Quantifying Temporal Variations in the Local Sediment Budget: Sand Resource Management at Sebastian Inlet, FL

Gary A. Zarillo and Florian G. Brehin

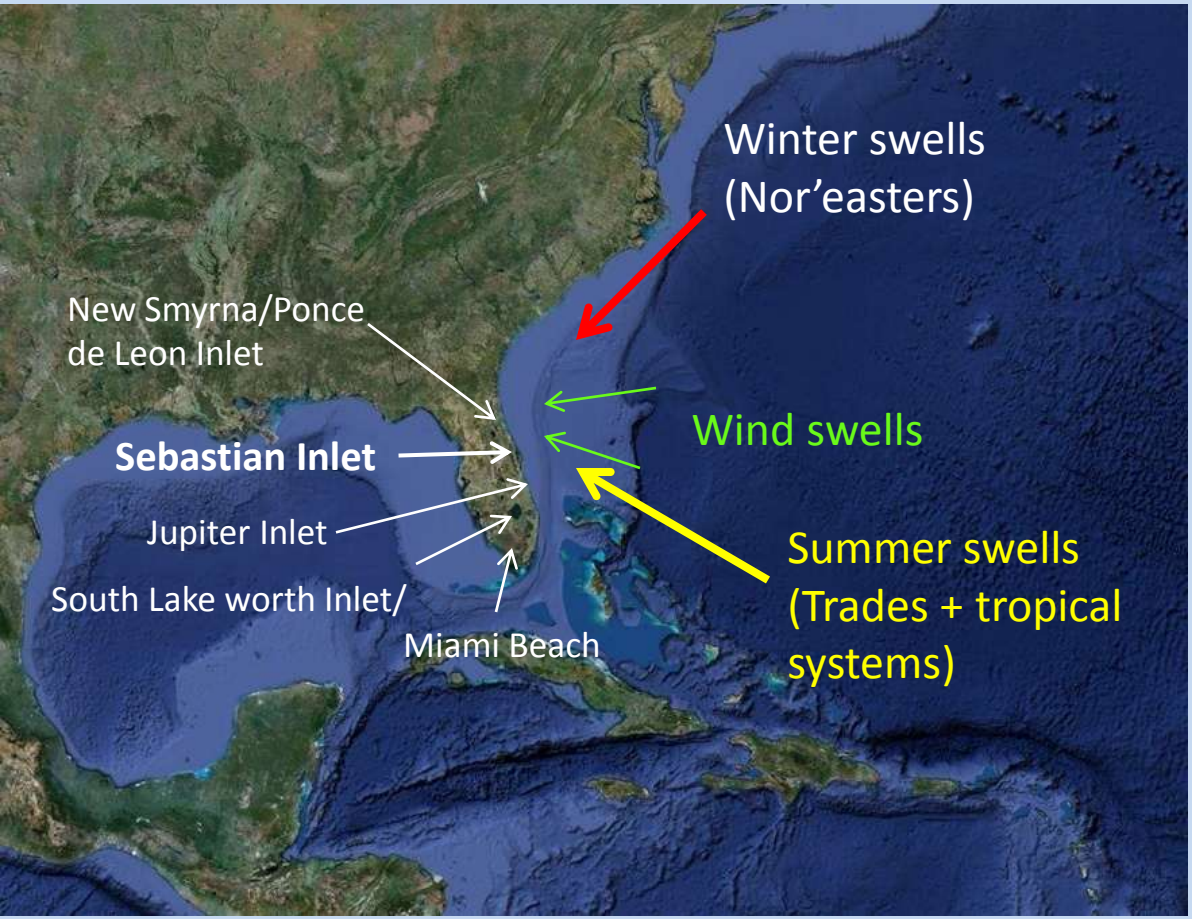
Dept. of Marine and Environmental Systems
Florida Institute of Technology
Melbourne, FL

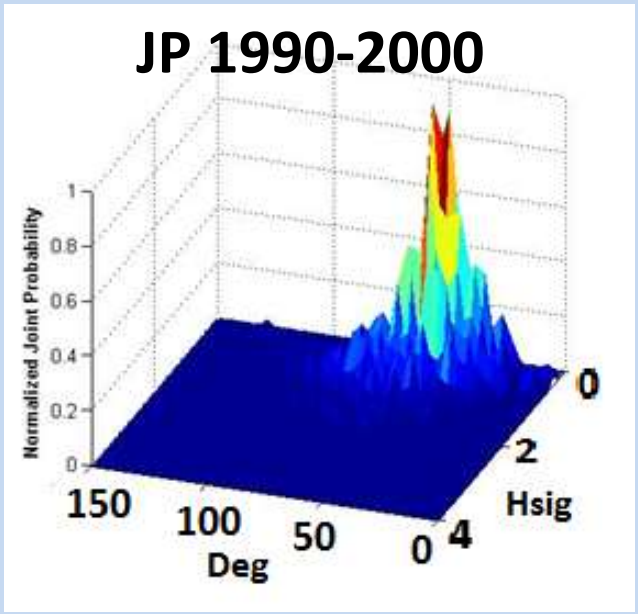
http://www.sebastianinletdistrict.com/

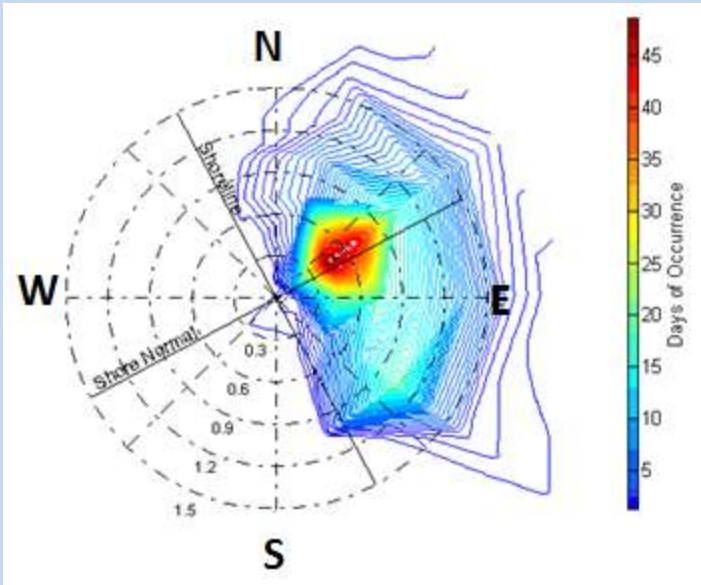
Presentation Outline

- ***Location and Physical Setting***
- ***Database and Morphology***
- ***Sand Budget Methods***
- ***Regional Sand Budget***
- ***Local Sand Budget Calculations***
  - ***Longer term sand budget***
  - ***Shorter term sand budget***
- ***Conclusions***

