



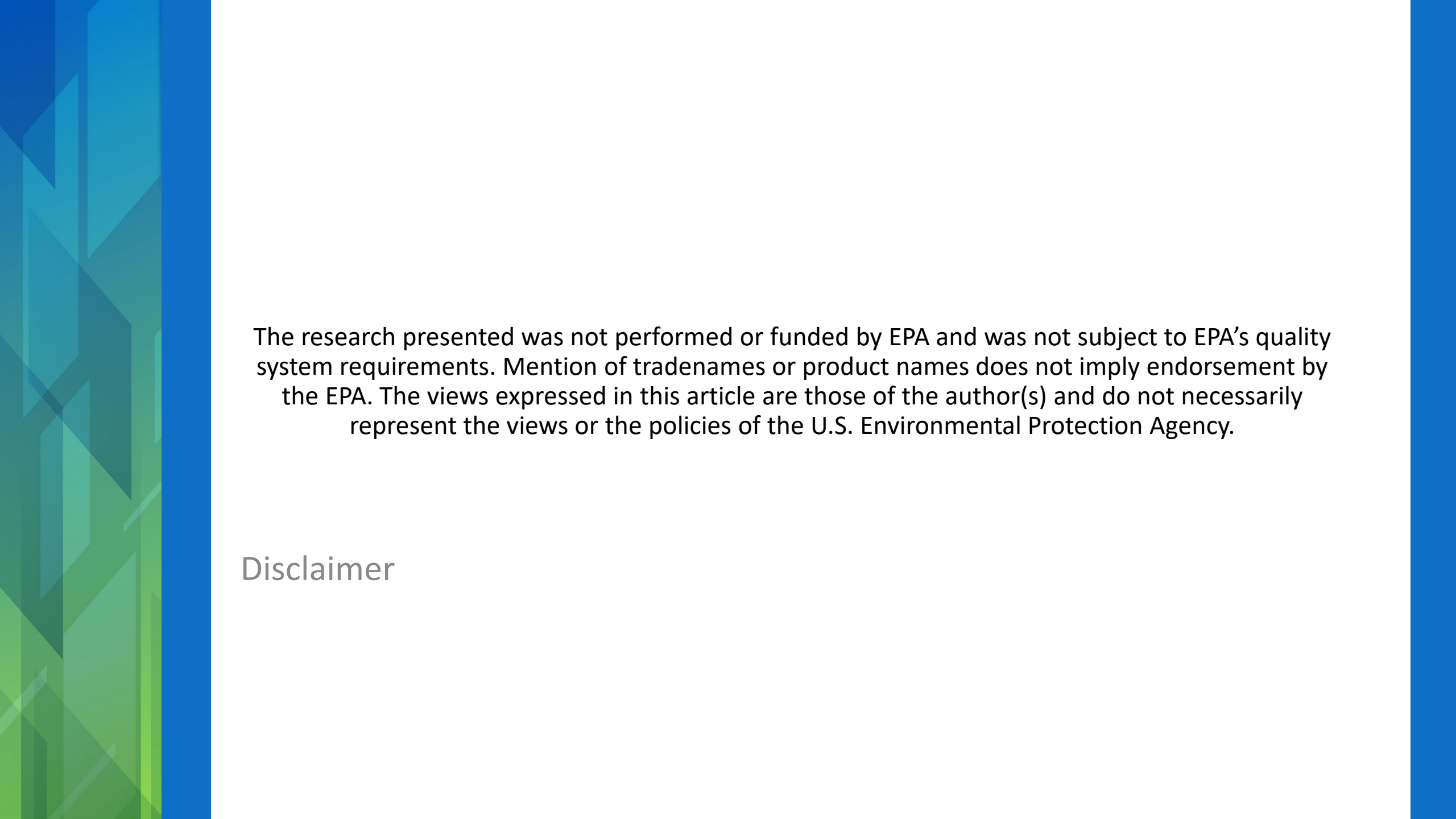
A screening level risk assessment of metal and organic contaminants in the Everglades National Park, Biscayne National Park and Big Cypress National Preserve (South Florida, USA)

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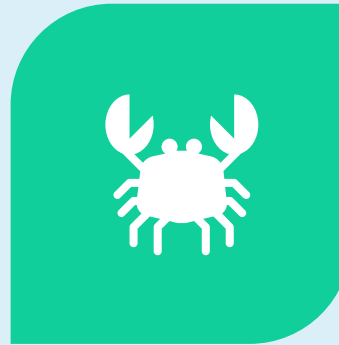
South Florida environment



