1.05	Complete	3,020,000	
GSB-D3	F43	2F	79-2-1	9.5	90	25%	1.04	Not Done	1,030,000	
GSB-D3	F46	2G	97-5	4.3	90	25%	1.04	Not Done	470,000	
GSB-D3	F49	2A	VC98-6	15	165	25%	1.25	Complete	2,990,000	
GSB-D3	F47	2D	VC98-5	10.1	200	25%	1.28	Complete	2,440,000	
GSB-D3	F54	2H	ICONS 67	17.2	90	25%	1.19	Not Done	1,870,000	
GSB-D3										11,820,000
GSB-D4	F61	3A	79-3-7, 79-3-9, VC98-7	7	609	25%	1.06	Complete	5,150,000	
GSB-D4	F67	3B	VC98-8	4.6	90	25%	1.21	Not Done	500,000	
GSB-D4										5,650,000
MB-D1		no suitable borrow areas							0	
MB-D1										0
MB-D2	W5	4A	CB-37, VC98-12	13	74	25%	1.26	Complete	1,160,000	
MB-D2	W5	4B	CB-43	20	140	25%	1.10	Complete	3,380,000	
MB-D2	W13	4C	CB-40	20	90	25%	1.22	Not Done	2,180,000	
MB-D2										6,720,000
SB-D1	W18	5A	VC98-18, VC98-20	14.5	132	25%	1.16	Complete	2,310,000	
SB-D1	W20	5B exp	CB-14, CB-15, CB-22, CB-23, CB-24	18	300	25%	1.21	Not Done	6,530,000	
SB-D1	W23	5B	CB-12, CB-13, 79-5-1, VC98-21, VC98-22, VC98-23, VC9	13	610	25%	1.20	Complete	9,580,000	
SB-D1	W28	5C	CB-11	15	43	25%	1.17	Not Done	780,000	
SB-D1										19,200,000
SB-D2	W44	6B	97-Alt1	17.8	23	25%	1.19	Not Done	490,000	
SB-D2										490,000
SB-D3	P10	6C	79-6-17, SHIN 12	9.9	110	25%	1.18	Not Done	1,320,000	
SB-D3	P12	6D	SHIN 15	10.2	90	25%	1.28	Not Done	1,110,000	
SB-D3										2,430,000
P-D1	P14	6A	79-6-13	15	74	25%	1.22	Completed	1,340,000	
P-D1	P16	6E	ICONS 34	10	90	25%	1.05	Not Done	1,090,000	
P-D1	P18	6F	79-6-8	9	90	25%	1.16	Not Done	980,000	
P-D1	P23	6G	79-6-5	10	90	25%	1.25	Not Done	1,090,000	
P-D1	P25	6H	79-6-2	10	90	25%	1.10	Not Done	1,090,000	
P-D1	P29	6I	VC98-30	15	90	25%	1.17	Not Done	1,630,000	
P-D1	P39	7A	VC98-32	8	90	25%	1.16	Completed	870,000	
P-D1	M1	7B	79-7-9	12	90	25%	1.09	Not Done	1,310,000	
P-D1	M2	7C	79-7-7	11	90	25%	1.23	Not Done	1,200,000	
P-D1	M6	7D	79-7-3	5	90	25%	1.19	Not Done	540,000	
P-D1	M8	7E	VC98-33	15	90	25%	1.10	Not Done	1,630,000	
P-D1										12,770,000
M-D1	M11	8A	79-8-9, VC98-34	15	184	25%	1.23	Completed	3,340,000	
M-D1	M15	8B	ICONS 29	11	90	25%	1.06	Not Done	1,200,000	
M-D1	M19	8C	79-8-1	8	90	25%	1.09	Not Done	870,000	
M-D1	M27	8D	VC98-35	13.3	90	25%	1.13	Not Done	1,450,000	
M-D1										6,860,000
Total Borrow Volume Available										**75,090,000**

For Fire Island, the median grain size modeled for west Fire Island was 1.36 Φ, and it was 0.94 Φ for east Fire Island (USACE, 2014b). Along the length of Fire Island, five grain size models were developed (USACE, 2014c). In 2009, several beaches on Fire Island were renourished. The constructed beaches had the following grain sizes (Coastal Planning and Engineering, Inc. 2009a):

Project Area	Mean Grain Size, □	Percentage of USGS surficial samples deemed "adequate"
Western Fire Island SFD-5	0.86	22%
Western Fire Island Sta. 29+00	0.94	23%
Western Fire Island Sta. 60+00	1.47	36%
Central Fire Island Sta. 26+00	0.92	23%
Fire Island Pines Sta. 12+00	1.00	25%
Davis Park Sta. 18+00	0.69	17%

For the restoration project after "Superstorm" Sandy, the U.S. Army Corps of Engineers (USACE) designed beach renourishment based on grain-size models calculated from suites of samples for designated sections of the shoreline. In Long Beach Island, the modeled grain sizes (USACE 2014; Coastal Planning and Engineering Inc. 2009b) were:

Location	Median Φ	Location	Percentage of USGS surficial samples deemed "adequate"
City of Long Beach	2.18	unspecified	53%
Atlantic Beach	2.18	40.5857; -73.7291	53%
Lido Beach	2.25	40.5857; -73.6231	55%
Neptune Blvd	1.89	40.5831; -73.6467	46%
Long Beach Blvd.	1.94	40.5832; -73.6582	48%
Lindell Rd.	1.94	40.5837; -73.6812	48%

* Assuming a normal distribution, the median equals the mean.