Location and Wave Climate

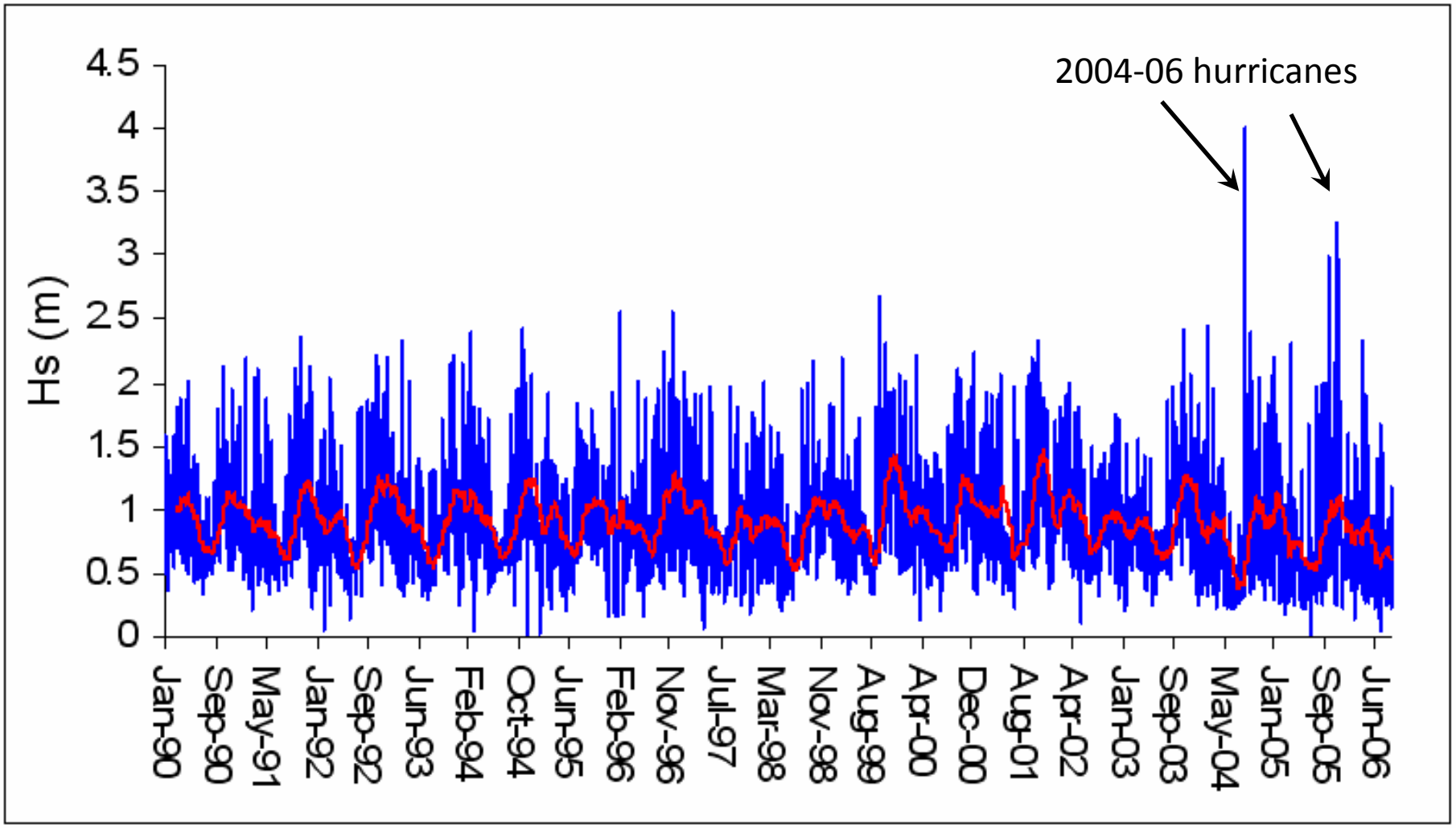




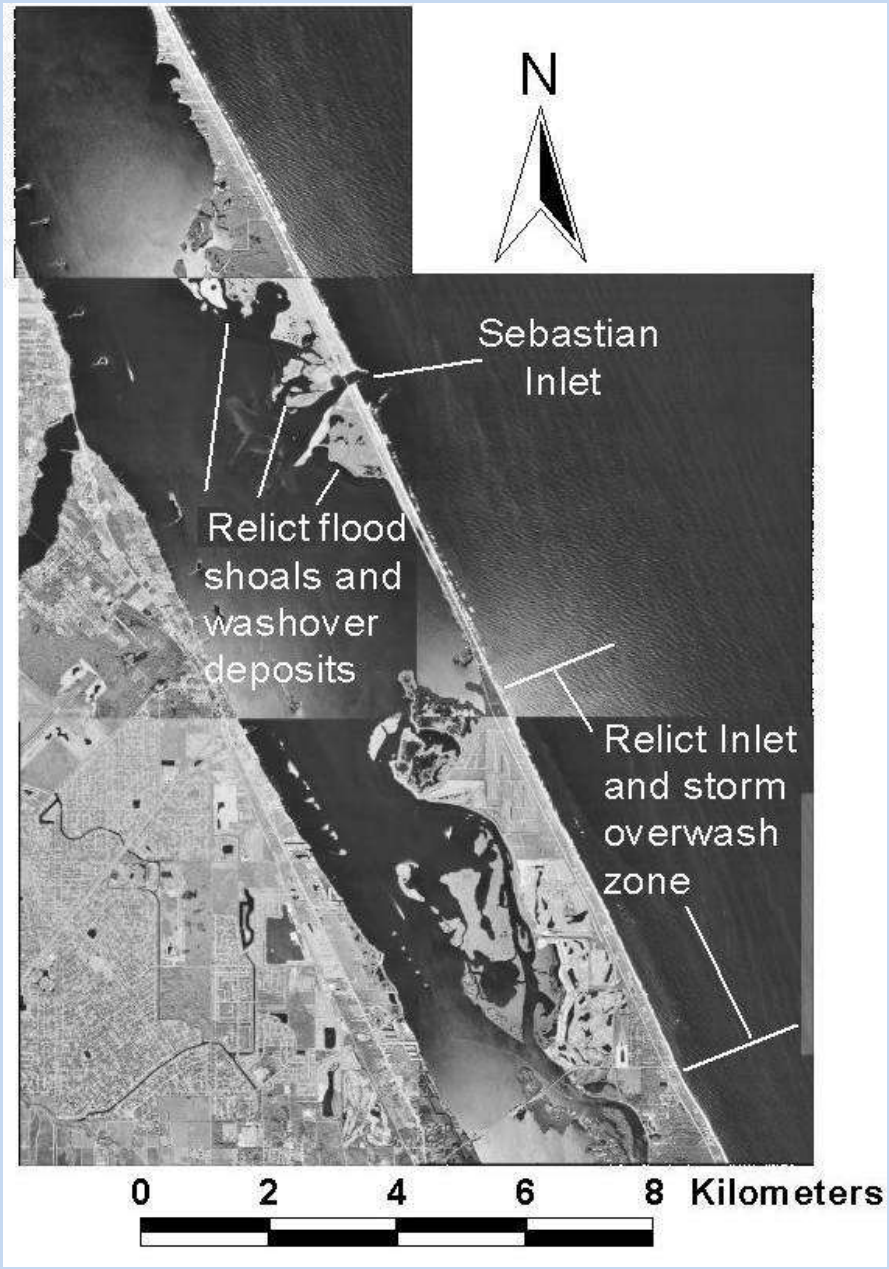


Wave Climate

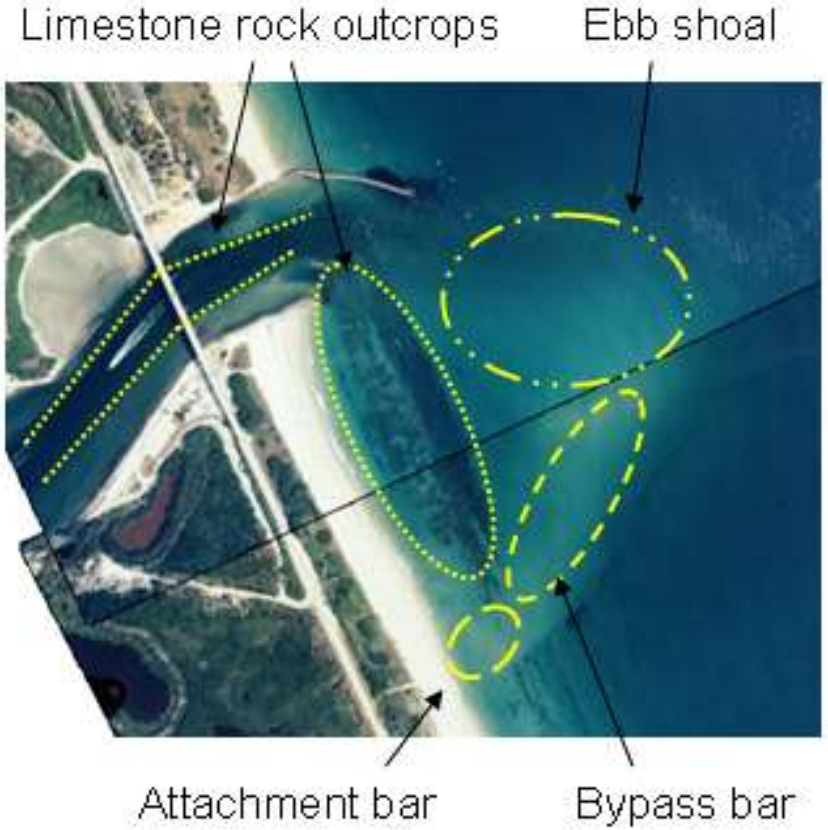
Seasonal Wave Regime 1990 -2006



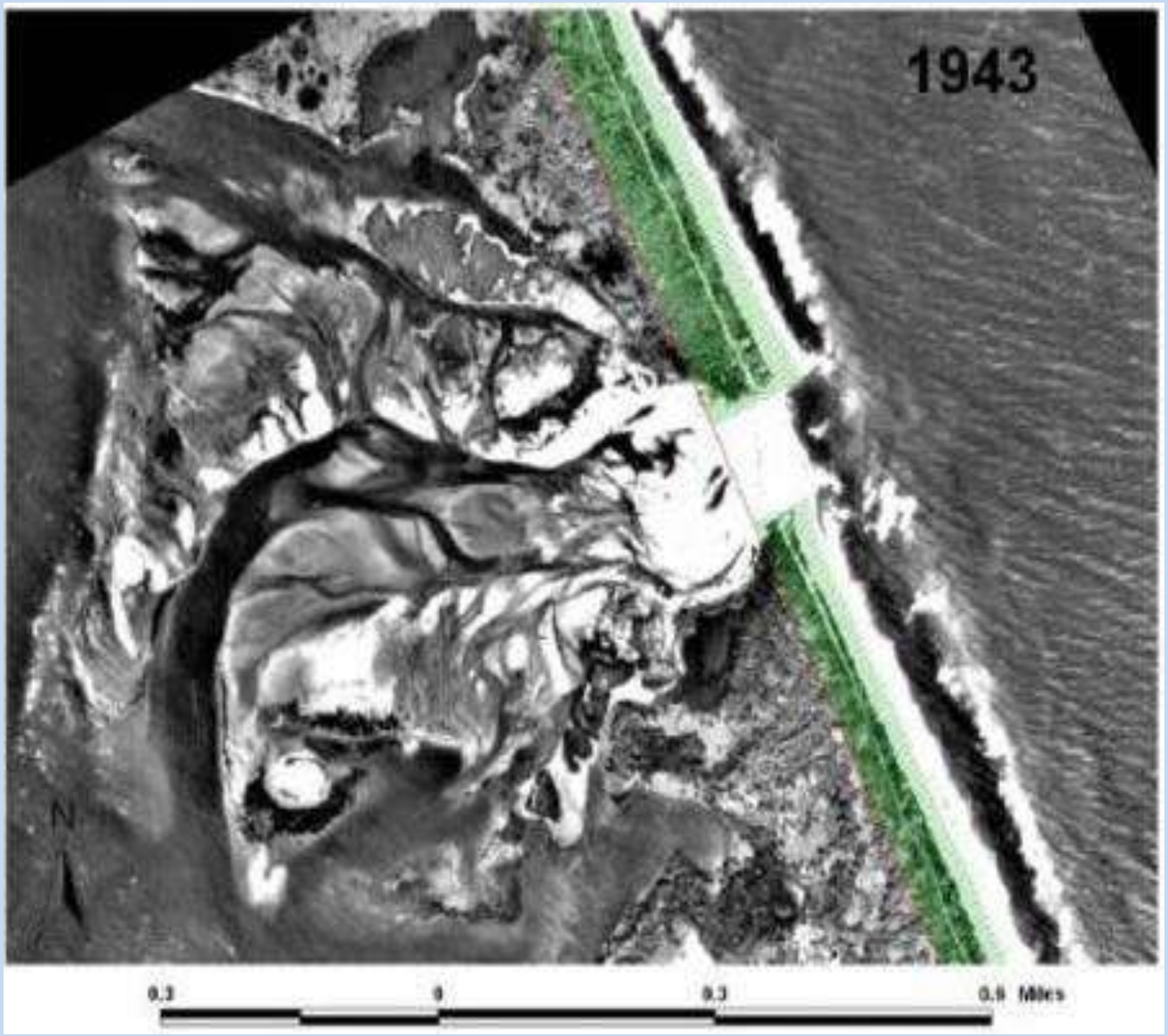
Geomorphic Setting



Geomorphic Setting

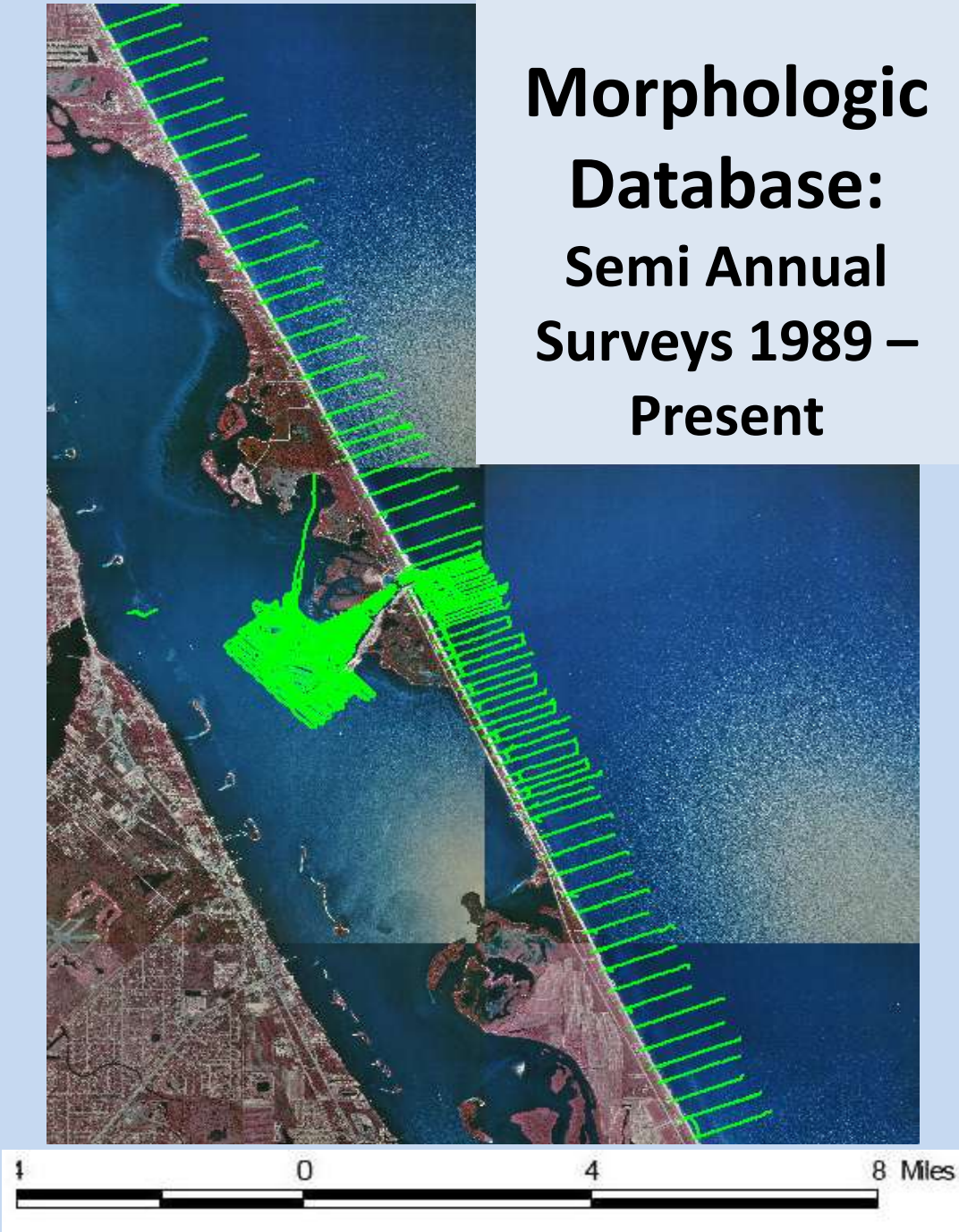


