

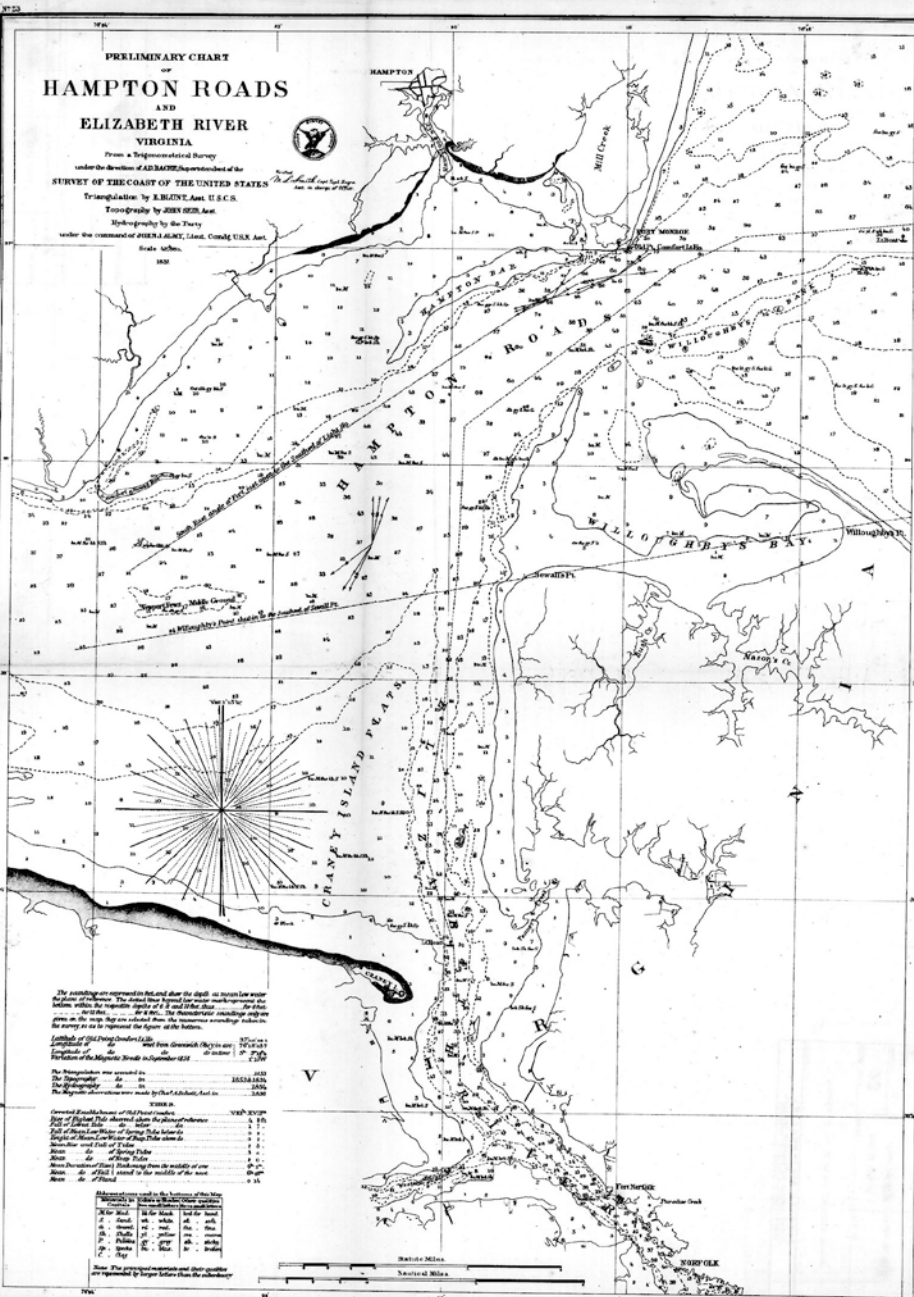
Synoptic Risk Assessment for Ship Passage and Hydrographic Uncertainty Representation



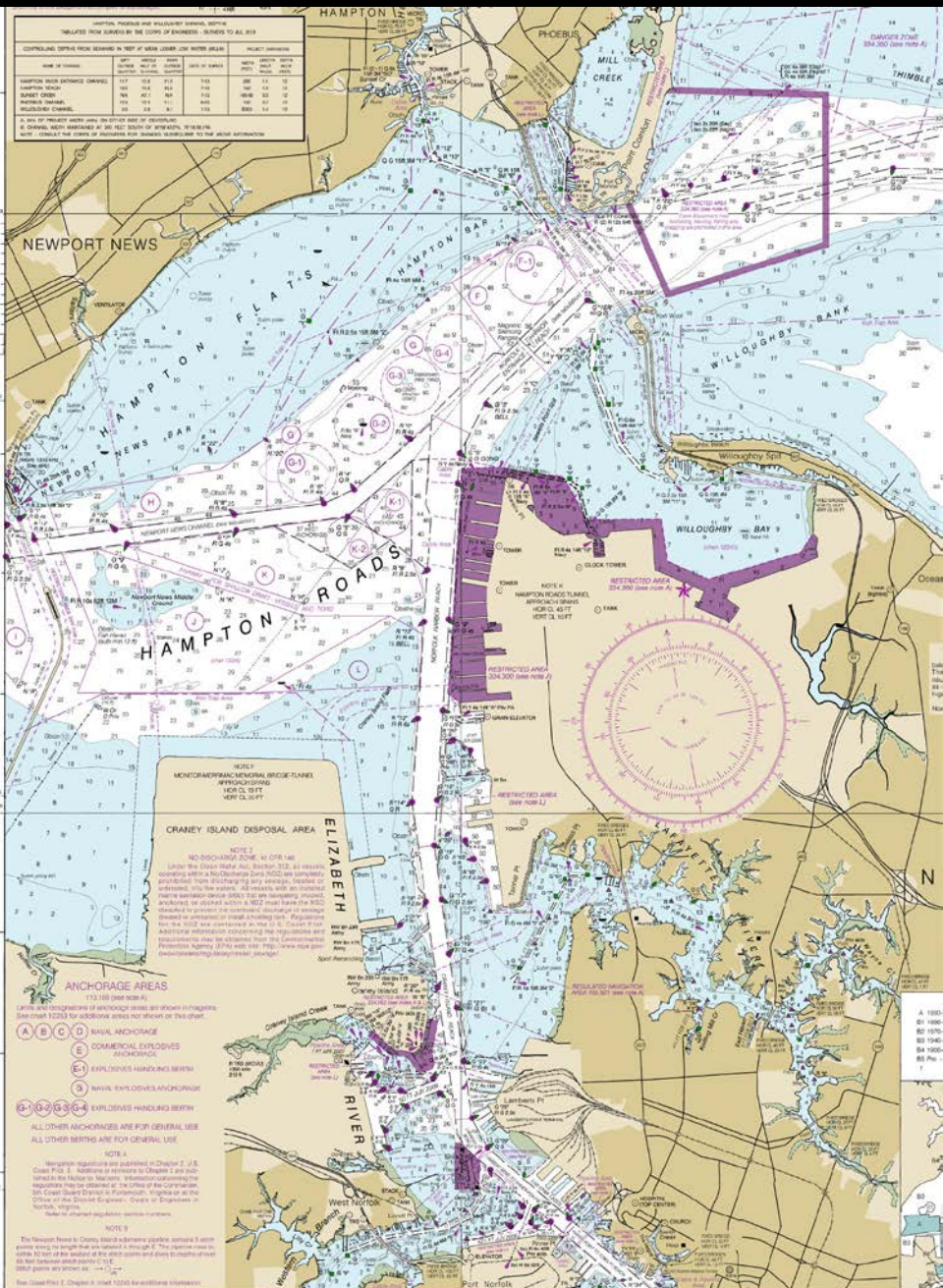
Brian Calder

Center for Coastal and Ocean Mapping &
NOAA-UNH Joint Hydrographic Center
University of New Hampshire

From a Trigonometrical Survey
under the direction of AD RACE, Superintendent of the
SURVEY OF THE COAST OF THE UNITED STATES
Triangulation by E. BLUNT, Asst. U. S. C.
Topography by JOHN SMITH, Asst.
Hydrography by the Tuxey
under the command of JOHN J. ALLEN, Lieut. Comdr. U. S. N.