Grain-size models for the beach at Rockaway had a grain-size model value of 1.79 Φ (USACE 2016). At Long Beach the average value was 2.21 Φ (USACE 2014). Across the study area from Breezy Point to Montauk Point, the design-beach phi-size decreases by about 0.44 Φ per minute of longitude[2], from 1.79 Φ to 1.05 Φ, representing a fraction of "adequate" surficial sand of about 43% to 25% respectively (Figure 2). That is to say, the beach sand gets coarser from west to east. Because an adequate sand supply for beach nourishment is generally coarser than the native beach sand, there will likely be more sand found on the shelf that is adequate for beach nourishment of beaches in the west than for beaches in the east.

SUSTAINABILITY

If the total volume of sand required for beach nourishment project is more than a few percent of total supply of available offshore sand, the sustainability of the resource depends on the rate at which sand may be redistributed by natural processes on the sea floor, but incomplete knowledge regarding sediment transport and the interactions between the shelf and nearshore system pose significant challenges in managing and possibly utilizing this resource. The inner continental-shelf is a mobile sea bed; however, determining net sediment fluxes remains an elusive goal. Rates of transport and regional patterns of pathways for mobile sand that would be needed to estimate sustainability of specific borrow areas are not well known. Modeling is possible (e.g. Warner et al. 2008; Byrnes et al. 2004) although specific data needed to exercise such models is often lacking.

Another approach relies on monitoring bedforms and changes in bathymetry tempered, as discussed earlier, by uncertainties in the process of bathymetric surveying. Repeated bathymetric surveys can document sand accumulation, if it is large enough. The storm conditions on the east coast of the U.S. during Superstorm Sandy shifted large sand deposits many yards and caused deposition of layer of sand a foot or more thick (Goff et al. 2015). The rate of recovery of borrow areas might be documented by subsequent, post-dredging bathymetric surveys of the borrow areas. While dredging

[2] A rate of change of 0.44 Φ per minute of longitude here is equivalent to about 0.29 Φ per kilometer of shore or 0.47 Φ per statute mile of shoreline.

scars are known to persist for years, evidence of infilling of historical borrow areas was recognized over a couple of decades (e.g., Byrnes et al. 2004; Schwab et al. 2013). Historical borrow areas were covered in the latest (2011) geophysical survey; evidence of infilling was recognized in borrow sites dredged in 1994 and 1996 (Schwab et al. 2013). For example, a bathymetric profile across the CP&E Western Borrow Area clearly shows an area excavated in 2009 one to two meters below the ambient sea floor (Figure 3a) with no evidence of recovery. On the other hand, the Fire Island Pines Borrow Area excavated in 1997 is indistinct perhaps indicating that ambient sand transport has substantially replenished the area (Figure 3b). The evidence is sparse, but recovery does seem to occur, with recovery times on the order of decades.

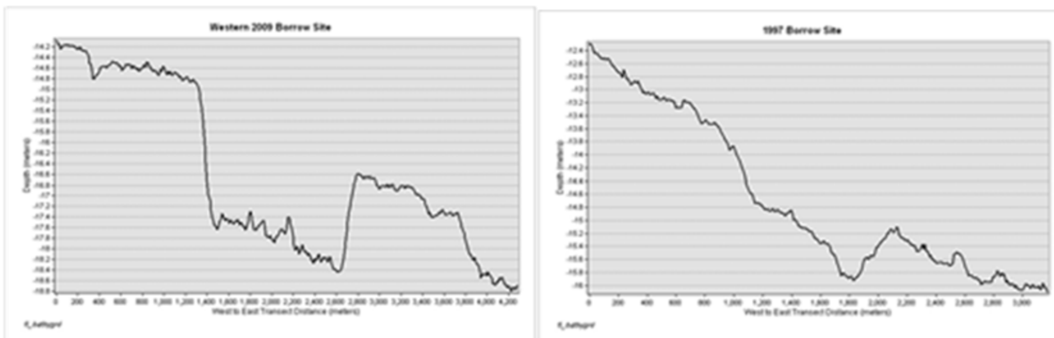

Figure 3. a. 2011 survey of the CP&E Western Borrow Area which had been dredged in 2009. b. 2011 survey of the Fire Island Pines Borrow Area which had been dredged in 1997.