Sebastian Inlet Evolution 1943 - 2007

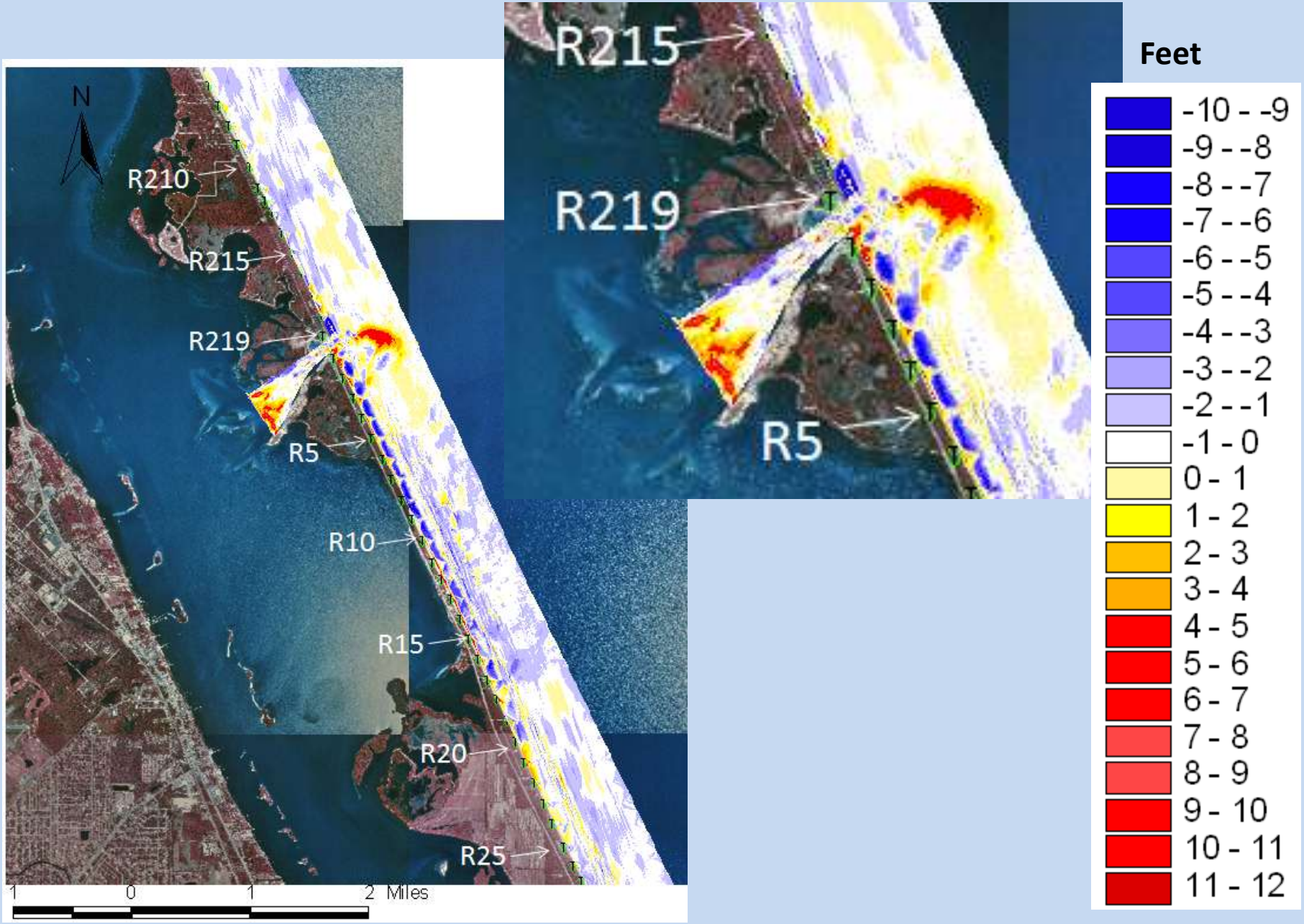


Morphologic Database:

Semi Annual Surveys 1989 – Present

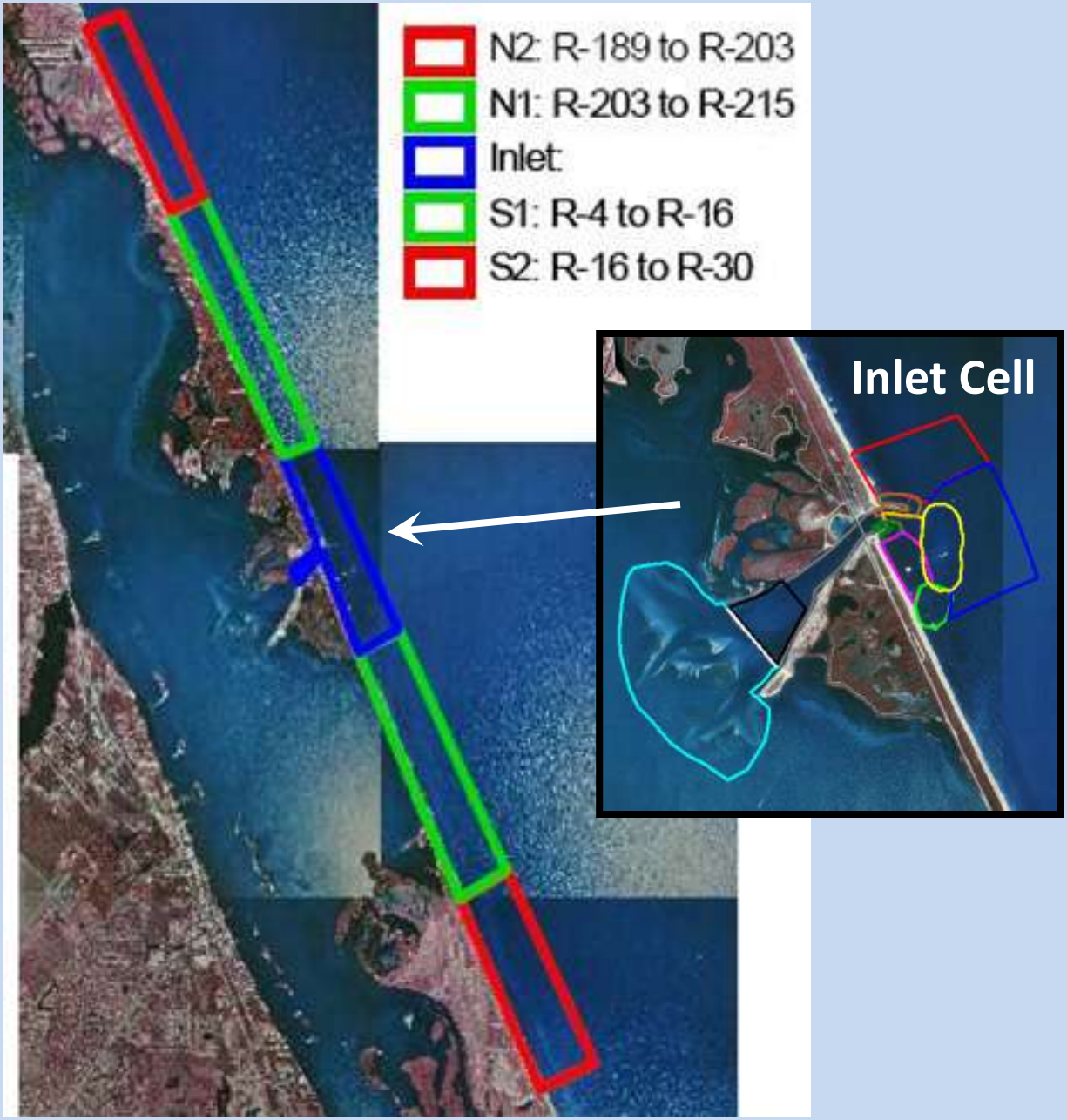


Net Topographic Change 2000 - 2010

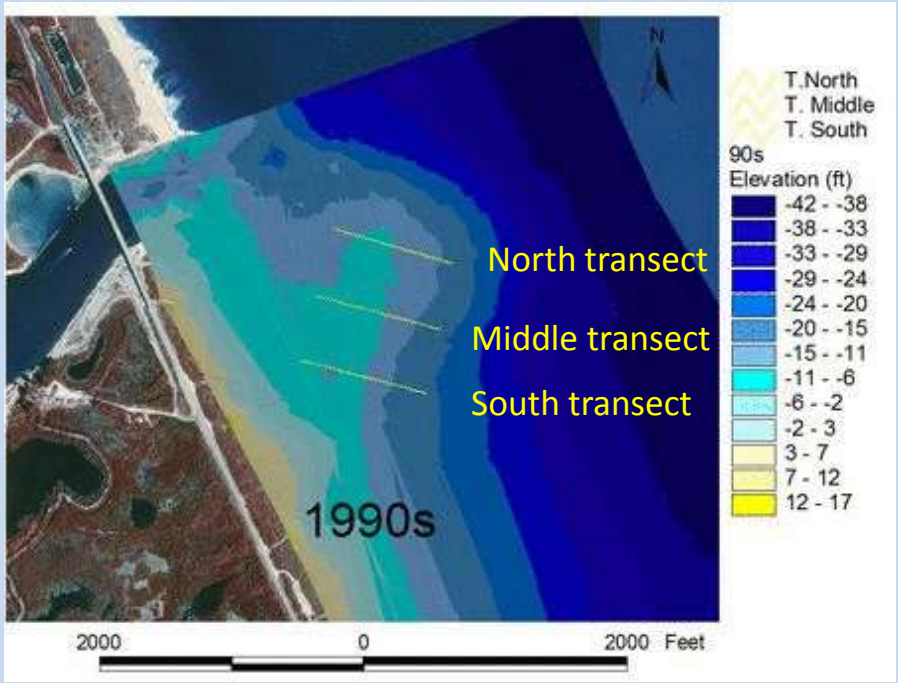


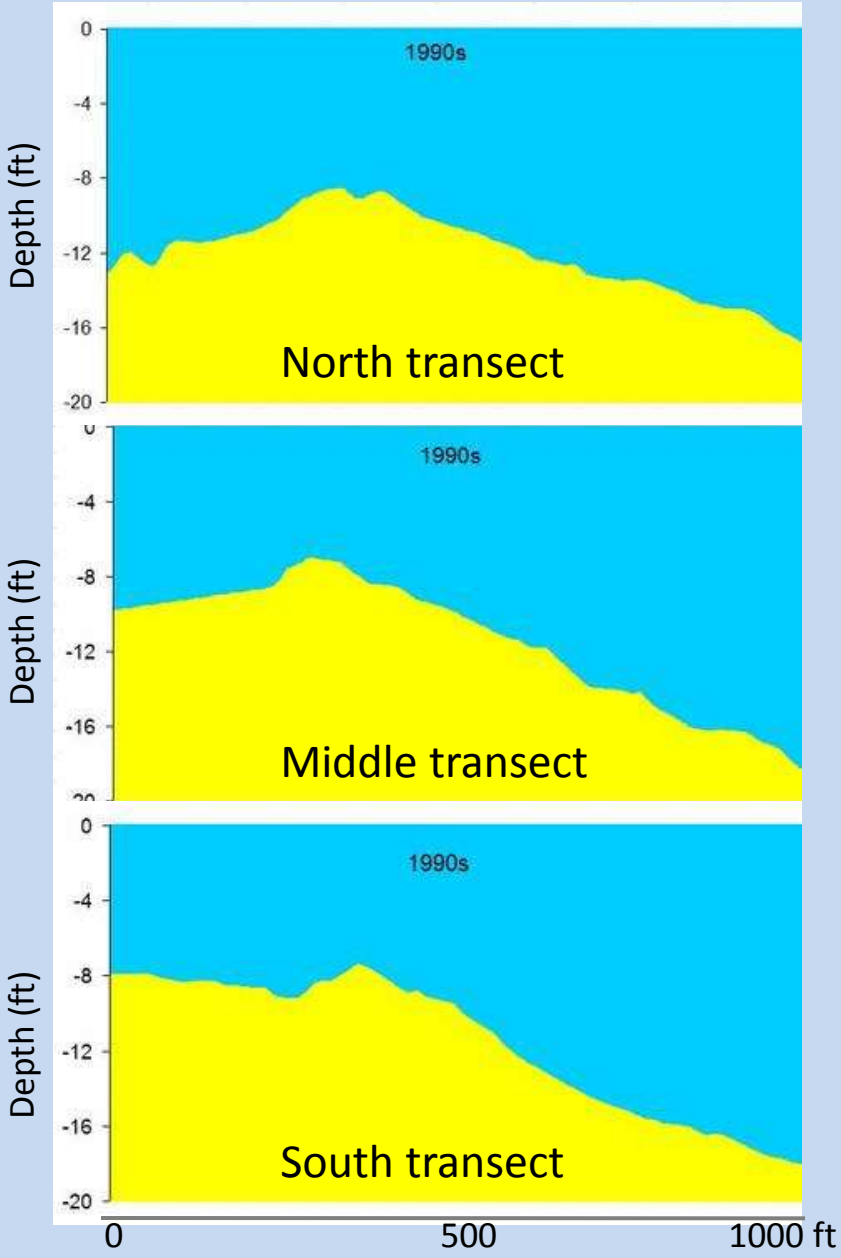
Morphologic Features Forming Inlet Sand Reservoirs