CAPITAN, PANGLOSS AND PANGLOSS OFFSHORE TUBS/LINER FROM SURVEYS BY THE COMPS OF ENGINEERS - SURVEYS TO JUL 2019						
CONTROLLING DEPTH FROM SURVEYED TO TIE IN AT VERTICAL JOINTS (SEE TUBER BUILT)				PROJECT INFORMATION		
NAME OF TUBS/LINER	SPOT	MEASURED DEPTH (M)	DEPTH TO SURFACE (M)	WATER DEPTH (M)	WATER DEPTH (M)	WATER DEPTH (M)
WATSON TUBER ENTRANCE CHANNEL	117	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	118	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	119	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	120	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	121	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	122	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	123	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	124	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	125	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	126	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	127	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	128	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	129	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	130	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	131	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	132	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	133	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	134	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	135	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	136	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	137	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	138	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	139	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	140	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	141	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	142	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	143	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	144	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	145	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	146	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	147	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	148	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	149	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	150	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	151	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	152	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	153	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	154	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	155	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	156	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	157	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	158	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	159	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	160	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	161	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	162	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	163	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	164	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	165	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	166	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	167	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	168	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	169	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	170	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	171	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	172	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	173	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	174	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	175	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	176	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	177	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	178	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	179	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	180	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	181	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	182	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	183	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	184	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	185	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	186	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	187	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	188	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	189	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	190	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	191	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	192	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	193	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	194	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	195	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	196	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	197	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	198	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	199	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	200	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	201	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	202	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	203	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	204	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	205	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	206	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	207	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	208	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	209	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	210	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	211	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	212	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	213	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	214	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	215	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	216	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	217	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	218	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	219	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	220	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	221	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	222	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	223	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	224	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	225	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	226	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	227	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	228	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	229	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	230	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	231	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	232	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	233	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	234	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	235	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	236	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	237	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	238	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	239	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	240	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	241	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	242	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	243	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	244	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	245	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	246	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	247	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	248	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	249	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	250	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	251	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	252	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	253	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	254	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	255	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	256	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	257	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	258	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	259	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	260	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	261	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	262	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	263	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	264	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	265	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	266	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	267	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	268	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	269	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	270	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	271	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	272	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	273	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	274	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	275	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	276	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	277	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	278	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	279	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	280	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	281	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	282	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	283	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	284	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	285	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	286	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	287	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	288	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	289	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	290	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	291	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	292	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	293	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	294	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	295	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	296	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	297	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	298	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	299	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	300	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	301	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	302	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	303	10.8	9.3	7.03	2.8	1.3
WATSON TUBER	304	10.8	9.3			



SOURCE

A 1990-2013

B1 1990-2001

B2 1970-1989

B3 1940-1969

B4 1900-1939

B5 Pre - 1900

f

NOS Surveys

NOS Surveys

NOS Surveys

NOS Surveys

NOS Surveys

NOS Surveys

Miscellaneous Surveys

full bottom coverage

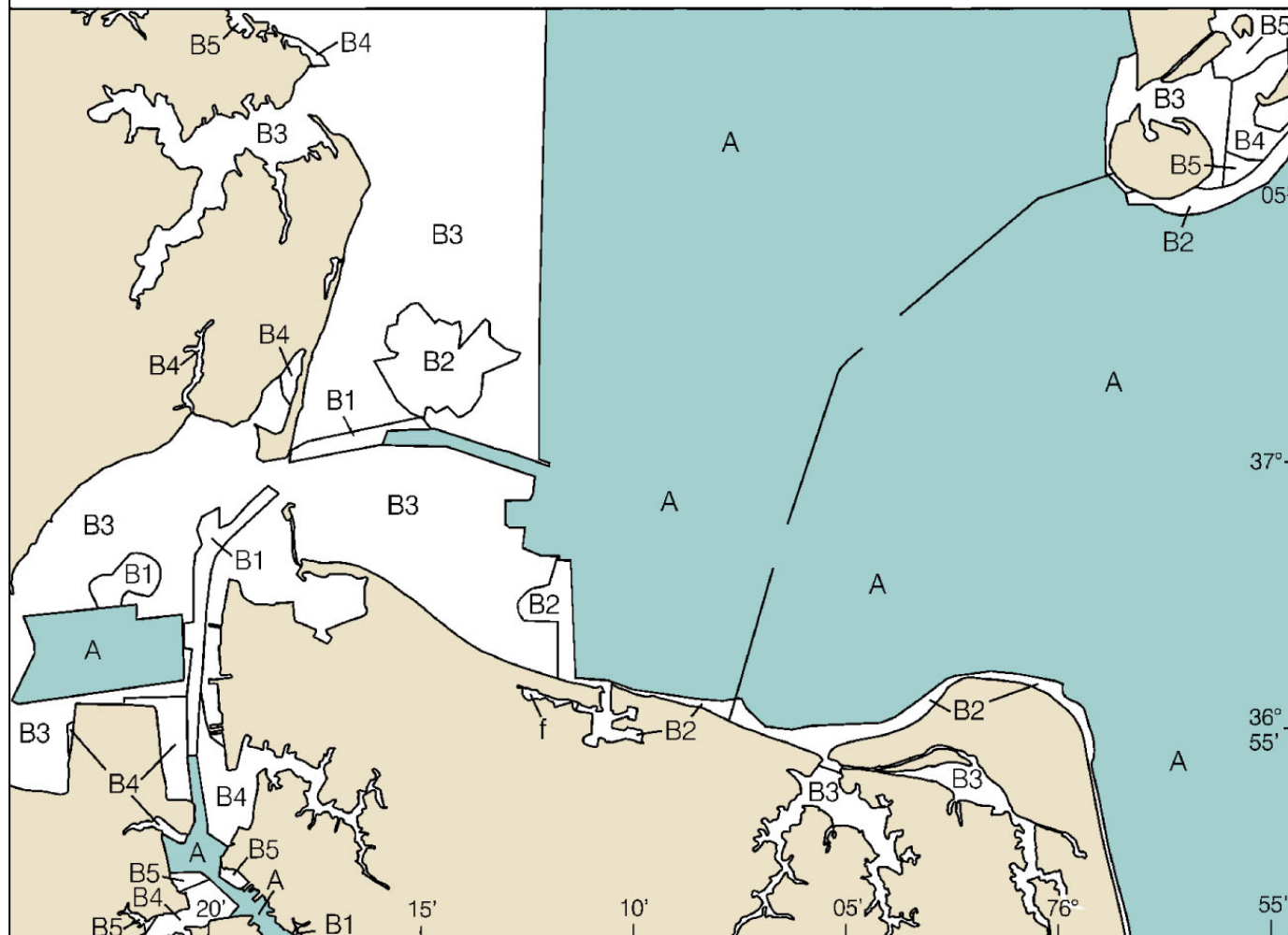
partial bottom coverage

partial bottom coverage

partial bottom coverage

partial bottom coverage

partial bottom coverage



We're answering the question:

“What did we do?”

... and not:

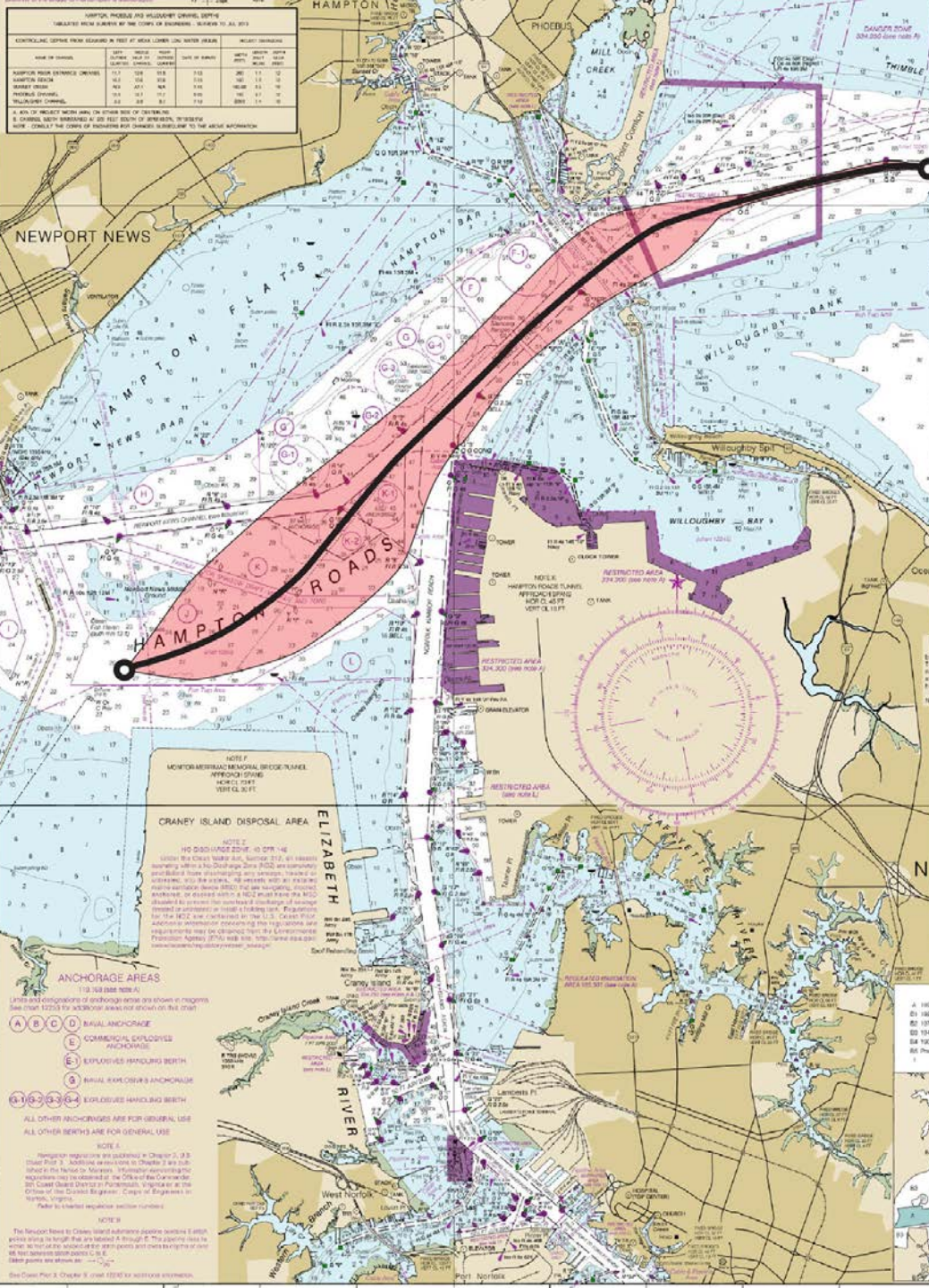
“How much do we know about the area?”

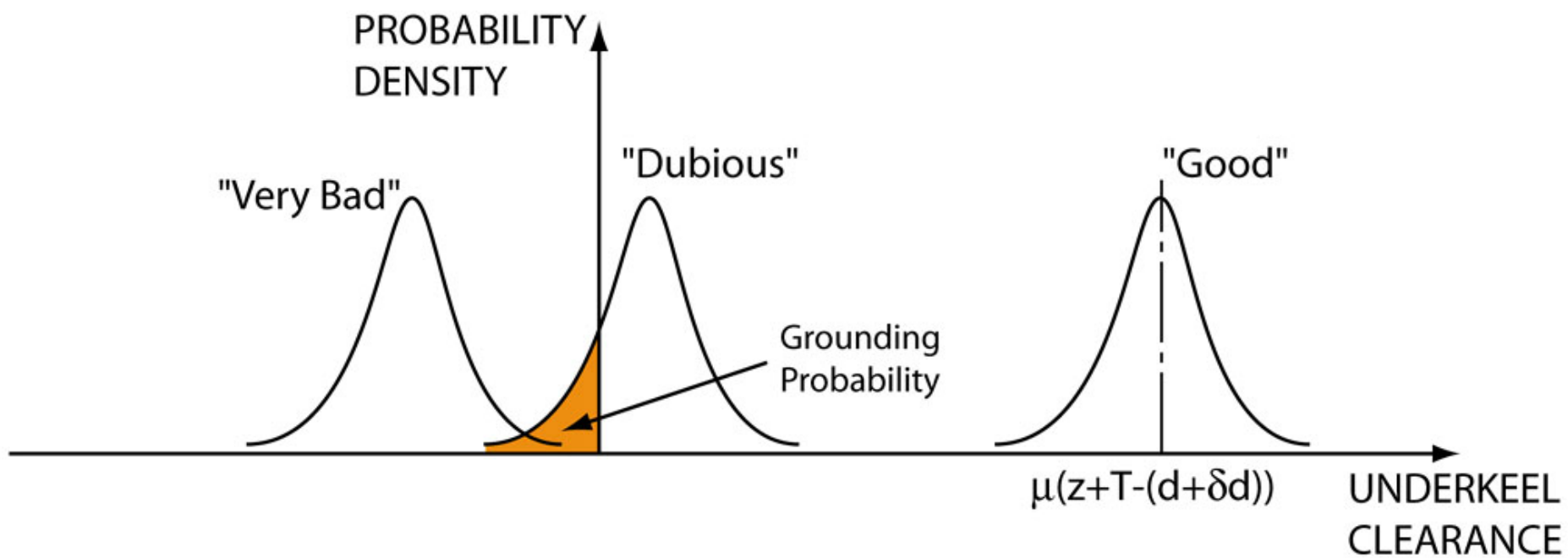
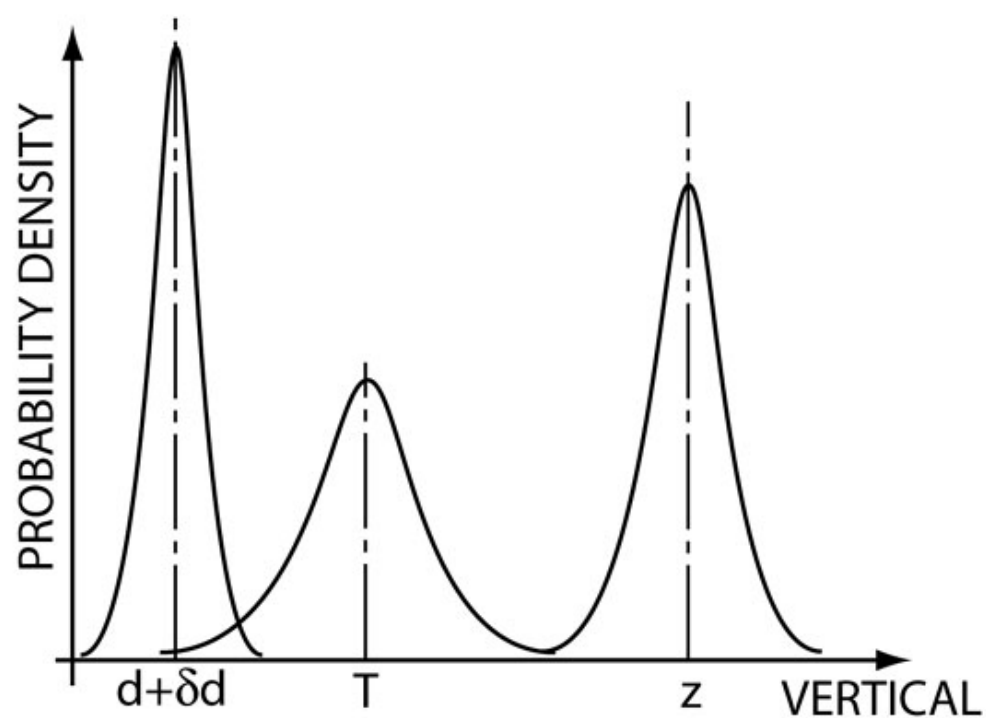
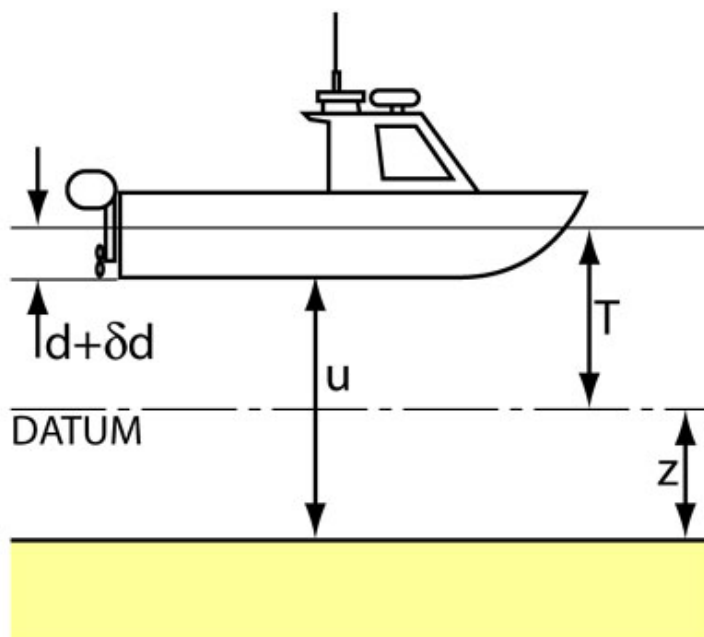
The user's question is more like:

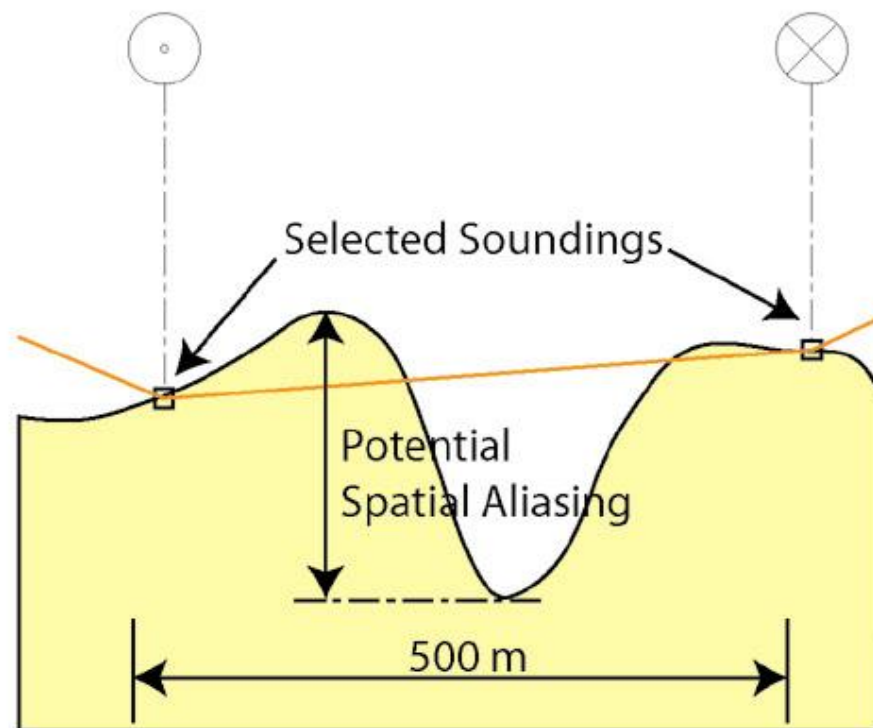
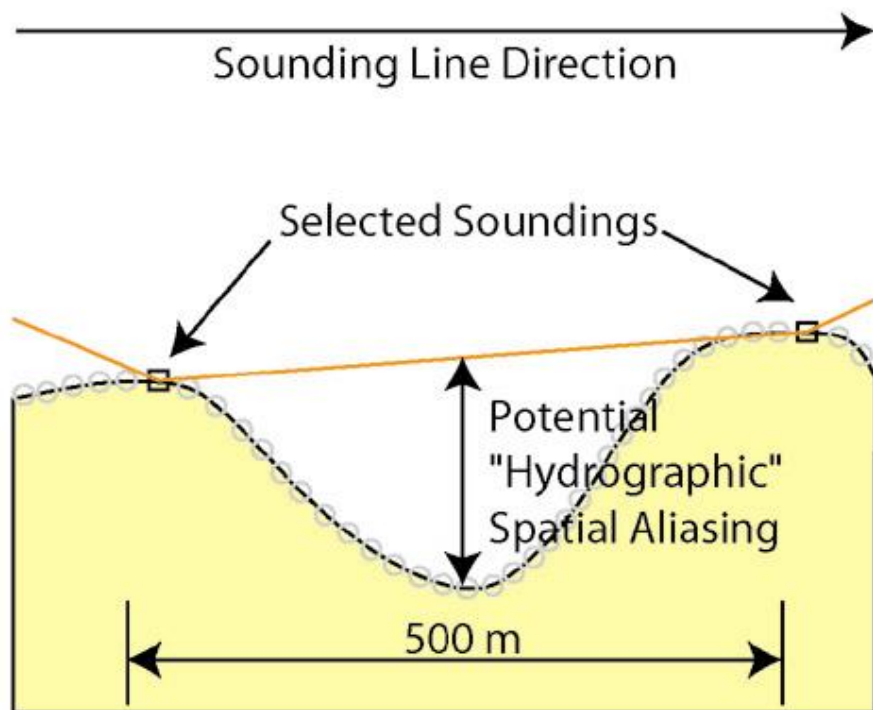
“What's my chance of going there safely?”

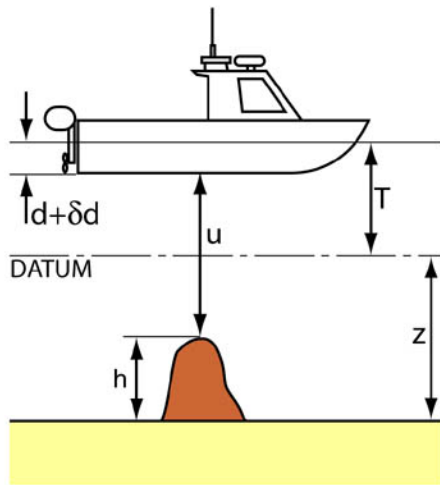
NATION, PHASES AND INFLUENCING COUNTRIES, DEPTHE LIBERATED FROM INFLUENCING OF OTHER COUNTRIES, JULY 1973 TO JUL 1973									
CONTROLLING COUNTRY FROM INFLUENCING OF OTHER COUNTRIES LONG WATER VARIOUS									
NAME OF COUNTRY	1970		1971		DATE OF LIBERATION	1972		1973	
	LIBERATED	INFLUENCING	LIBERATED	INFLUENCING		LIBERATED	INFLUENCING	LIBERATED	INFLUENCING
AUSTRIAN POWER INFLUENCING COUNTRIES	11.1	12.0	11.0	11.0	7.11	10.0	7.1	12	
AMERICAN DESIGN	10.1	10.0	10.0	10.0	7.11	10.0	7.1	12	
AMERICAN DESIGN	10.1	10.0	10.0	10.0	7.11	10.0	7.1	12	
PROTECTOR COUNTRIES	10.1	10.1	10.1	10.1	7.11	10.0	7.1	12	
INFLUENCING COUNTRIES	10.0	10.0	10.0	10.0	7.11	10.0	7.1	12	

A NOTE: CONTROLLING COUNTRY FROM INFLUENCING OF OTHER COUNTRIES
B. COUNTRY LIBERATED FROM INFLUENCING OF OTHER COUNTRIES, JULY 1973 TO JUL 1973
C. COUNTRY LIBERATED FROM INFLUENCING OF OTHER COUNTRIES, JULY 1973 TO JUL 1973