DREDGING INTENSITY

Dredging intensity has been defined as volume of sand extracted/area/time (ICES 2014), but "volume" can be an elusive parameter. Some projects had been documented as permitted volumes or barge-loads while others use in-place volumes, all have inherent uncertainties. For contracting purposes, volumes extracted are often verified by pre-and-post-project surveys at the site of placement or at the borrow site. Bathymetric surveys include inherent uncertainty both in recorded water depth and the ship's location. Errors can be 0.15 or 0.25 m (e.g. Wijnberg and Terwindt 1995). An error of 0.05m in depth alone in a survey covering 2.5 km of shoreline across a nearshore width of 40 meters amounts to an uncertainty of 50,000 m3 (Gibeaut, Gutierrez and Kyser 1998). Uncertainties of this magnitude, however, may be tolerable in a project that might involve a million cubic meters or more. Where extractions are concentrated in deep areas over small areas, such uncertainties can be negligible in the calculation of pre- and post-volumes. In many instances, however, deep areas are avoided intentionally to prevent adverse impacts on wave conditions or water column stratification and, instead, sand is removed in thin layers over larger areas. Because of the resolution of the surveys, disturbance of the seafloor involving the extraction of thin layers over large areas around the margins, and the habitats in those areas, may go undocumented.

Bathymetric surveys aside, modern monitoring systems are capable of recording real-time data on dredging operations such as location, ship speed, depth of cut, and sediment mixture concentration to name a few (Francingues et al., 2000). In the U.S., monitoring systems used for federal projects record date, time, position, speed, vessel draft, dragarm depths, density of the pumped slurry, and pumping rate then use these data to calculate displacement, hopper volume, ullage (the amount by which the hopper falls short of being full), draghead position, and the depth of the cut (http://dqm.usace.army.mil/, accessed December 2017). The US Army Corps of Engineers' Mobile

District maintains DMP databases for federal beach nourishment, coastal restoration, and navigation projects. The DMP collects real-time information every six seconds. Although some of these data are proprietary, official users might obtain basic nonproprietary information from the DQM support team <https:dqm.usace.army.mil>. The record of displacement is particularly useful because, when dredging in the borrow area, the displacement of the vessel will increase from one reading to the next. However, complete data such as this is not collected everywhere and, even when it is collected can be effectively unavailable to resource managers because of its proprietary classification.

In principle, total extracted volume can be calculated from the DMP data, but evaluating volume extracted/area/time can be very difficult, and even impossible (ICES 2015). As discussed, excavated volumes are determined routinely by bathymetric surveys instead. For assessment of habitat impact, the data to calculate aggregate time a dredger spends in designated borrow site might be used as a surrogate for volume/area/time. Not only are measurements of time/area likely to be more widely available, but also they are capable of locating areas of habitat disturbance that are undetected in bathymetric surveys because of uncertainties in the measured water depth. In the absence of DMP data, the Automatic Identification System (AIS) vessel tracking data might be used to assess the intensity of dredging activity in specific areas. AIS is capable of providing a vessel's longitude and latitude, in addition to its course, heading and speed, routinely aggregated at five-minute intervals. AIS positioning data for a particular vessel in the U.S. and time period can be assembled by the U.S. Coast Guard upon request.

The GIS application described here (Bokuniewicz and Jang, 2018) can provide a method of tracking the use of designated borrow areas in order to maintain the ability to manage offshore sand resources in a coordinated and sustainable manner. Results can be displayed in a graphic image called a "heat map", or "density map", or "timeprint", where various intensities of colors represent the number vessel locations in each designated cell over the entire time period of interest

(https://www.navcen.uscg.gov/?pageName=NAISDataFormats accessed December, 2017).

"Time" could be reported either as the total number of hours or minutes dredged over the course of a year. In the U.S., because most large beach renourishment projects are done by the U.S. Army Corps of Engineers, the federal fiscal year may be most appropriate. A test case had been run by the Working Group on the Effects of Extraction of Marine Sediments on Marine Ecosystems of the International Council for the Exploration of the Sea (ICES 2016). Using both Belgian EMS data and the commercial EMS data of the Netherlands, output maps were generated showing the total time dredged, a "timeclock-print", in an area of 50x50m over the course of the year 2014 (De Backer et al. 2017).

It would seem that a time-clock print gives a good view on the actual footprint of aggregate dredging and it allows for comparison between states. It should be noted that dredging time per area does not take into account other important parameters such as the size of the dredging vessel, the type of material extracted and whether screening takes place or not.

A past renourishment project at Smith Point County Park was used to explore the assessment of dredging intensity. The operation was the second stage of the total project, undertaken between October 5, 2015 and April 22, 2016. Sand was dredged in the vicinity of borrow site 5b-ext. The Dutra Dredge Stuyvesant was used (8432 gross tonnage, 11,144 CY capacity, draws 17 feet empty, 34.8 feet loaded).

DQM data was aggregated every five minutes identifying a load number, date and time, vessel longitude, vessel latitude, vessel speed, vessel heading, vessel course, forward vessel draft, aft vessel draft and displacement. In general Dredge Quality Management (DQM) data is proprietary. If NY State wanted to obtain it a FOIA (Freedom of Information Act) request would need to be submitted to the NY District project manager or solicit specific information from the DQM support team <https:dqm.usace.army.mil>.