Sediment Budget Cells

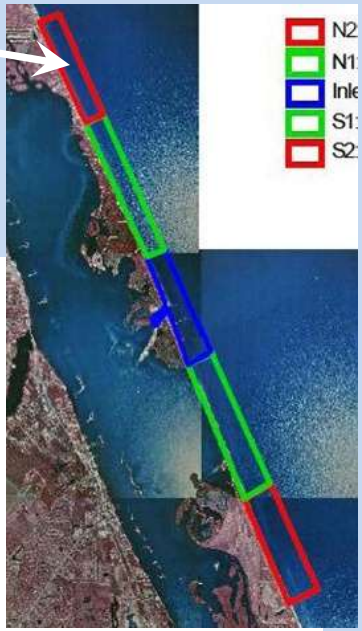


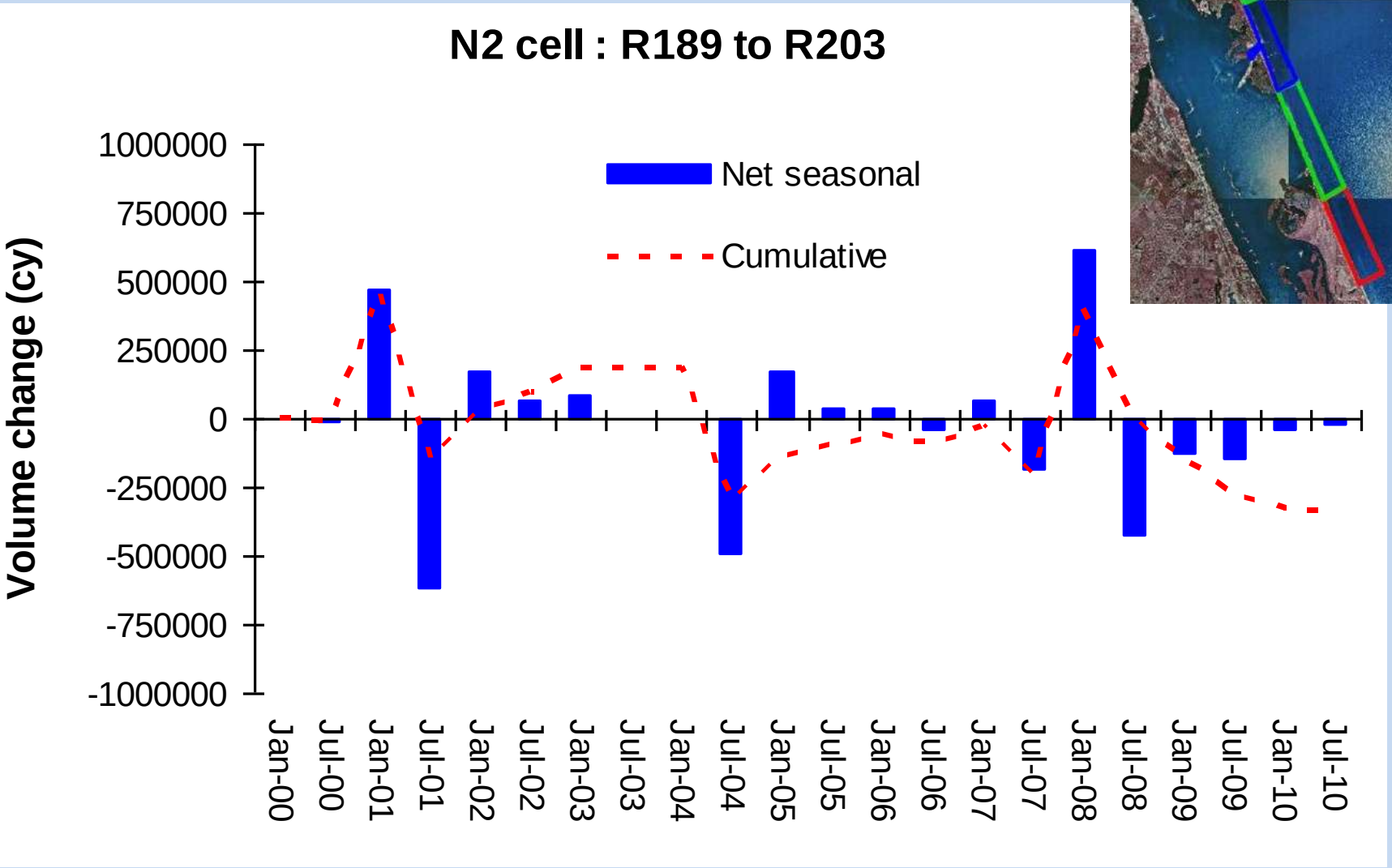
Inlet Cell Morphologic Evolution



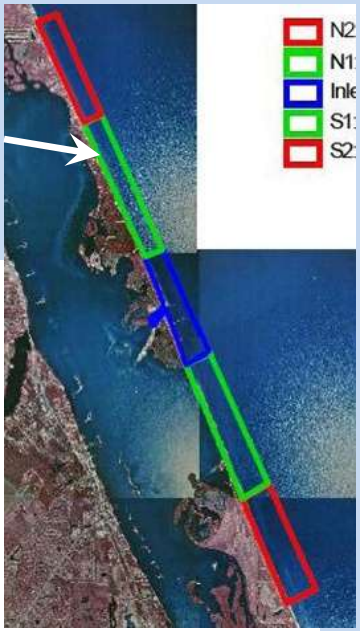


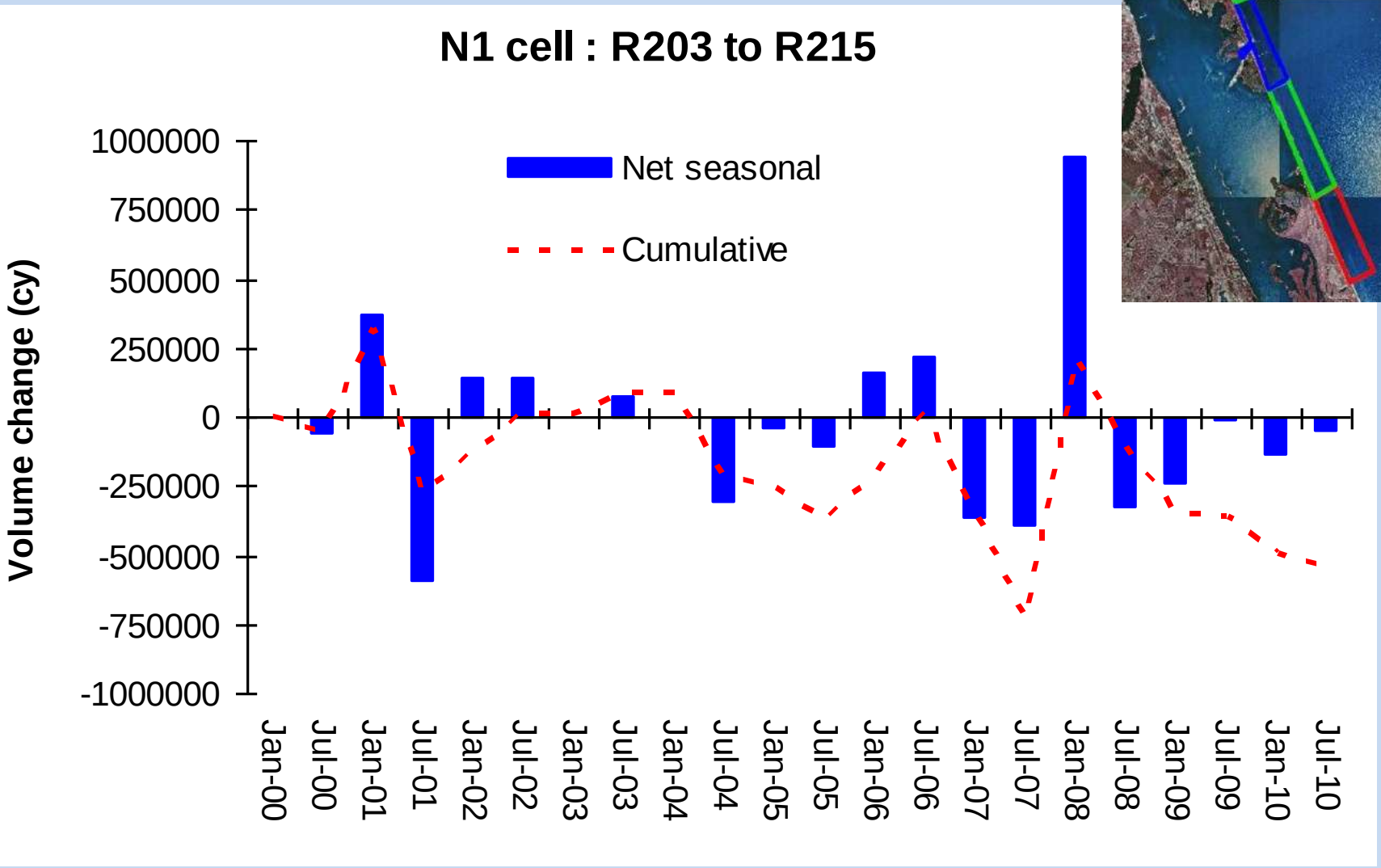
Sand Volume Changes 2000 - 2010



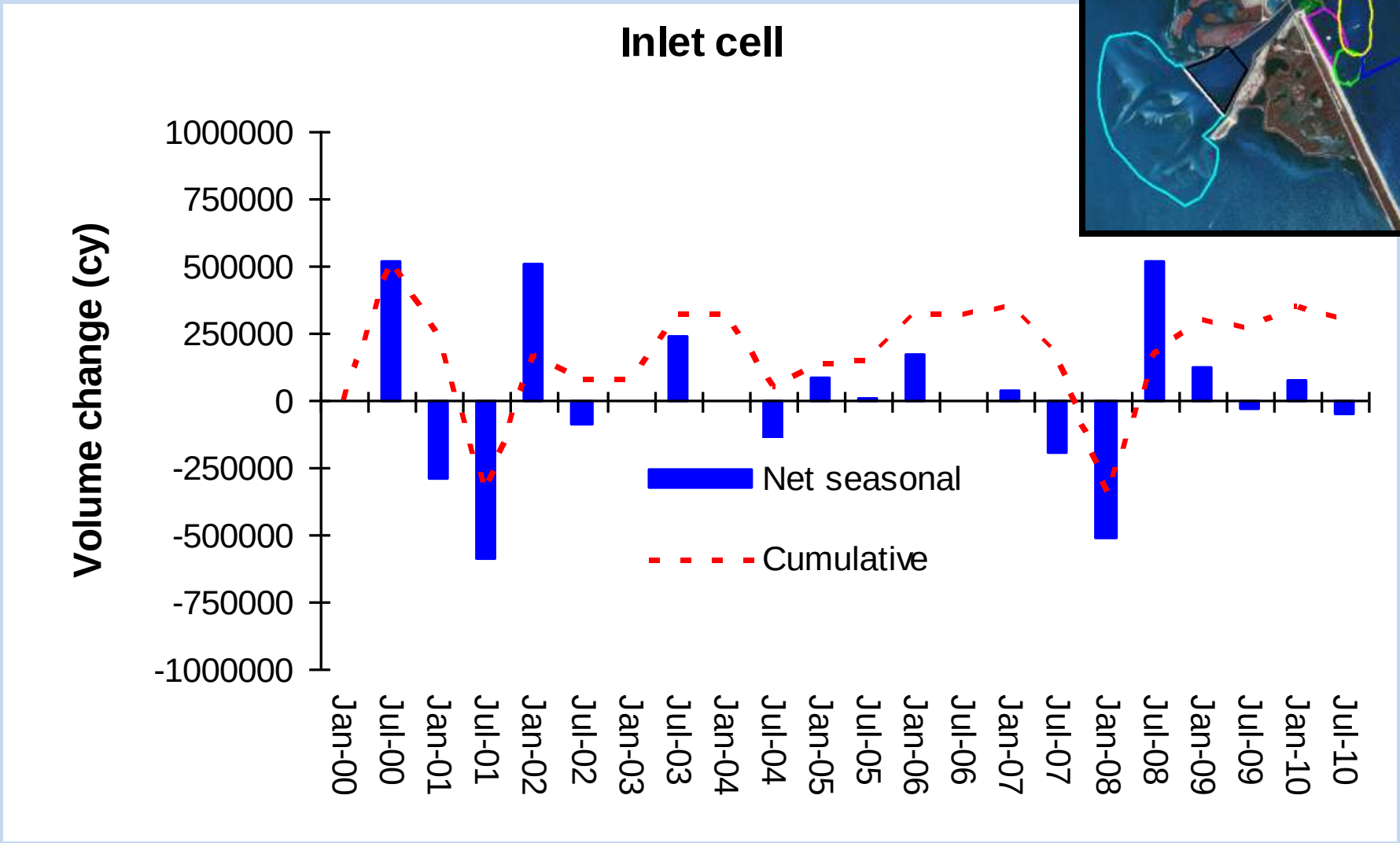


Sand Volume Changes 2000 - 2010

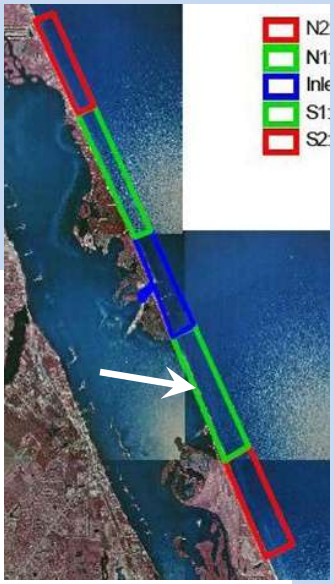


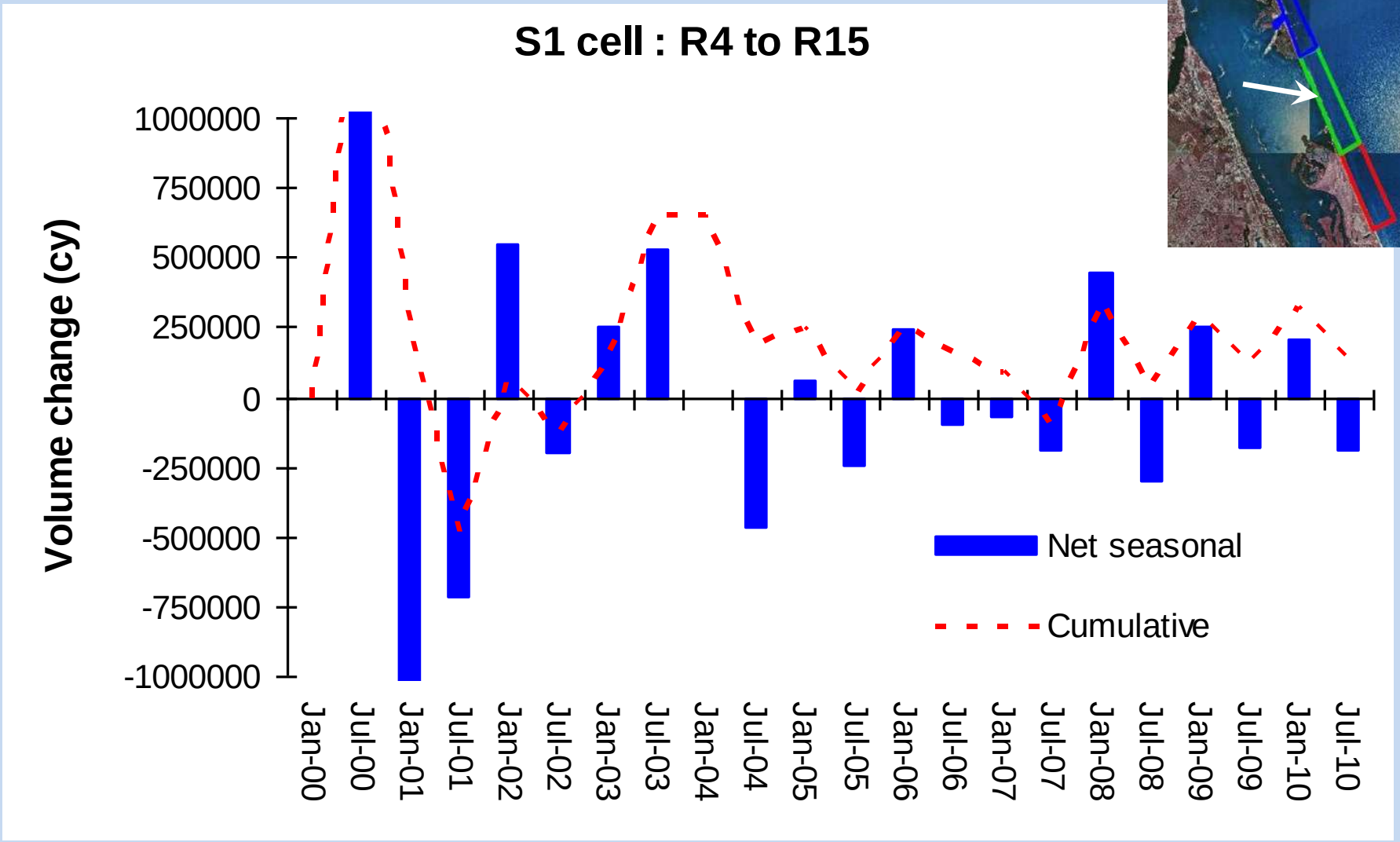


Sand Volume Changes 2000 - 2010

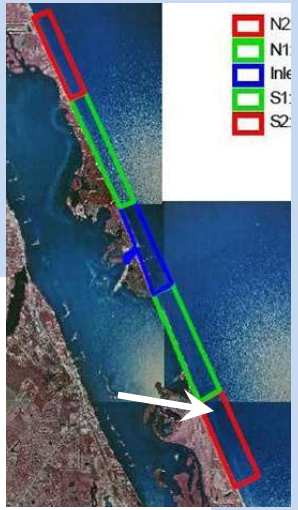


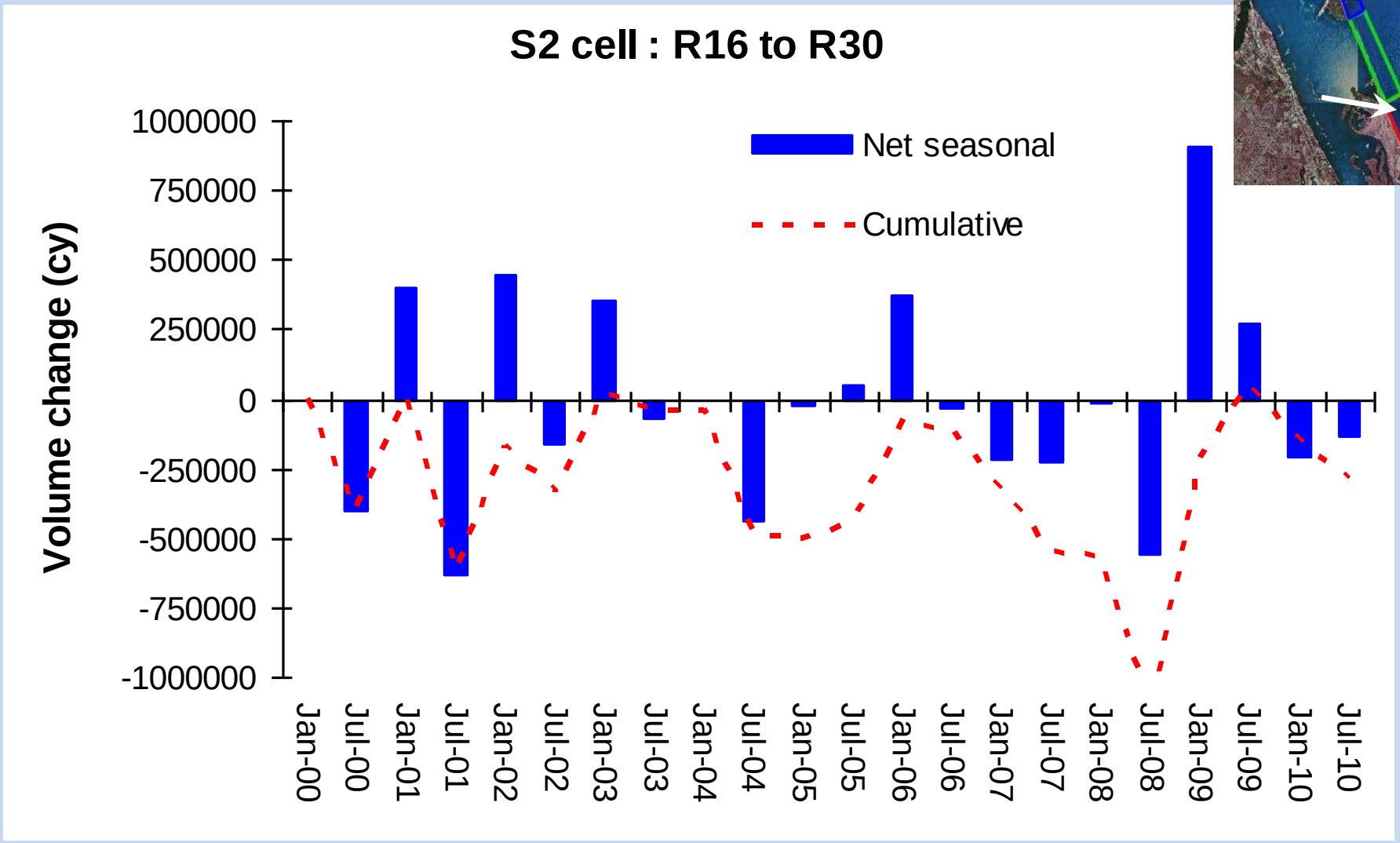
Sand Volume Changes 2000 - 2010



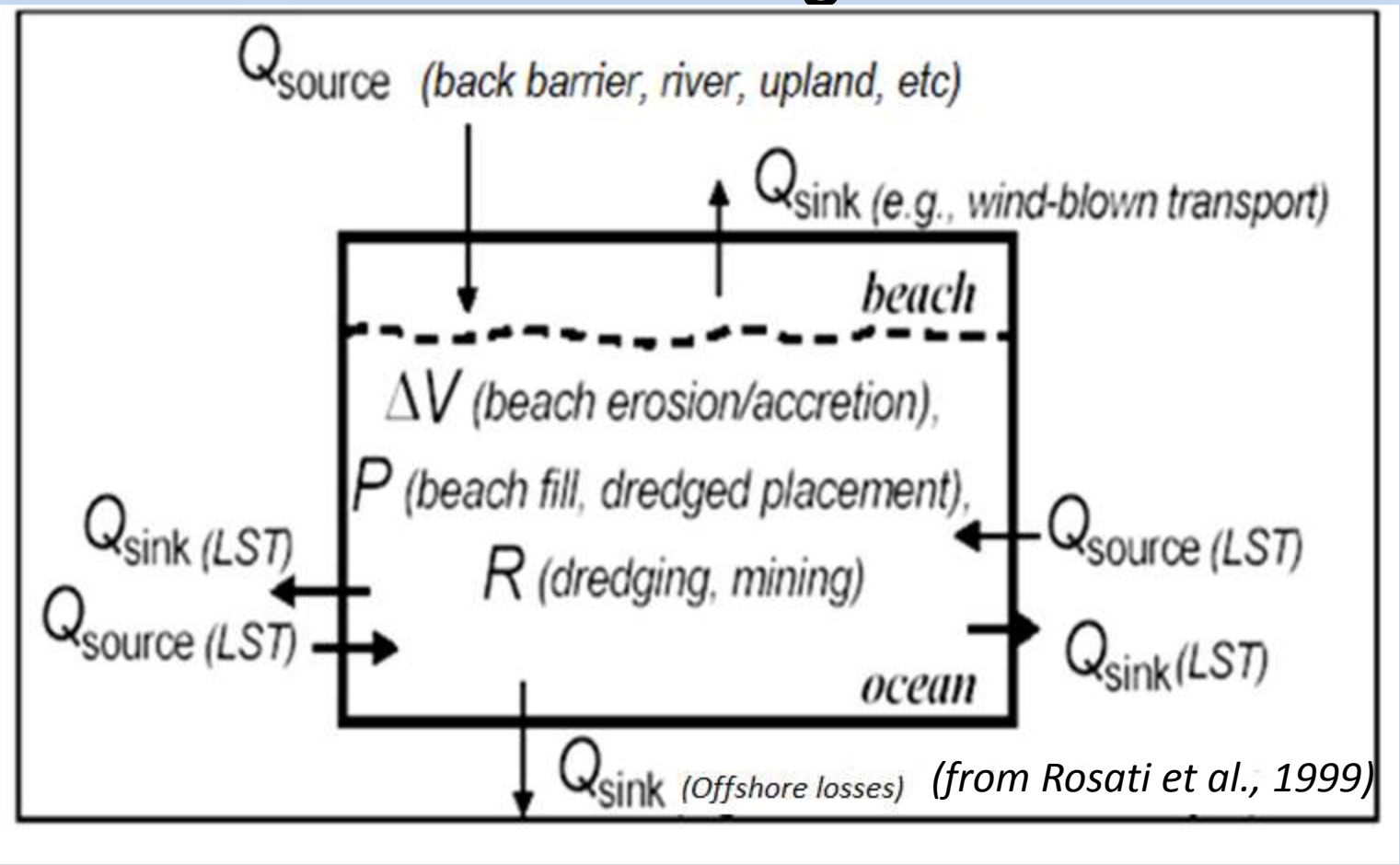


Sand Volume Changes 2000 - 2010





Sediment Budget Cell



$$\Sigma Qsource - \Sigma Qsink - \Delta V + P - R = residual$$

- **ΔV the net volume change within the cell**
- **P and R the amount of material placed and removed from cell,**