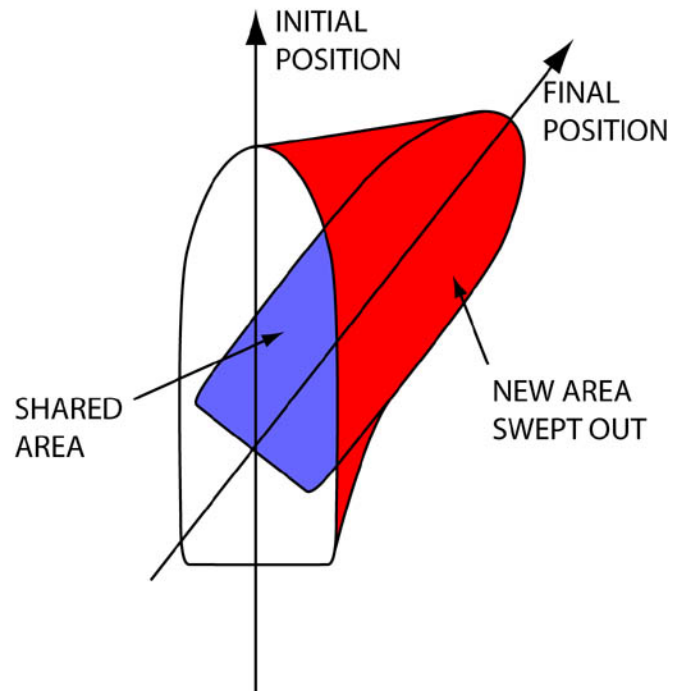
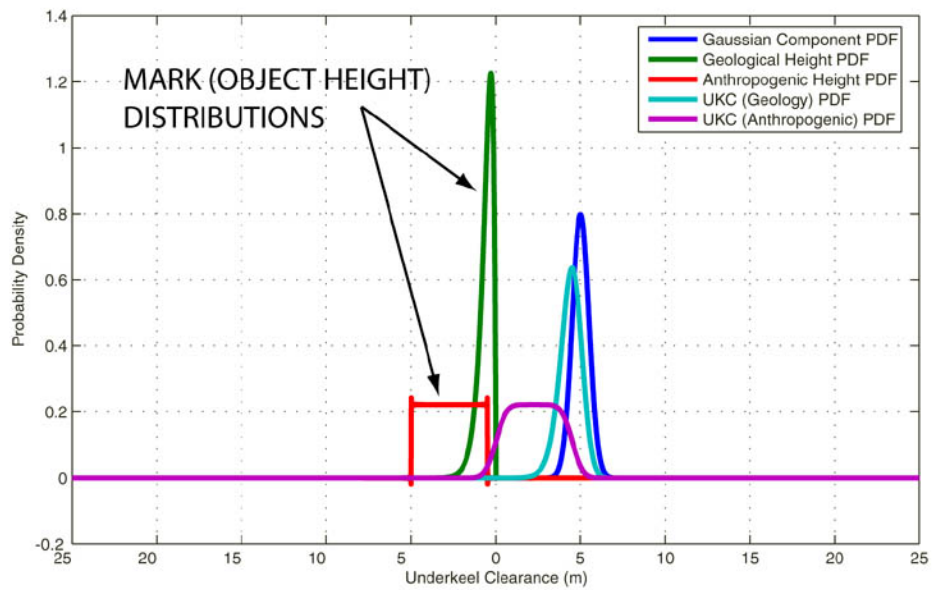
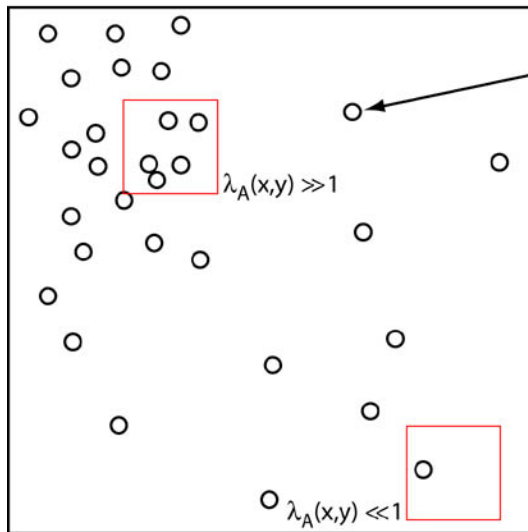


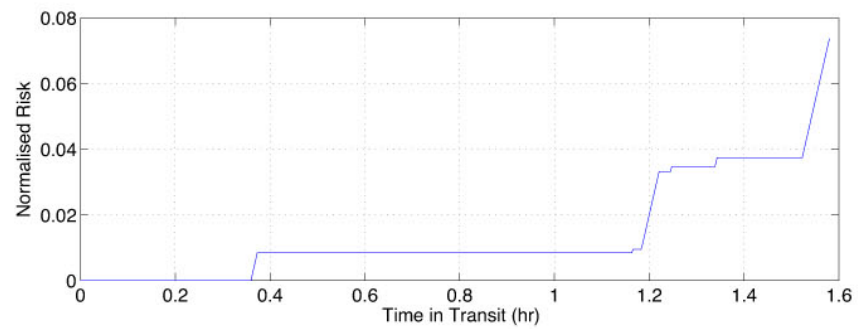
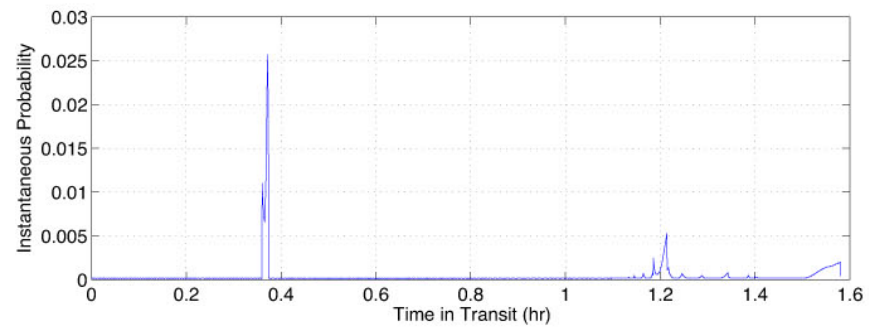
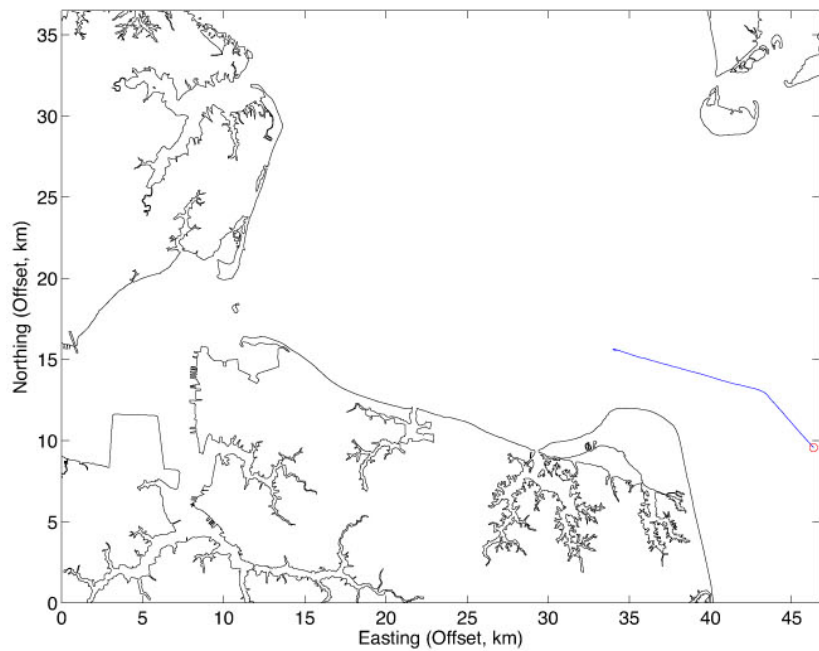