Methods

In order to create a raster dataset in which the values of each cell represent the total amount of time that vessels have spent in a predefined cell (100 m x 100 m), various steps of data manipulation and data conversion were performed using ArcGIS 10.5.1 as follows:

1. A 'vessel positions' feature class in the file geodatabase was created using the 'From X-Y Table' option in ArcGIS because the 5-min interval vessel point data in Comma Separate Value (CSV) contains the vessel longitude (X) and the vessel latitude (Y). The NAD 1983 geographic coordinate system was selected as the input coordinate system of the vessel point data.

2. Because the time density needs to be summarized by metric cell (100 m x 100 m), the vessel point data in the NAD 1983 geographic coordinate system was projected to the WGS 1984 Web Mercator Auxiliary Sphere projected coordinate system.

3. A new integer field, called VALUE, was added to the attribute table of the vessel point data to store the 5-min time interval. Using Field Calculator, all cells in the VALUE field were populated with the numeric value 5.

4. To convert the vessel point data to raster, the Point to Raster tool was used. Parameters used for this conversion are as follows: the VALUE field of the point data as value field of output raster, SUM as cell assignment type, and 100 as cell size. The cell assignment type makes the Point to Raster tool compute total time per each cell by summing up the numeric values of the VALUE field of point features within each cell (100 m x 100 m).

For this illustration, the process was repeated four times, first using all locations in the designated area. Second, because AIS data includes the speed of the vessel and the dredgers travel at slower speeds when actually extracting sand, the speed may be used as a filter on the location data. Locations in the designated area when the vessel was travelling more slowly may discriminate between times of actual dredging and locations representing transit through the area. Because the data is a snapshot in a five-minute interval, the vessel could have been traveling more slowly anytime between the previous snapshot and the subsequent snapshot. As a result, the minimum speed for each entry was calculated over 15 minutes, around three successive entries. The dredging speed was taken as being less than two knots (Robert Ramsdell, 2017, Great Lakes Dredge & Dock Company, personal communication). So a second heat map was generated on a subset of these locations when the vessel speed was less than two knots.

Third, by trial and error, the data in the designated borrow area were edited to include only positions where the change in displacement was greater than 50 tons. A fourth heat map was compiled from a subset of locations where the speed was less than two knots and displacement changed by more than 50 tons. The geospatial patterns and the summary statistics of the output raster within the hypothetical borrow area were examined for each case.

Results

For this example, 48,484 individual locations were provided.   Of those, 8,732 positions, or 18% of the ship's positions were in the hypothetical borrow area. Because each recorded position occupies a five-minute time period, the aggregate time the dredge spent in each cell can be calculated. The time the dredge spent in a single cell ranged from 1 to 120 minutes. The distribution was concentrated in the western section of the hypothetical borrow area (Figure 4).

For a dredging speed less than two knots, 7,729 positions were identified. The aggregate time that the dredge spent in a single cell ranged from five to 100 minutes. This distribution was very similar to that of all recorded positions (Fig. 3) with slow-speed activities concentrated in the western section of the hypothetical borrow area.

6,371 positions recorded positive increases in displacement, indicating that the vessel was actively dredging (or possibly taking on water). The total time spent in single cells ranged from five to 80 minutes. Applying both the filter for speed and that for increase in displacement, 6050 positions were identified. The aggregate time spent in a single cell ranged from five to 80 minutes. In terms of the distribution of dredging intensity, there did not seem to be substantial advantage to selecting by speed or displacement. As a result, the basic AIS data would be adequate to capture dredging intensity.

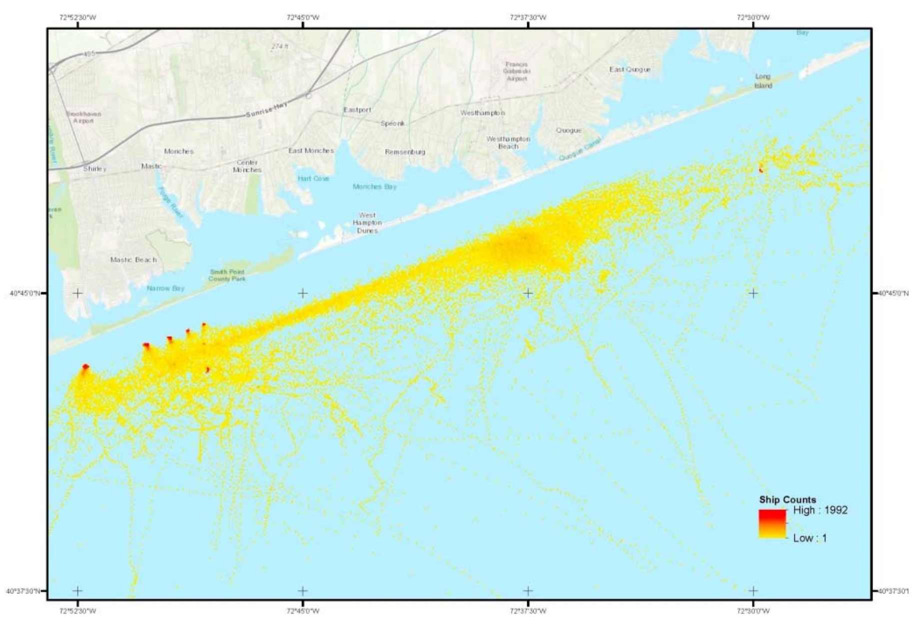

Figure 4. Heat map of dredge positions. The dredged area is represented by the warm colors to the right while the discharge locations are represented by the five reddish areas to the left