- **Residual - degree to which the cell is balanced**

Regional Sand Budget 1972 -2002

from Florida Dept. Env. Protection (FDEP)

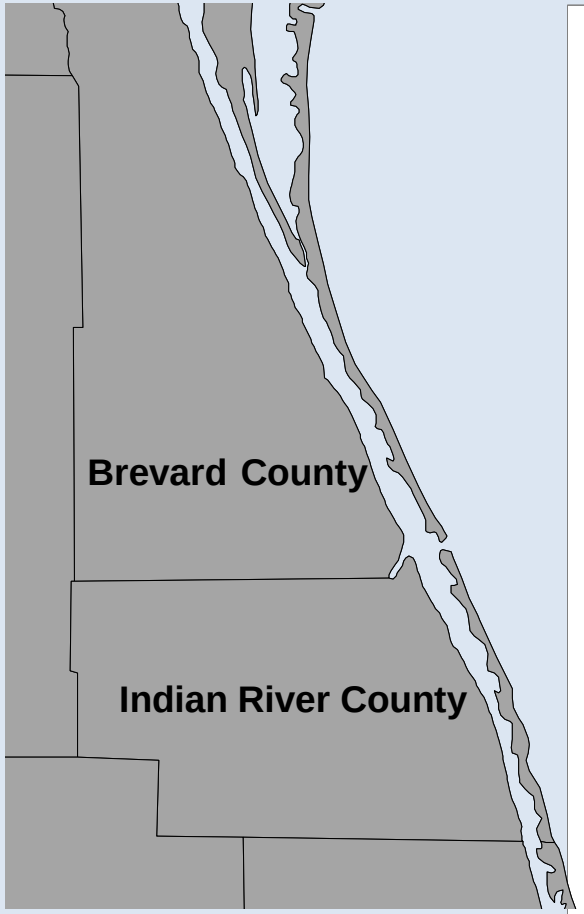
Beach Profile Data

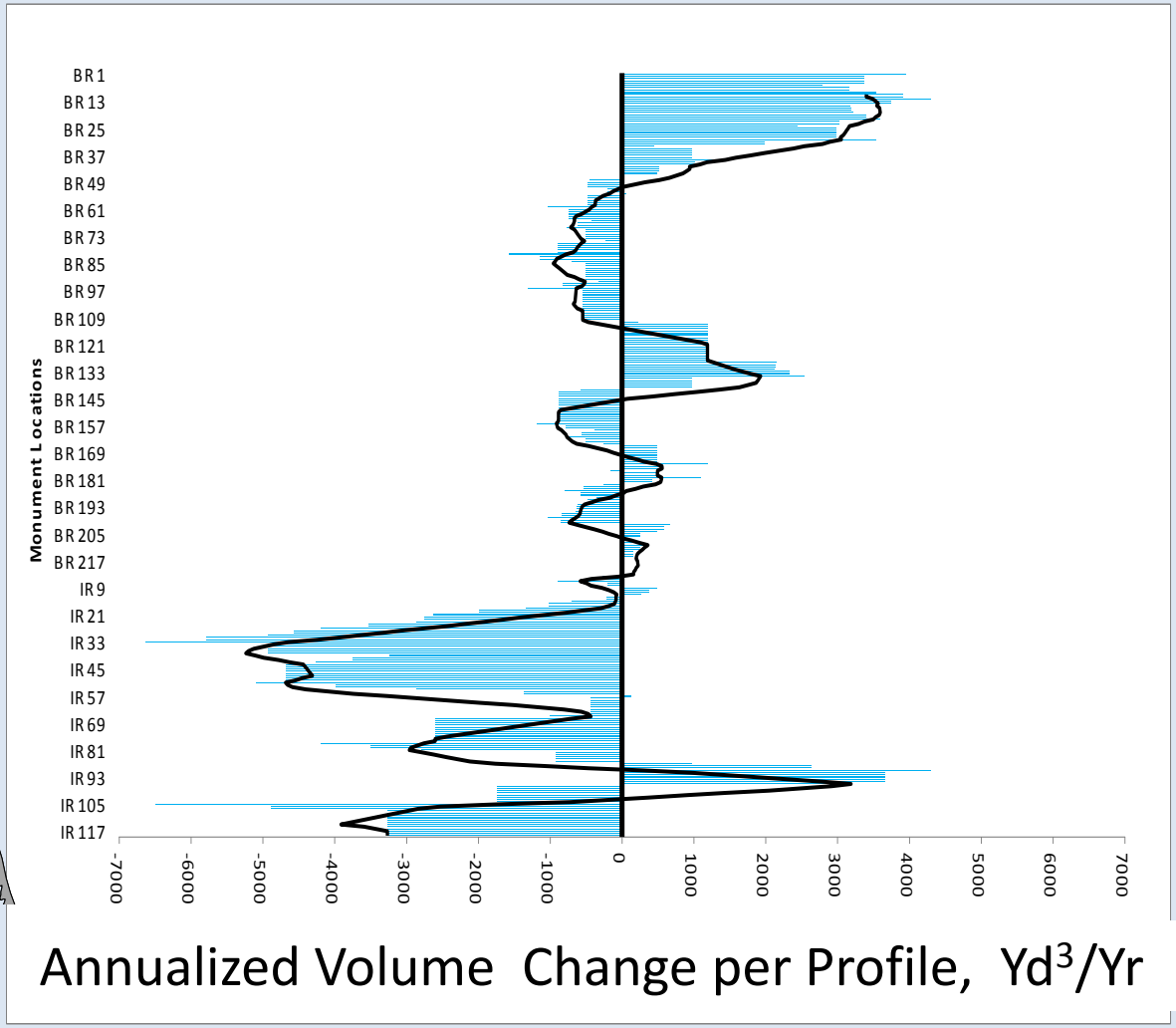
	Placement (yd^3/yr)	Volume Change (yd^3/yr)	Average Annual Littoral (yd^3/yr)
			-126,000
BR1-BR42	250,878	113,227	11,651
BR42-BR110	63,577	-37,095	112,323
BR110-BR140	62,867	41,061	134,128
BR140-BR173	0	-15,384	149,512
BR173-BR182	0	4,914	144,598
BR182-BR200	0	-11,498	156,096
BR200-BR215	0	4,593	151,503
Inlet	**0**	**54,380**	**97,123**
IR4-IR16	44,672	-2,787	144,582
IR16-IR30	0	-42,650	187,232
IR30-IR86	1,703	-165,517	354,452
IR86-IR96	0	31,900	32,2552
IR96-IR119	428	-69,333	392,313

Regional Sand Budget 1972 -2002

From Florida Dept. Env. Protection (FDEP)

Beach Profile Data