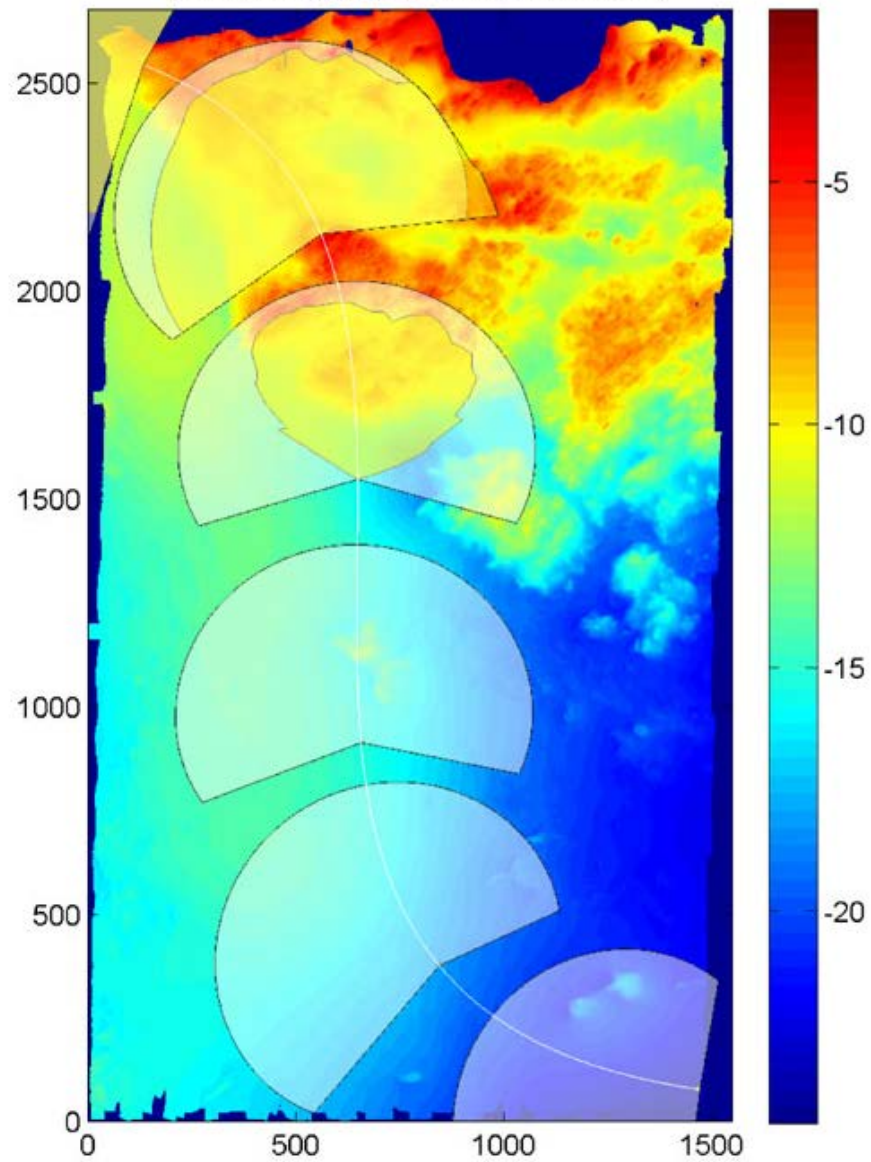
$$u = z + T - (d + \delta d) - h$$

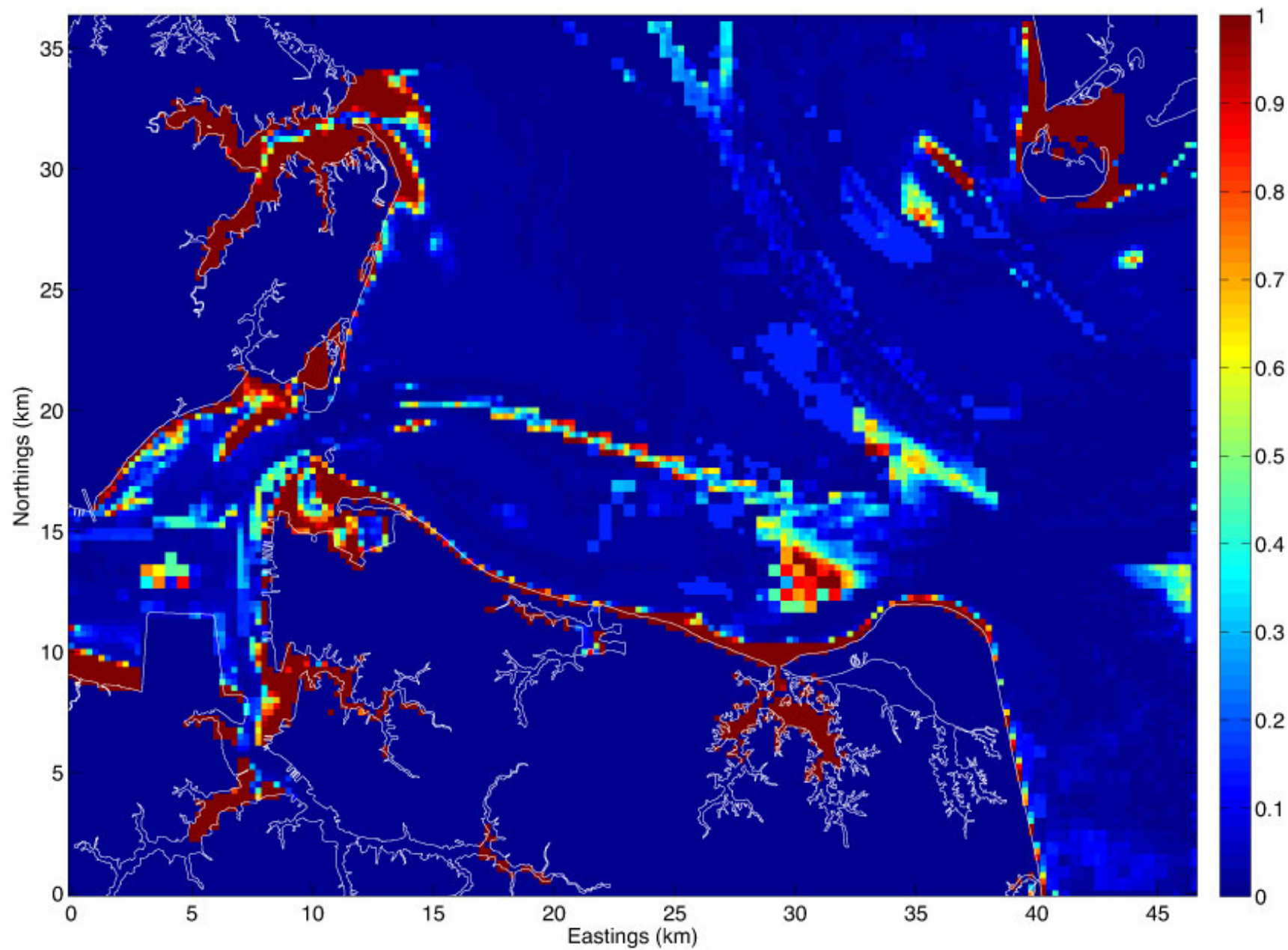
NON-HOMOGENEOUS MARKED
SPATIAL POINT PROCESS MODEL