Data was edited to include only positions where the change in displacement was greater than 50 tons (and the position was east of 73 degrees longitude). This amounted to 6050 positions identified (Figure 5). The aggregate time spent in a single cell ranged from five to 80 minutes

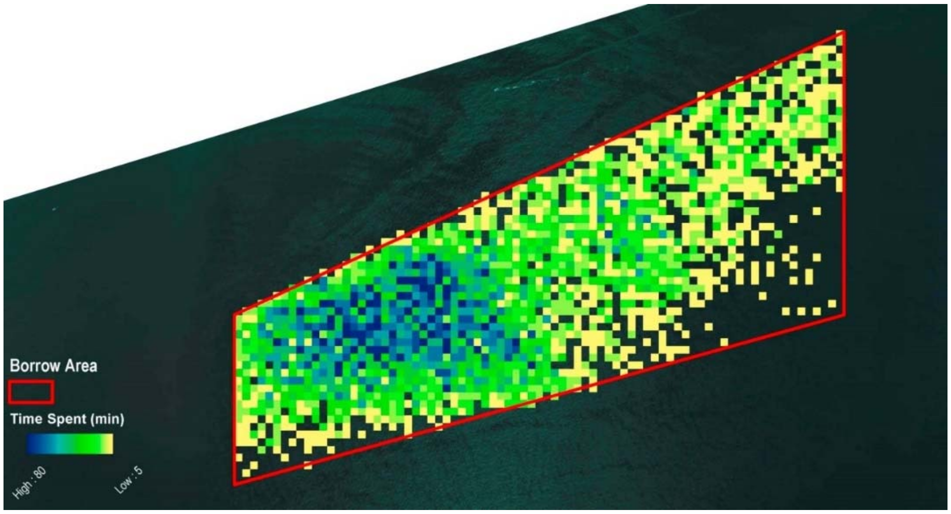

Figure 5. Heatmap of dredging activity representing the occurrence of all dredge positions in 100-meter cells showing an increase in displacement of more than 50 tons and a speed less than 2 knots

DISCUSSION

Resource monitoring

In many countries, e.g. in the UK, Belgium, Netherlands and Denmark, monitoring of designated borrow areas from offshore sand is carried out by the resource management agencies. An assessment of dredging intensity can provide the actual footprint of actively dredged areas. These agencies keep track of volumes extracted, volume remaining in the designated area, compliance with license conditions, bathymetric changes, changes in sediment type and condition of marine communities, relying not only on traditional benthic sampling, but also routine multibeam seismic surveys and fairly frequent determination of dredging intensity. Although dredging intensity has been defined as volume extracted/area/time (ICES 2014), hours dredged/area/year has been shown to give a good view on the actual dredging footprint in studies in the UK, Belgium, the Netherlands and Denmark. Data from a black box (EMS) or AIS is typically provided every 10 or 30 seconds, but, for resource management, degrading the data to a time interval of five minutes is, perhaps, adequate and more manageable. If the full data set is used, resolution on a grid size of 50 x 50m is possible. Times spent in a 50 x 50 m grid cell ranged from less than 15 minutes to over two hours/year. If a longer time period is used, larger grid cells should be necessary in order to capture gradients in the intensity. For data provided at time intervals of five minutes, a cell size of 100 x 100m is suggested, but a coarser resolution may be adequate and necessary. A five-minute interval at 2 knots covers 300 m; one-minute data would be a 60 m grid. The UK uses 500 x 500 m grids for reconnaissance, but the higher resolution of 50 to 100 m would be more appropriate for resource and habitat assessments.

Within the designated areas, times of active dredging can be determined by noting when the pumps are turned on, but this information is only available if black boxes (EMS) are used. If AIS data is used, times of active dredging can be identified by the speed of the vessel. Speed thresholds used are country-dependent because it depends on the sediment type extracted, the type of dredger used and whether static (or "anchor") dredging is allowed. Anchor dredging can create isolated, deep holes, because, in some settings, there is concern that deep holes may go hypoxic. A two-knot speed limit seems to work fine for identifying times of active dredging although larger vessels operate faster. A lower limit of 0.5 knots has been used by Belgium to avoid static, or anchor, dredging.

For compliance, positioning errors occur due to the use of different projections as well as typographical errors in coordinate entries can put the vessel outside of the designated borrow area. This might be especially critical near pipelines or cable crossings; the Netherlands maintains a 1000 m buffer, but Denmark only 200 m. If dredging occurs outside the designated license area, the captain is notified of positon errors, however, it can be important to have a face-to-face inspection on board to resolve errors quickly.