Local Sand Budget

Recent Fill Projects

Project Time and Type	Placement	Volumes (yd^3)
2003. Indian River County Beach Restoration	R-4 to R-16	589,350
2007. Phase 1: mechanical bypassing from sand trap	R-4 to R-12	95,700
2007. Phase 2 shelf sand ridge	R-8 to R-17	204,900

Local Sand Budget

Annualized Placement and Removal

	Time period	Season	Placement S1 (cy/yr)	Removal Inlet (cy/yr)
Longer term	2000 - 2010	winter	88,000	9,500
		summer	88,000	9,500
	2002 - 2010	winter	110,000	11,900
		summer	110,000	11,900
	2005 - 2010	winter	58,000	19,000
		summer	58,000	19,000
Shorter term	2007 - 2010	winter	97,000	31,000
		summer	68,000	0
	2008 - 2010	winter	0	0
		summer	0	0

Local Sand Budget

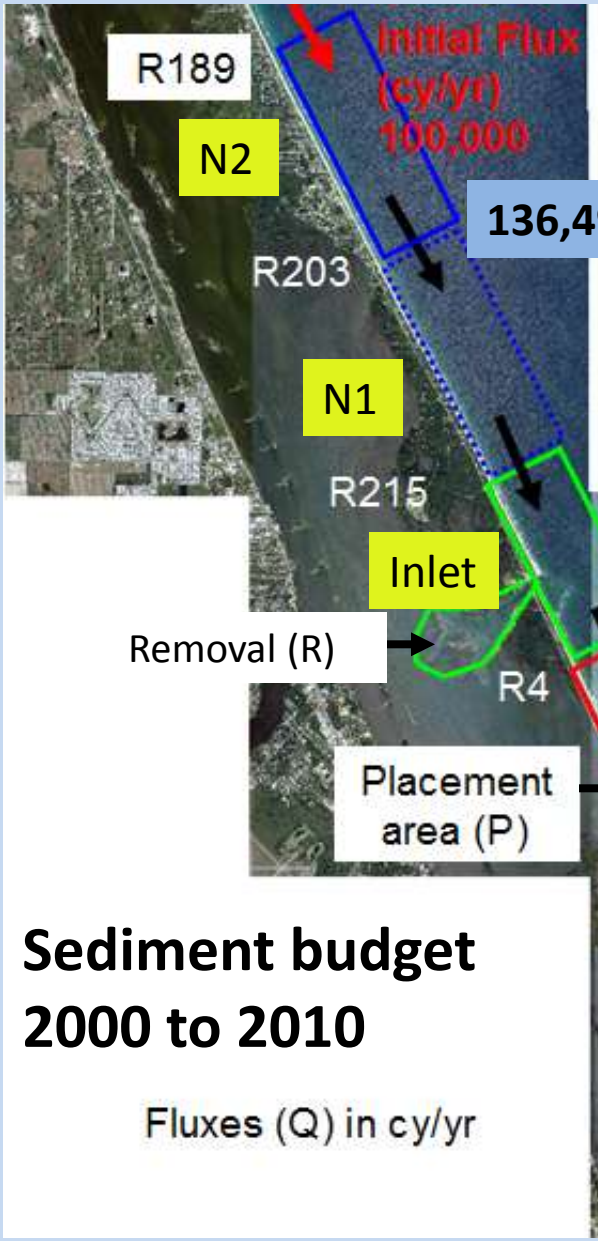
Longer Term Sand Budget

- **10 yr (2000 – 2010)**
- **8 yr (2002 – 2010)**
- **5 yr (2000 – 2005 and 2005 – 2010)**