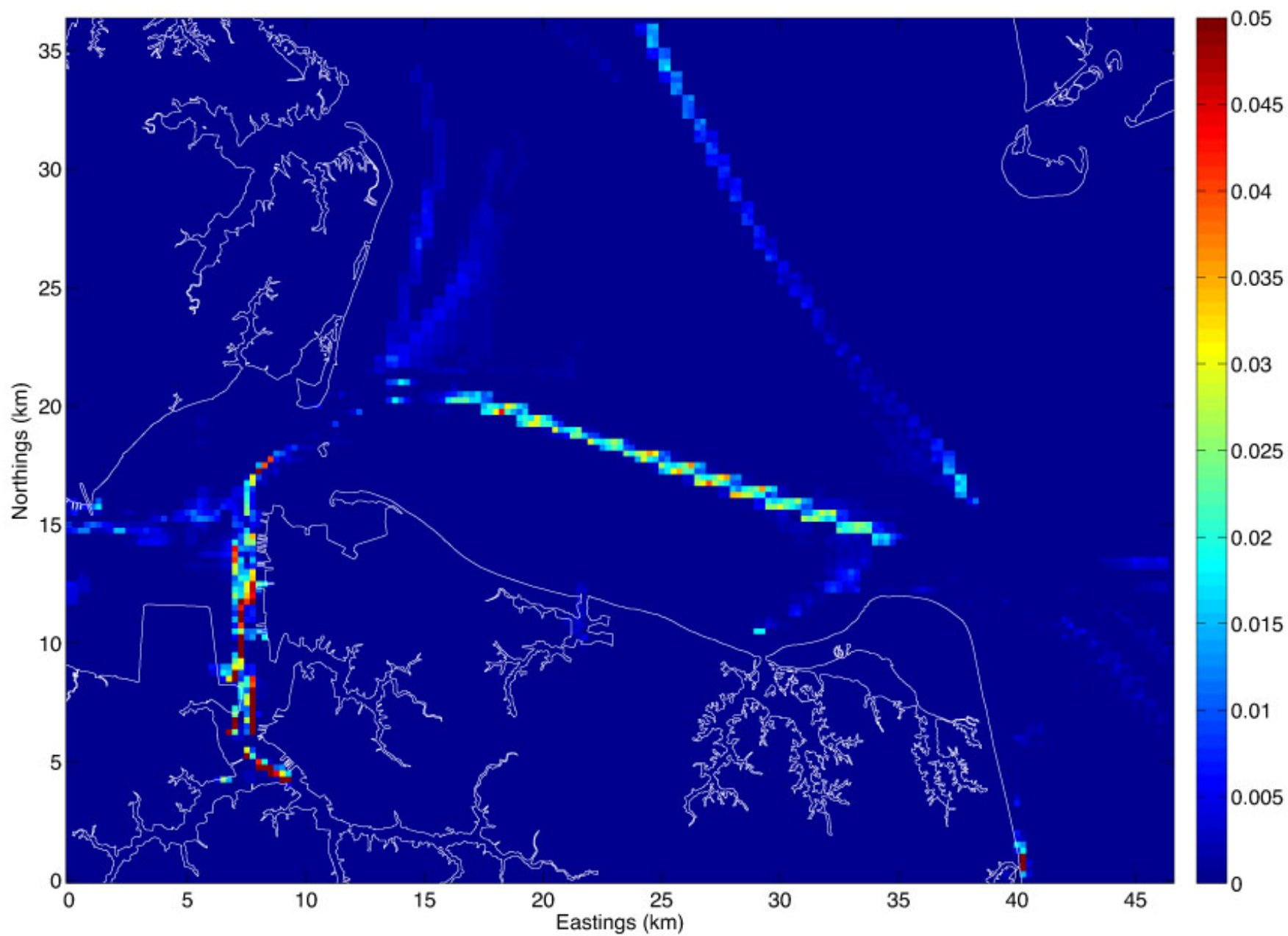


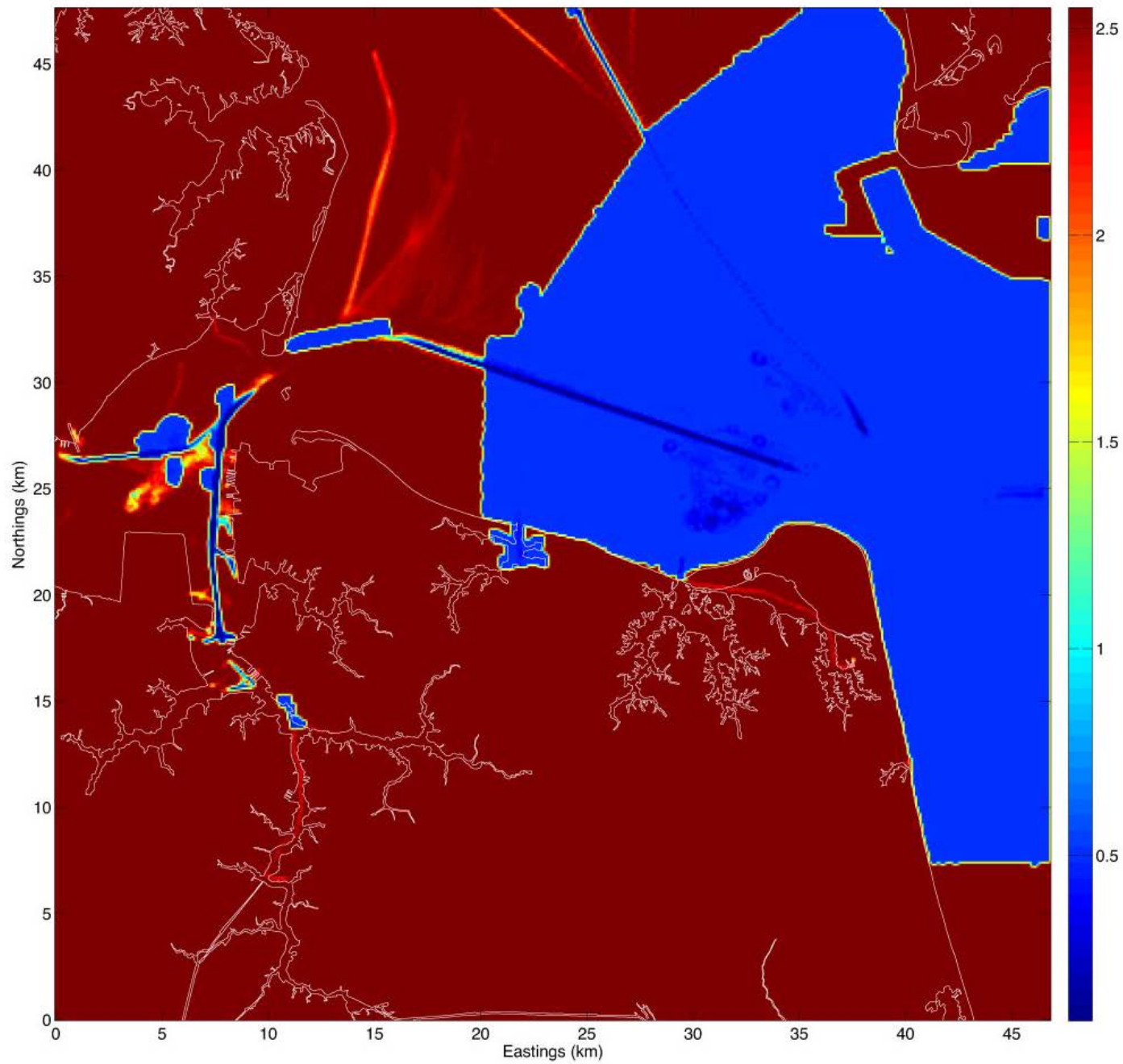


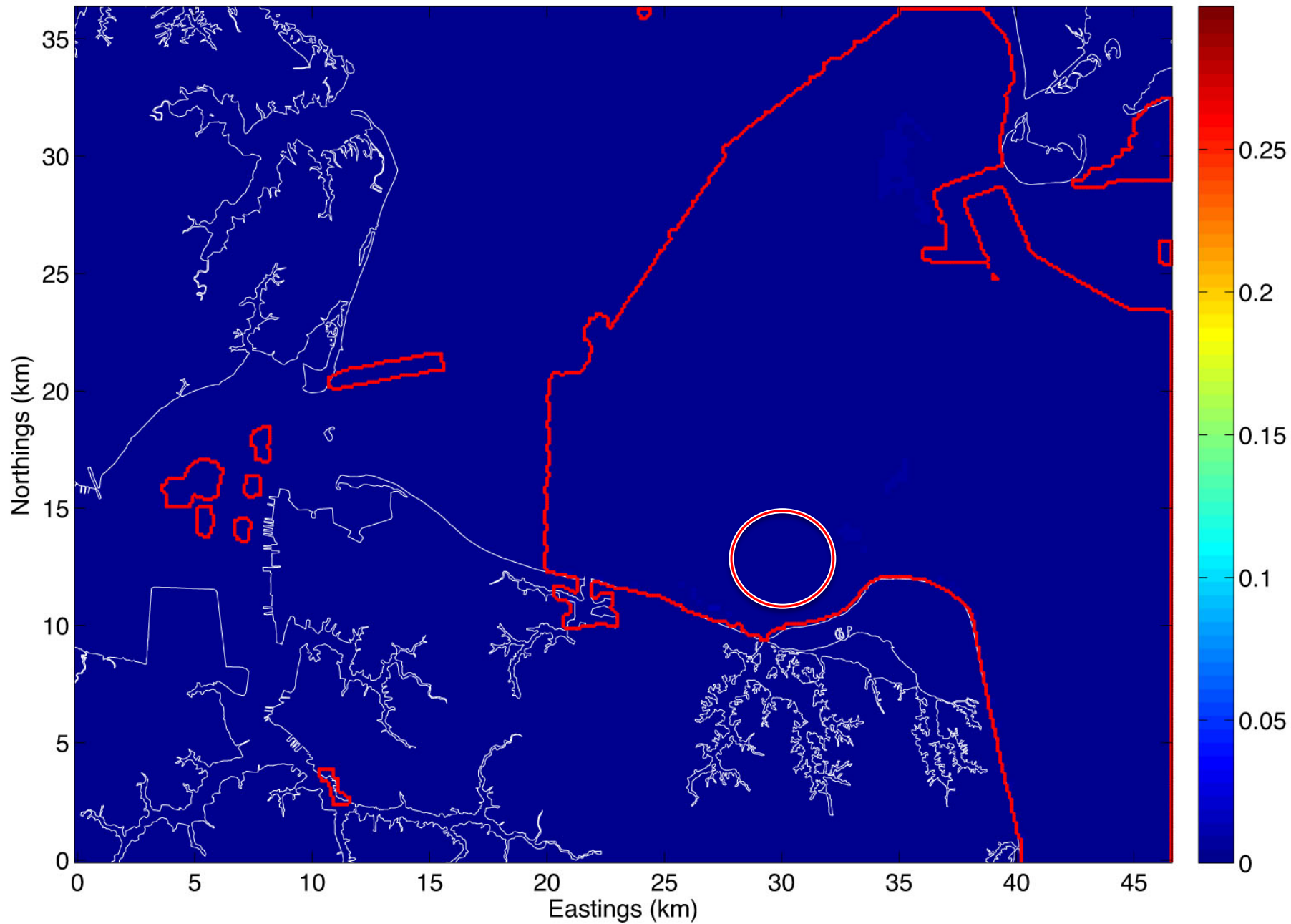
Large Ship Profile
Bathymetry (m), with Log Risk Overlay