"Volume" can be an elusive parameter. Some projects had been documented as permitted volumes or barge-loads while others use in-place volumes and all have inherent uncertainties. For contracting purposes, volumes extracted are often verified by pre-and-post-project surveys at the site of placement or at the borrow site. Bathymetric surveys include an inherent uncertainty both in recorded water depth and ship location. Errors can be six to ten inches (e.g. Wijnberg and Terwindt 1995). An error of two inches in depth alone in a survey covering about 1.6 miles of shoreline across a nearshore width of 44 yards amounts to an uncertainty of over 65,000 CY (Gibeaut, Gutierrez and Kyser 1998). Uncertainties of this magnitude, however, may be tolerable in a project that might involve a million CY or more. Where extractions are concentrated in deep areas over small areas, such uncertainties can be negligible in the calculation of pre- and post-volumes. In many instances, however, deep areas are avoided intentionally to prevent adverse impacts on wave conditions or water column stratification and, instead, sand is removed in thin layers over larger areas. Because of the resolution of the surveys, disturbance of the seafloor involving the extraction of thin layers over large areas around the margins, and the habitats in those areas, may go undocumented.:

Investigators in Belgium have found good agreement between volume determined by repeated multibeam surveys and volumes calculated from EMS, or AIS, data (Figure 6). Calculating the volume for position data, however, requires identifying each dredge trip to the borrow area and the capacity of the particular dredge. It is assumed that once a dredging session begins that the dredge does not leave the borrow area until fully loaded. The volume is then calculated as the product of the number of trips and the specific dredge capacity.

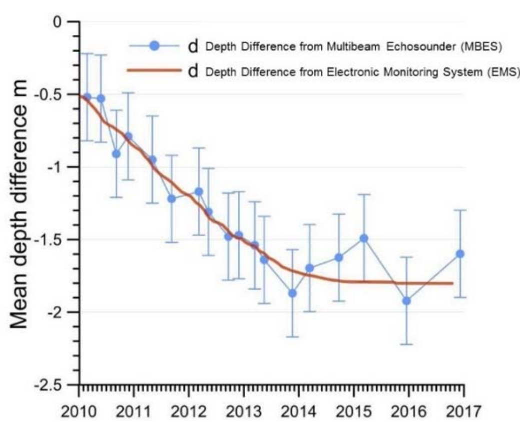

Figure 6. Comparison of volumes estimated from repeated bathymetric surveys with an accounting of dredger visits to the borrow site.

Habitat mapping

Offshore habitats mapping has come to rely on the use of abiotic proxies to provide high-resolution habitat maps to resource managers (Brown and Blondel 2009; Buhl-Mortensen et al. 2015). Multibeam echo sounders in particular have revolutionized mapping of benthic habitats (Brown and Blondel 2009), because their products can discriminate differences in habitat value using bathymetric information, such as slope, and topographic roughness, resolved to one-square-meter areas over large parts of the sea floor (Calvert et al. 2015). Discrimination of habitats over distances of as little as 200 meters has been found to capture important changes over distances of tens of meters among the clutter of very small-scale variation (Calvert et al. 2015). As a result, the ability to map bottom disturbances caused by the intensity of dredging on this scale would be useful.

CONCLUSIONS

The record of past dredging activity to exploit offshore sand resources is incomplete, and although it can present a picture of sand demand, it is not adequate to accurately forecast future demands. Data in project reports and permits are not routinely compiled or summarized in one place after the fact. The Army Corps of Engineers' database of Federal projects does not include State and local projects because those entities are not authorized to harvest sand from offshore sources (However, Suffolk County does carry out maintenance dredging of inlets which results in material used for beach nourishment in both Nassau and Suffolk Counties, for which good records are kept.). In addition, some projects are initiated, delayed or terminated unpredictably and specific projects require sand of specific quality. The quality and extent of sand resources for future depends on the project location, because the grain size at the borrow area must match, or be coarser than, the native sand at the receiving site. Potentially suitable, offshore sand reserves amount to only a fraction, perhaps 30%, of the total volume of sand offshore. In general, the beach sand becomes coarser to the east so sand reserves that are suitable for eastern beaches likely are fewer. In addition, regarding borrow area recovery, evidence is sparse but recovery does seem to occur, with recovery times on the order of decades, long-term monitoring is required. Annual information on active, designated borrow areas, footprint of actual dredged areas, volume extracted, dates of placement, the volume of sand placed, the beach location of placement, and the borrow area must be assembled from diverse sources. This probably requires the attention of a dedicated effort from knowledgeable individuals within different agencies, including the New York District Army Corps of Engineers, NYS DEC, BOEM, NYS DOS, NYC DEP, Nassau and Suffolk County.

Precise locations of dredging within identified borrow areas can be monitored at high resolution in near-real time using electronic monitoring system like the automatic identification system for marine traffic. Resource managers elsewhere apply such measures of dredging intensity to assess both physical and biological impacts. Multibeam backscatter in combination with bathymetric information has been used to discrimination of habitats over distances of as little as 220 yards.