Local Sand Budget – 10 Years

	2000 - 2010			
	winter/winter		summer/summer	
Budget Cell	Δ V (cy/yr)	Q (cy/yr)	Δ V (cy/yr)	Q (cy/yr)
North2	-36,183	136,183	-36,490	136,490
North1	-51,829	188,011	-54,180	190,671
Inlet	***36,413***	***142,098***	***29,551***	***151,619***
South1	33,382	196,717	12,932	226,687
South2	-16,434	213,151	-29,411	256,098

Local Sand Budget – 10 Years



	SUMMER BUDGET	WINTER BUDGET
	136,490	136,183
	190,671	188,011
	151,619	142,098
	226,687	196,717
	256,098	213,151

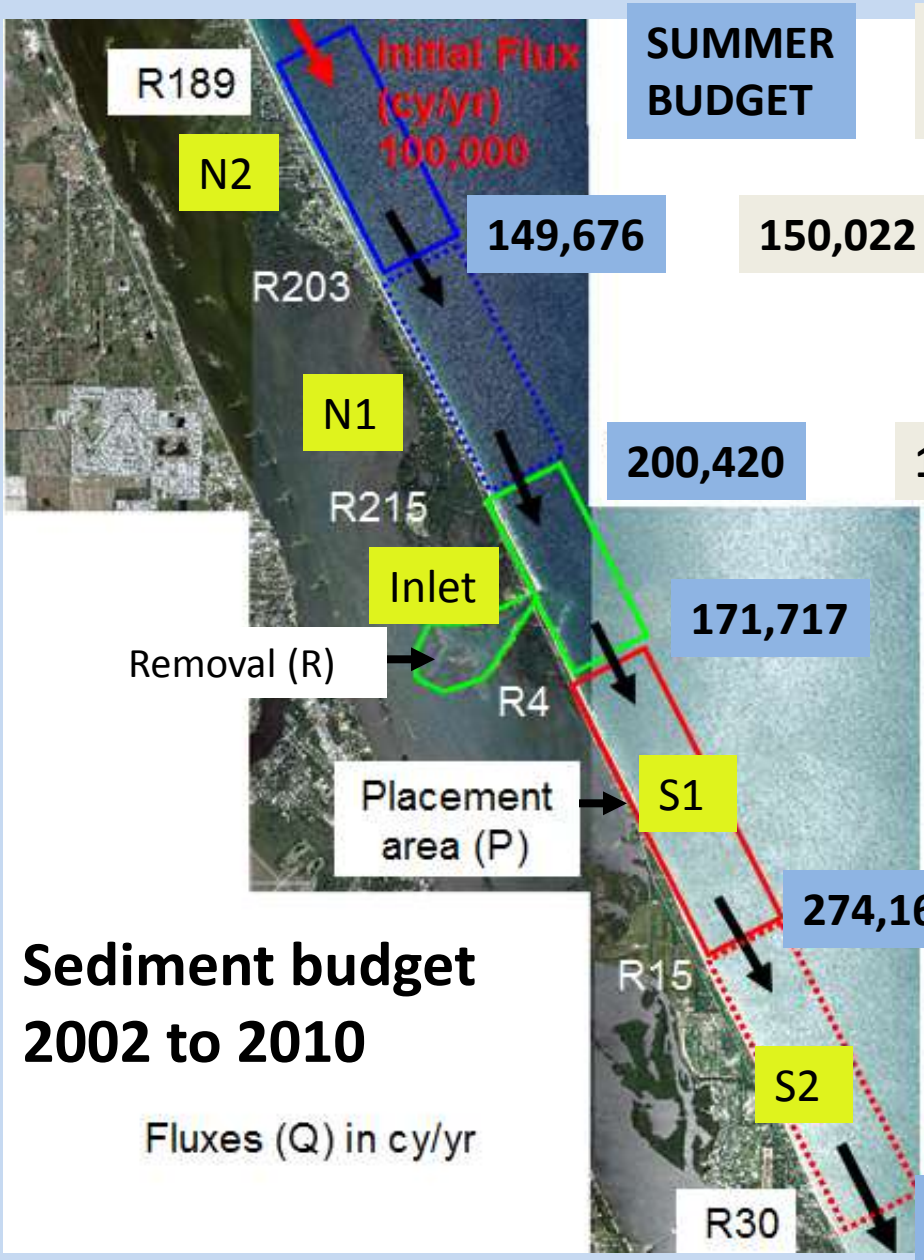
Sediment budget 2000 to 2010

Fluxes (Q) in cy/yr

Local Sand Budget – 8 Years

	2002 - 2010			
	winter/winter		summer/summer	
Budget cell	Δ V (cy/yr)	Q (cy/yr)	Δ V (cy/yr)	Q (cy/yr)
North2	-50,222	150,222	-49,676	149,676
North1	-47,537	197,759	-50,744	200,420
Inlet	***24,646***	***161,213***	***16,804***	***171,717***
South1	33,093	238,121	7,549	274,168
South2	2,220	235,900	-15,166	289,334

Local Sand Budget – 8 Years

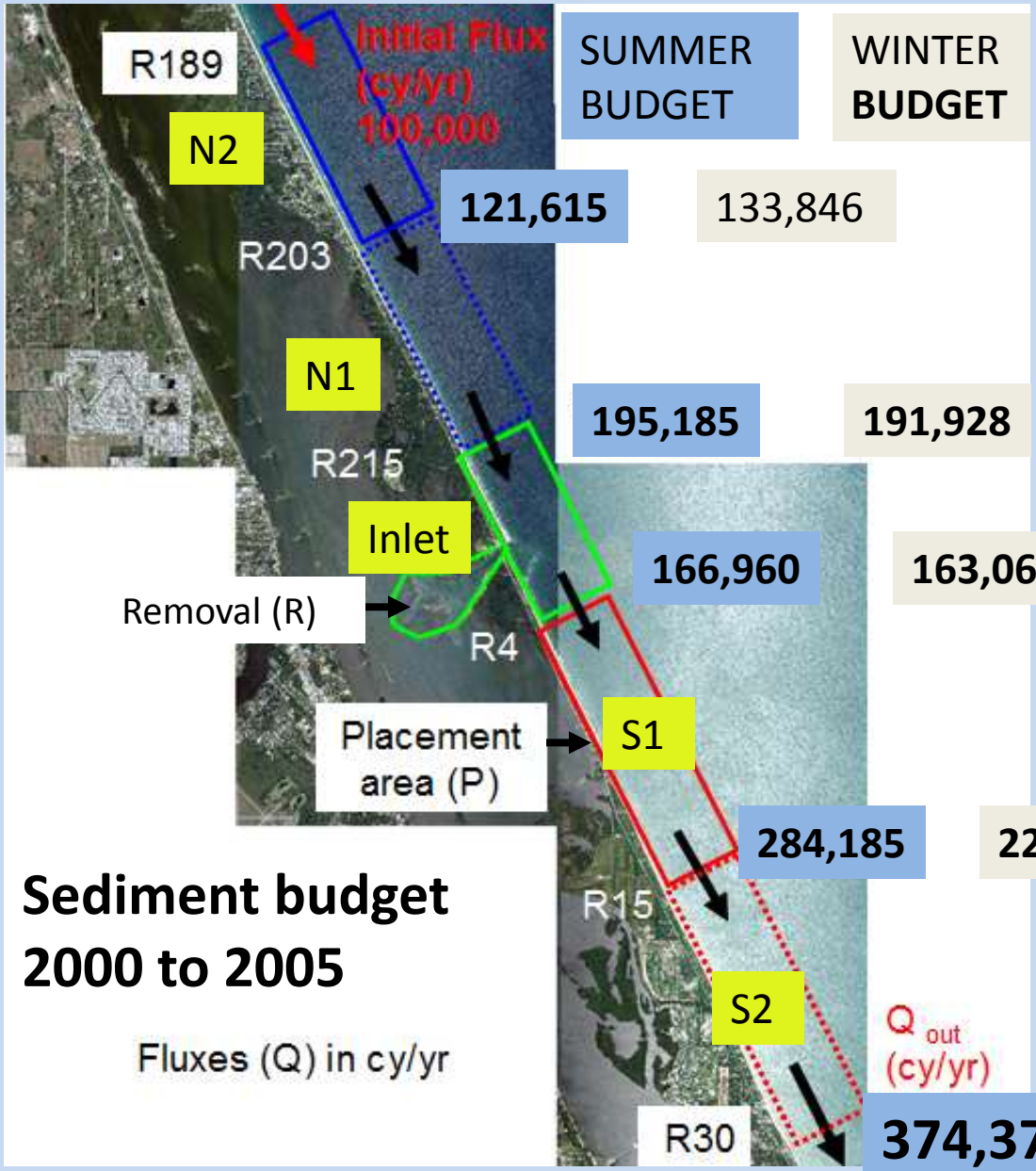


	SUMMER BUDGET	WINTER BUDGET
	149,676	150,022
	200,420	197,759
	171,717	161,213
	274,168	238,121
Q_{out} (cy/yr)	289,334	235,900

Local Sand Budget – 5 Years

	2000 - 2005			
	winter/winter		summer/summer	
Budget cell	Δ V (cy/yr)	Q (cy/yr)	Δ V (cy/yr)	Q (cy/yr)
North2	-33,846	133,846	-21,615	121,615
North1	-58,082	191,928	-73,570	195,185
Inlet	***28,860***	***163,068***	***28,225***	***166,960***
South1	54,506	226,562	776	284,185
South2	-111,756	338,318	-90,191	374,376

Local Sand Budget – 5 Years



	SUMMER BUDGET	WINTER **BUDGET**
N2	**121,615**	133,846
N1	**195,185**	**191,928**
Inlet	**166,960**	**163,068**
S1	**284,185**	**226,562**
S2	**374,376**	**338,318**