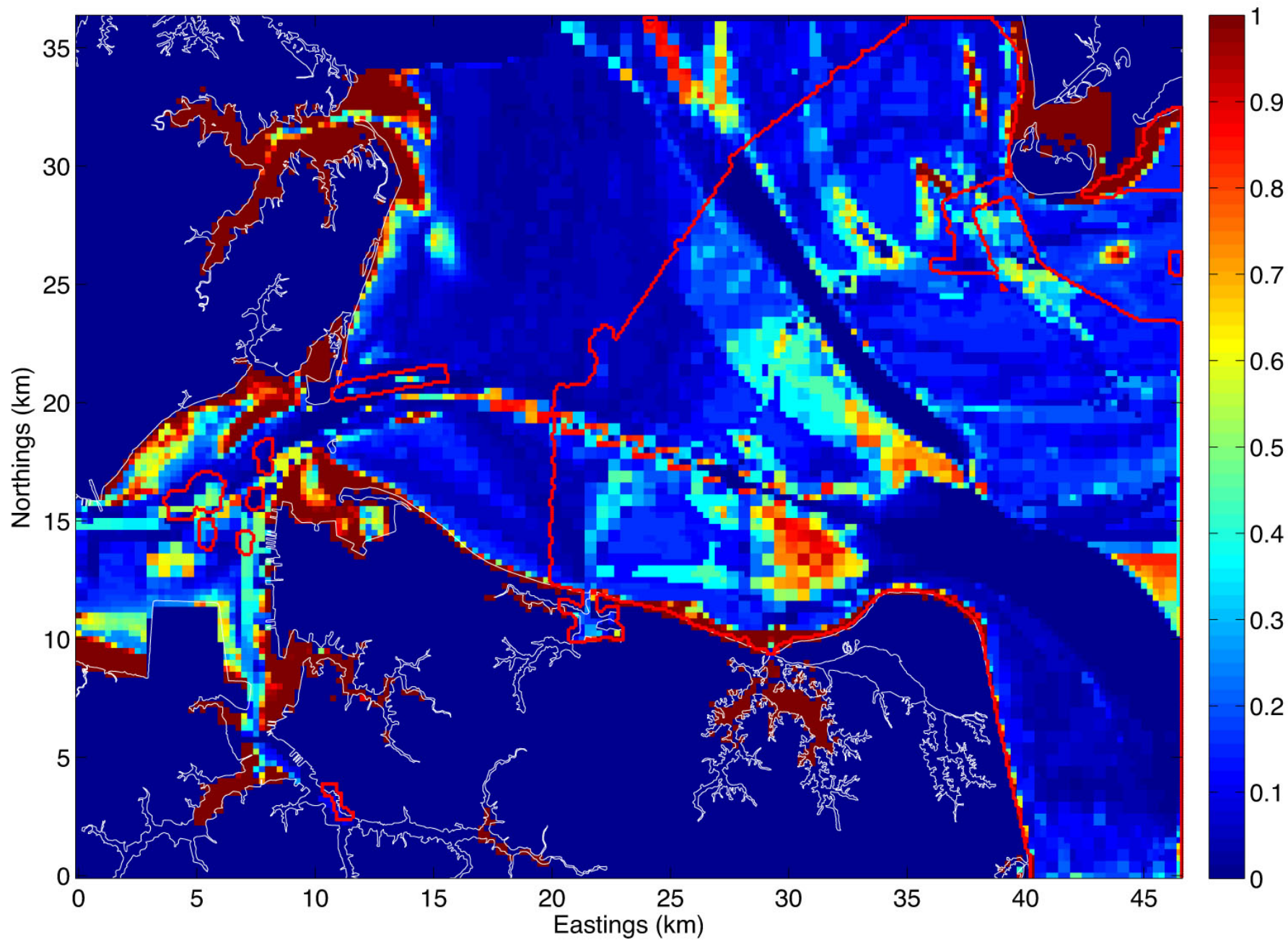




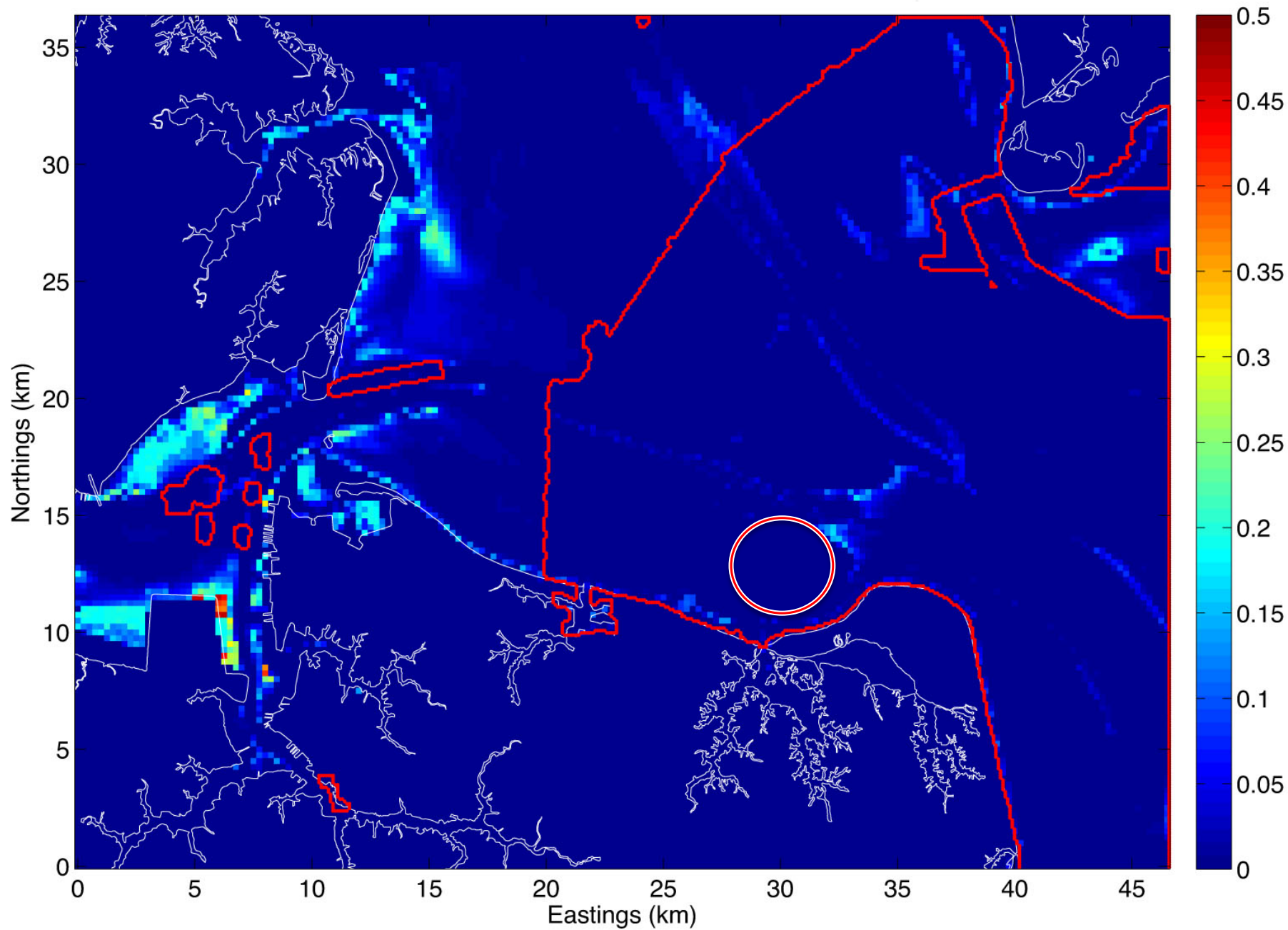




Predicted *a posteriori* potential gain



a posteriori predicted surface shipping risk



a posteriori potential remaining risk improvement

Summary

- Risk models provide estimates of:
 - Risk along transit [minimum risk transit selection]
 - Alternative route risk [real-time decision aid]
 - Risk per spatial cell [user-level “uncertainty” measure]
 - Potential risk improvement after survey [resurvey priority]
 - Predicted risk reduction by tool [survey tool selection]
 - Residual risk improvement achievable [survey completeness]
- Model calibration can be difficult
- AIS data can be used for calibration
 - Traffic density
 - Non-observable area priors
 - Keel-drag unobservable object reduction
 - Noisy: ~50% unusable for these purposes

Brian Calder

Center for Coastal and Ocean Mapping & NOAA-UNH Joint Hydrographic Center

Chase Ocean Engineering Lab, University of New Hampshire

24 Colovos Road

Durham, NH 03820, USA

brc@ccom.unh.edu

+1 (603) 862-0526

Proc. Transportation Research Board 4th Biennial Research and Development

Conference: From Sail to Satellites, Washington, D.C., 21-23 June 2016