High-resolution habitat maps do not exist, but would be needed to take advantage of maps of dredging intensity in the assessment of ecological impacts. Additionally, incomplete knowledge regarding sediment transport and the interactions between the shelf and nearshore system pose significant challenges in managing and possibly utilizing potential sand resources.

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APPENDIX 1

JOB STATUS (JS)
A Active-expect to award
BC Bids>25% of Gov Estimate-converted to RFP
BR Bids>25% of Gov Estimate-resolicit
BW Bids>25% of Gov Estimate-withdrawn
C Completed
CC Claim Pending
H Hold-Misc. Reason
HB Hold-Protest
HF Hold-Awaiting Funds
HP Hold-Awaiting Permit(s)
M Moved to Another FY
NB No Bids Received
OA Open by Amendment
P Proposed- >80% chance to award
T Terminated
U Undefined
W Withdrawn

WORK CLASS (WC)
M Maintenance
L Levee Construction or Repair
N New Work
B Both M&N
S Beach Nourish non-nav
W Wetland Nourish non-nav
U Undefined

DREDGE TYPE (DT)
B Bucket
D Dustpan
H Hopper
I Water Injection
N Nonconventional type
P Pipeline
S Sidecaster
W Combo-All Types
X Pipeline & Bucket
Y Pipeline & Hopper
Z Hopper & Bucket
U Unknown

MATERIAL UNITS (MU)
Y Cubic Yards
D Days
H Hours
L Lump Sum
M Cubic Meters
O Other
S Station
U Undefined

DISPOSAL TYPE (DS)
B Beach Nourishment
C Confined
D Underwater Confined
M Mixed Types
O Overboard & Open Water
S Open & Upland
T Beach & Upland
U Upland
W Wetland Nourishment or Creation
X Undefined

SMALL BUSINESS SET ASIDE (SA)
A 8a Set Aside
D Service Disabled/Veteran Owned
E Emerging Small Business
H Hubzone
N No Set Aside - Unrestricted
S Small Business Set Aside
U Unknown
V Veteran Owned
W Woman Owned

DOLLAR RANGE ($)

A	Up to $99,999
B	$100,000 - $499,999
C	$500,000 - $999,999
D	$1,000,000 - $4,999,999
E	$5,000,000 and above
U	Undefined

CONTRACT TYPE
CON Converted from IFB to RFP
F&R Fair and Reasonable
HL Hired Labor
IDIQ Indefinite Delivery Indefinite Quantity
MATOC Multiple Award Task Order
NEG Negotiated
RFP Request for Proposal
SS Sole Source