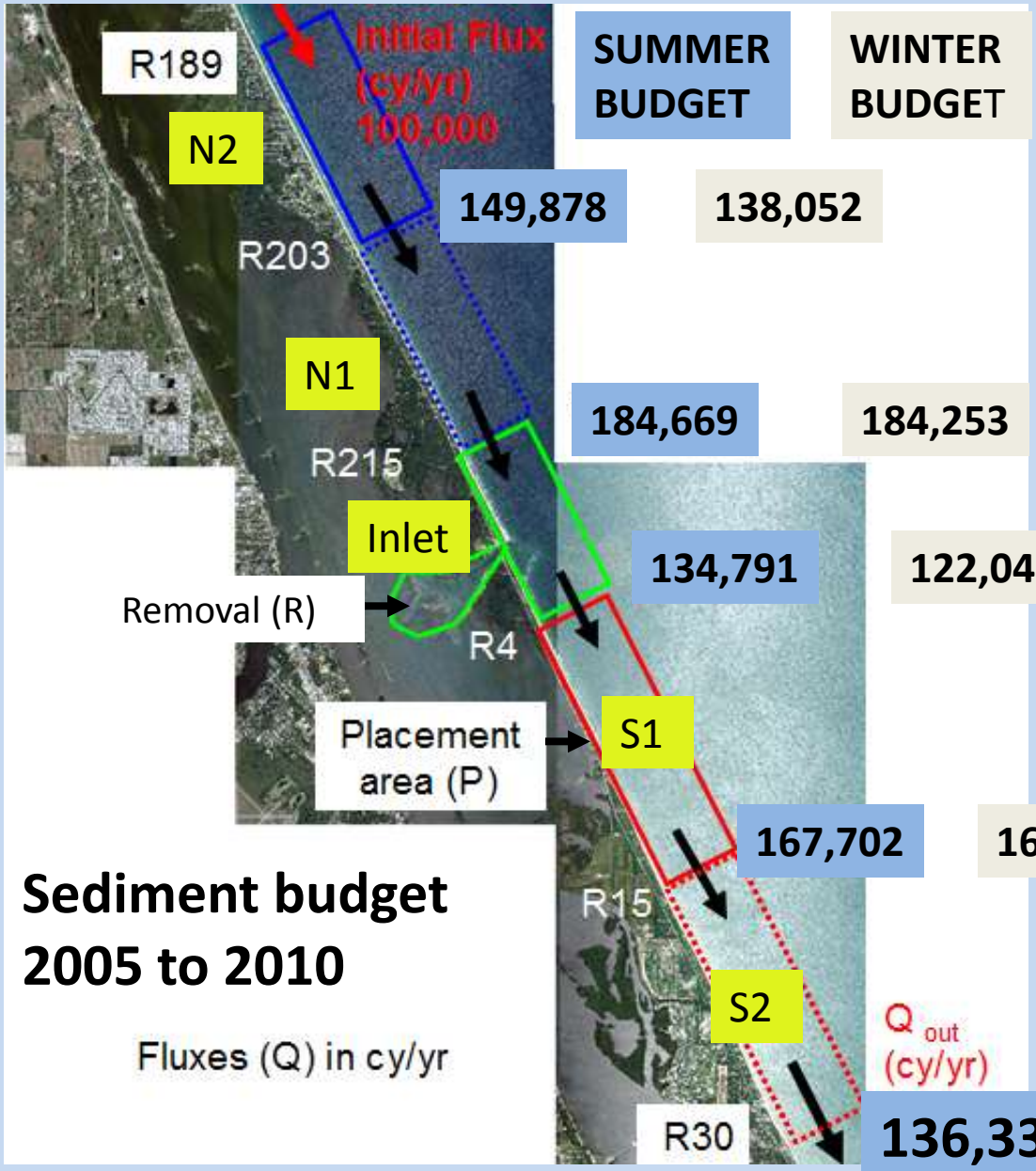
Sediment budget 2000 to 2005

Fluxes (Q) in cy/yr

Local Sand Budget – 5 Years

	2005 - 2010			
	winter/winter		summer/summer	
Budget cell	Δ V (cy/yr)	Q (cy/yr)	Δ V (cy/yr)	Q (cy/yr)
North2	-38,052	138,052	-49,878	149,878
North1	-46,201	184,253	-34,791	184,669
Inlet	***43,211***	***122,042***	***30,878***	***134,791***
South1	14,370	165,672	25,089	167,702
South2	69,355	96,317	31,370	136,333

Local Sand Budget – 5 Years



	SUMMER BUDGET	WINTER BUDGET
	149,878	138,052
	184,669	184,253
	134,791	122,042
	167,702	165,672
	136,333	96,317

Local Sand Budget

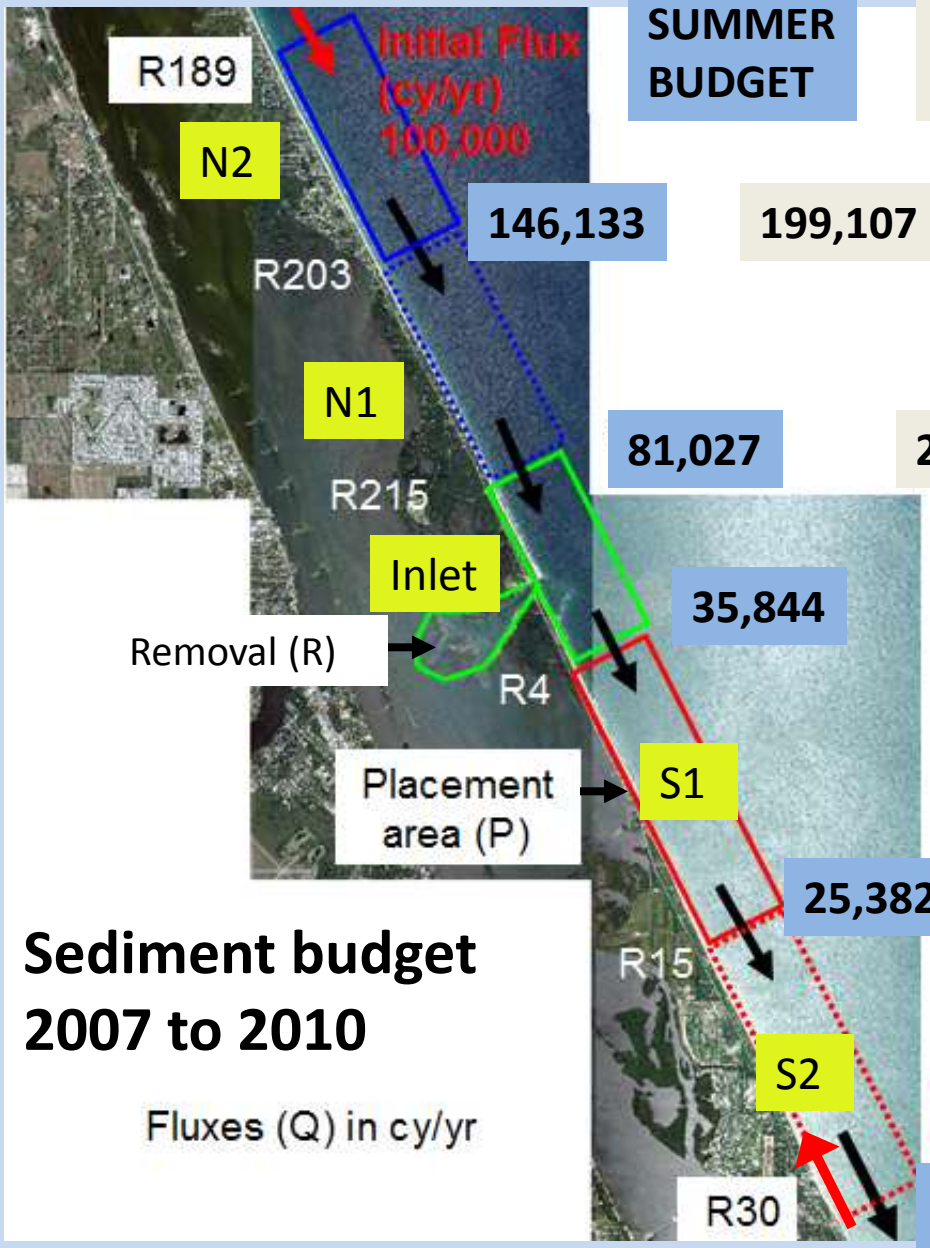
Shorter Term Sand Budget

- **2007 – 2010**
- **2008 – 2010**

Local Sand Budget – 3 Years

	2007 - 2010			
	winter/winter		summer/summer	
Budget cell	∆ V (cy/yr)	Q (cy/yr)	∆ V (cy/yr)	Q (cy/yr)
North2	-99,107	199,107	-46,133	146,133
North1	-47,633	246,740	65,106	81,027
Inlet	***-874***	***216,614***	***45,182***	***35,844***
South1	76,666	236,948	78,463	25,382
South2	57,570	179,378	85,743	-60,361

Local Sand Budget – 3 Years



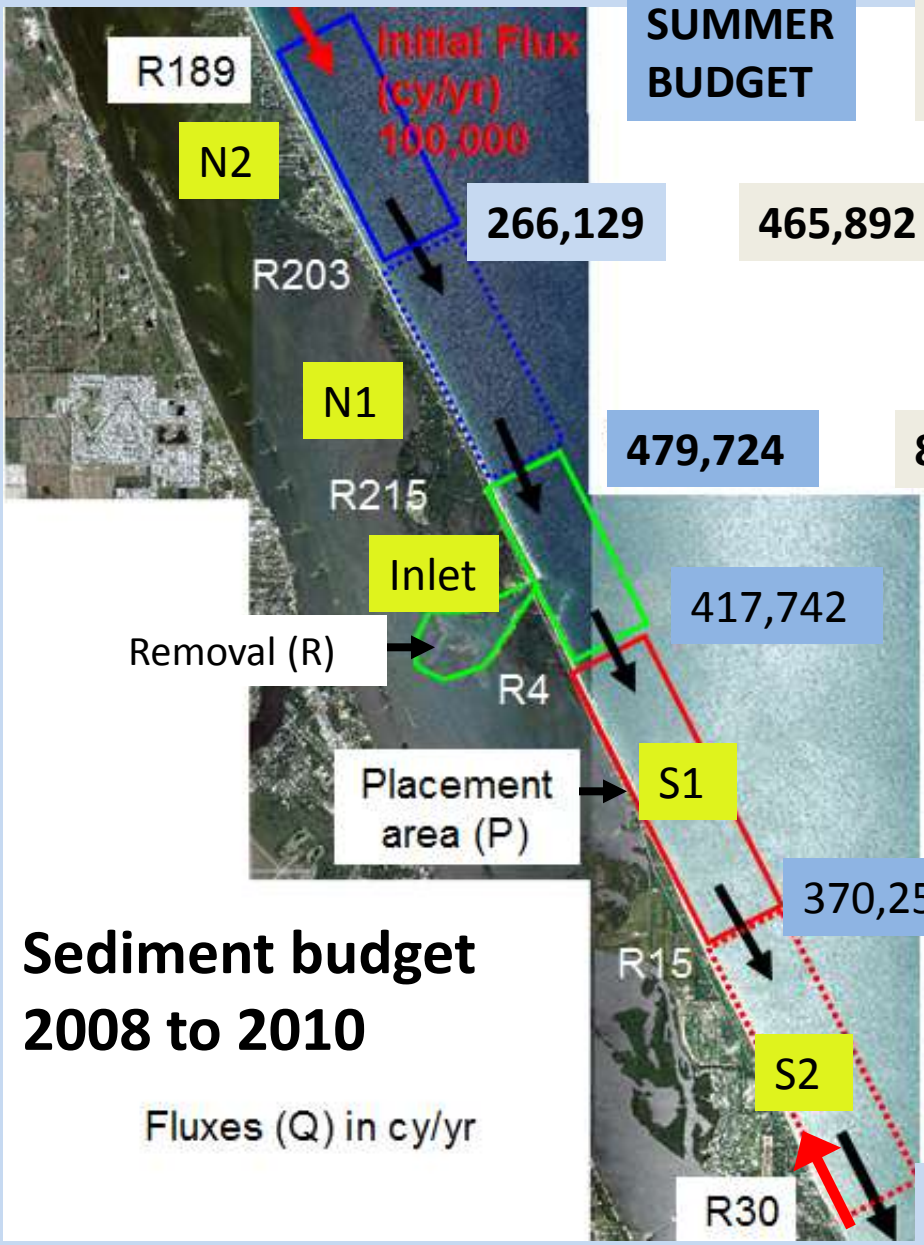
SUMMER BUDGET

WINTER BUDGET

Local Sand Budget – 2 Years

	2008 - 2010			
	winter/winter		summer/summer	
Budget cell	Δ V (cy/yr)	Q (cy/yr)	Δ V (cy/yr)	Q (cy/yr)
North2	-365,892	465,892	-166,129	266,129
North1	-350,582	816,473	-213,595	479,724
Inlet	***348,705***	***467,769***	***61,982***	***417,742***
South1	-10,476	478,245	47,486	370,256
South2	204,635	273,610	414,814	-44,558

Local Sand Budget – 2 Years



	SUMMER BUDGET	WINTER BUDGET
	266,129	465,892
	479,724	816,473
	417,742	467,769
	370,256	478,245
	-44,558	273,610

Local Sand Budget- Conclusions

- Large seasonal and inter-annual sand volume changes of up to 1 million cubic yards
- Net Sand Volume changes in sand budget cells relatively small at the decade time scale
- Volume changes in cells north of Sebastian Inlet are negative at most time scales
- Volume changes in cells south of Sebastian Inlet at the decade time scale are small and mitigated by fill projects

Local Sand Budget- Conclusions

- Volume changes in the S2 cell south of inlet are negative at the 5 year time scale between 2000 and 2005, even with fill placement

- Volume changes in the S2 cell south of inlet is positive at the 5 year time scale between 2005 and 2010 and mitigated by fill placement

- Cells to the south of the inlet benefit from erosion within cells north of the inlet, sand bypassing (natural and mechanical) and fill placement

Local Sand Budget - Conclusions

- Sebastian Inlet sand budget is in dynamic equilibrium when viewed at longer time scales
- Sand retention within the inlet cell averages about 16,000 to 36,000 cubic yards per year at the 8-10 year time scale
- Best Planning Time Scale is 5-10 years

Acknowledgements

Commissioners
Executive Director, Marty Smithson
and
Staff of the Sebastian Inlet District