APPENDIX 2

FY	DISTNAME	JOBNAME	JLATDEG	JLATMIN	JLATSEC	JLONDEG	JLONMIN	JLONSEC	PRDRTYPE	DISPTYPE	ACTUALCY	JOB_STATUS
1990	NEW YORK	East Rockaway/Jones Inlets	0	0	0	0	0	0	H	B	569,964	C
1990	NEW YORK	Fire Isl. to Jones Inlet, NY	0	0	0	0	0	0	P	B	797,500	C
1990	NEW YORK	Mattituck Harbor, NY	0	0	0	0	0	0	B	B	13,241	C
1991	NEW YORK	Lake Montauk Harbor, NY	40	40	0	-73	10	0	P	B	15,307	C
1992	NEW YORK	Fire Island to Jones Inlet	40	37	11	-73	19	0	P	B	1,515,000	C
1992	NEW YORK	Jamaica Bay, NY	40	33	0	-73	57	0	H	B	145,800	C
1993	NEW YORK	Robert Moses State Park	40	38	0	-73	19	0	P	B	540,000	C
1994	NEW YORK	Coney Island, NY	40	33	0	-74	0	0	P	B	2,317,513	C
1994	NEW YORK	Fire Island to Jones	40	37	0	-73	20	0	P	B	1,545,333	C
1994	NEW YORK	Jamaica Bay	40	33	0	-73	57	0	H	B	198,941	C
1994	NEW YORK	Jones Inlet, NY	40	35	0	-73	35	0	P	B	560,125	C
1995	NEW YORK	East Rockaway Inlet	40	33	0	-73	44	0	P	B	411,760	C
1995	NEW YORK	Lake Montauk Harbor, NY	73	10	0	-40	40	0	P	B	46,175	CC
1995	NEW YORK	Moriches Inlet, NY	40	46	0	-72	45	0	P	B	256,636	C
1995	NEW YORK	Rockaway Beach Nourishment	0	0	0	0	0	0	H	B	2,685,073	C
1996	NEW YORK	Jamaica Bay, NY	40	33	10	-73	58	1	P	B	225,837	C
1996	NEW YORK	Jones Inlet, NY	40	38	0	-73	32	0	Y	B	458,923	C
1997	NEW YORK	Fire Island to Jones, NY	40	38	30	-73	17	30	P	B	1,081,861	C
1998	NEW YORK	Gravesend Bay-Anchorage	74	1	0	-40	35	0	H	B	82,038	C
1998	NEW YORK	Jamaica Bay, NY	0	0	0	0	0	0	H	B	222,718	C
1999	NEW YORK	East Rockaway, NY	0	0	0	0	0	0	P	B	218,006	C
1999	NEW YORK	Fire Island to Jones, NY	0	0	0	0	0	0	P	B	1,107,718	C
2000	NEW YORK	Jamaica Bay, NY	0	0	0	0	0	0	H	B	228,610	C
2001	NEW YORK	Fire Island to Jones Inlet	0	0	0	0	0	0	P	B	1,325,990	C
2001	NEW YORK	Long Island Intracoastal, NY	40	50	30	-72	40	0	P	B	80,000	C
2001	NEW YORK	Sandy Hook/Barnegat Inlet NJ	0	0	0	0	0	0	H	B	2,492,908	CC
2001	NEW YORK	West Hampton Interim Proj NY	0	0	0	0	0	0	X	B	987,000	C
2002	NEW YORK	East Rockaway Inlet, NY	0	0	0	0	0	0	H	B	141,900	C
2002	NEW YORK	Jamaica Bay, NY	0	0	0	0	0	0	H	B	366,080	CC
2003	NEW YORK	Fire Island to Jones Inlet	0	0	0	0	0	0	P	B	1,444,831	C
2004	NEW YORK	East Rockaway Inlet, NY	0	0	0	0	0	0	H	B	224,091	C
2004	NEW YORK	Jamaica Bay, NY	0	0	0	0	0	0	H	B	204,197	C
2004	NEW YORK	Mattituck Harbor, NY	0	0	0	0	0	0	P	B	13,000	C
2007	NEW YORK	East Rockaway Inlet, NY	0	0	0	0	0	0	P	B	266,890	C
2008	NEW YORK	Jones Inlet, NY	0	0	0	0	0	0	P	B	625,625	C
2010	NEW YORK	East Rockaway Inlet, NY	0	0	0	0	0	0	Y	B	137,265	C
2010	NEW YORK	Orchard Beach, NY	0	0	0	0	0	0	H	B	267,496	C
2011	NEW YORK	Lake Montauk Harbor, NY	0	0	0	0	0	0	P	B	11,915	C
2012	NEW YORK	East Rockaway Inlet, NY	0	0	0	0	0	0	P	B	271,250	C

2012	NEW YORK	Long Island Intracoastal, NY	0	0	0	0	0	0	P	B	26,759	C
2012	NEW YORK	West of Shinnecock InletPL8499	0	0	0	0	0	0	P	B	424,915	C
2013	NEW YORK	Coney Island, NY (1C) SANDY	0	0	0	0	0	0	H	B	569,000	C
2013	NEW YORK	Fire Island to Jones Inlet SANDY	0	0	0	0	0	0	P	B	2,032,418	C
2013	NEW YORK	Jones Inlet, NY SANDY	0	0	0	0	0	0	P	B	665,470	C
2013	NEW YORK	Rockaway, NY (1A) SANDY	0	0	0	0	0	0	P	B	542,280	C
2013	NEW YORK	Rockaway, NY (1B) SANDY	0	0	0	0	0	0	P	B	2,888,660	C
2013	NEW YORK	West of Shinnecock Inlet - SANDY	0	0	0	0	0	0	P	B	450,000	C
2014	NEW YORK	GSB-GREAT SOUTH BAY REACH - SANDY	0	0	0	0	0	0	P	B	69,030	C
2014	NEW YORK	LAKE MONTAUK HARBOR, NY - SANDY	0	0	0	0	0	0	P	B	18,865	C
2014	NEW YORK	LI Intracoastal, NY - SANDY	40	37	3	-72	44	2	P	B	32,715	C
2014	NEW YORK	MATTITUCK HARBOR, NY	0	0	0	0	0	0	P	B	110,631	C
2014	NEW YORK	WESTHAMPTON, NY INTERIM - SANDY	0	0	0	0	0	0	U	B	1,023,316	C
2015	NEW YORK	FIRE ISLAND-MORICHES STABILIZATION2	0	0	0	0	0	0	Y	B	1,556,953	A

APPENDIX 3

Import X-Y EXCEL File (as NAD 83)
Geographical coordinate system:
Create Future Class
Change to a projected coordinate system

- Data Management Tool - Projection & Transformation
- Might use WS 1984 Web Mercator or maybe VTM
- In the projected layer add a Column to the Attribute Table Called “COUNT” and populate it With “1”s (using Field Calculator)

Change “Geoprocessing Environment” Raster Analyses to “as specified” 100 for a 100 m square cell size or you might be able to skip this step and to do it in the next step.

Convert to Raster:

- Data Management   Conversions to Raster
- Point to Raster
- Cell Assignment Type on “Count” Column. Set to SUM (but could try “COUNT” “Cell Size” “100” this might do it
- Instead of setting it in the Geoprocessing Environment
- “Add Basemap” Topology