LARGE PORTION OF LAND
USES ARE ECOLOGICALLY
PROTECTED



FRESHWATER SYSTEMS
INCLUDE THE EVERGLADES
AND LAKE OKEECHOBEE



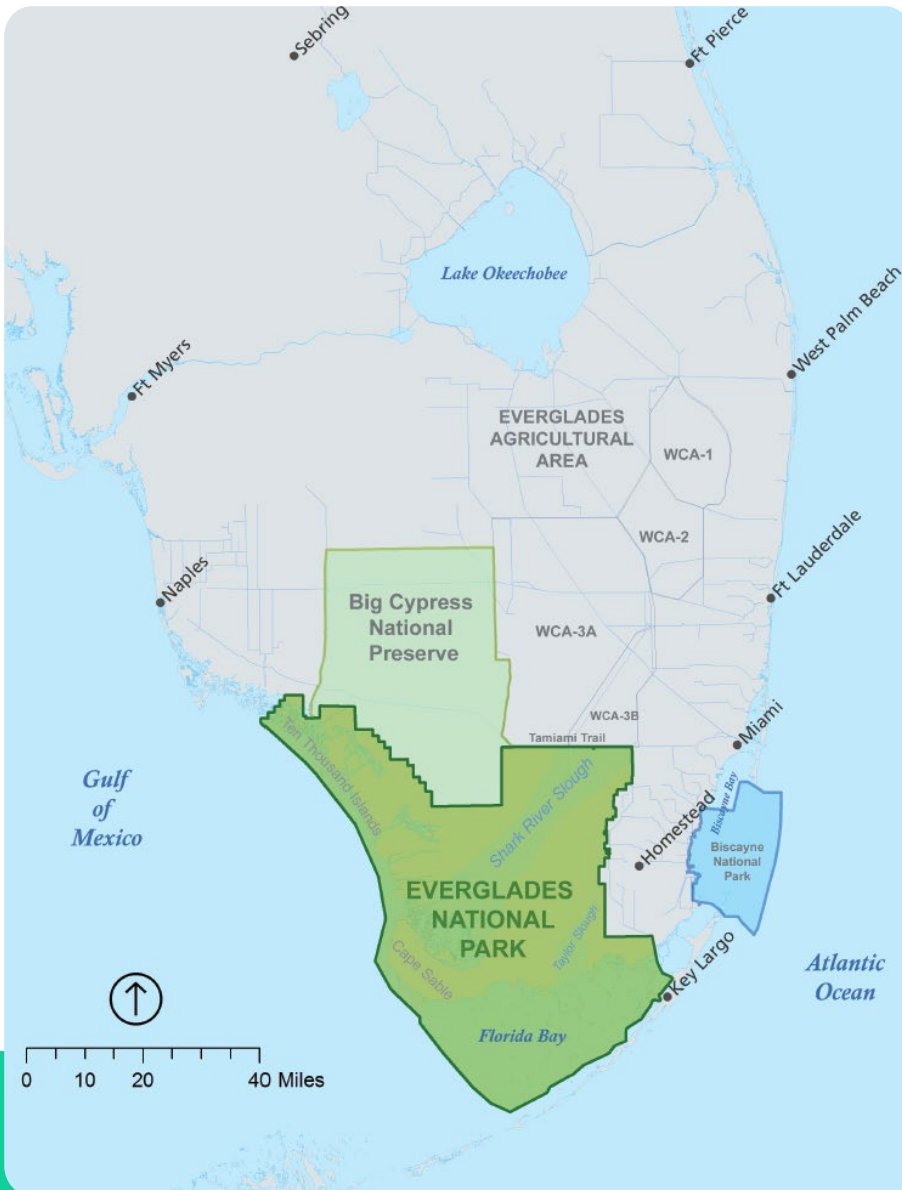
MARINE ZONE INCLUDES
BISCAYNE AND FLORIDA BAY



ALSO CONTAINS A HIGHLY
URBANIZED SYSTEM AND
YEAR-ROUND AGRICULTURE

South Florida restoration

- Massive restoration effort- Comprehensive Everglades restoration Plan (CERP)
- Water quantity and quality for human and ecological use are a focus of CERP
- Pollution from localized and distant sources as well as legacy pollutants
- Past work has found organic pollutants (e.g., pesticides) and metal concentrations in monitoring data to be of hazardous concern



Map from:
NPS/FIU. 2016. Contaminant Assessment and Risk Evaluation Project Everglades National Park, Biscayne National Park, & Big Cypress National Preserve. Summary Report. Prepared by the National Park Service and Florida International University.

CARE project

- Researchers at Florida International University and Everglades National Park
- Chemistry, ecotoxicology, risk assessment
- Close data gaps on contaminants in South Florida, particularly protected regions

Gardinali, P., J. Castro, N. Quinete, and G. Rand. 2015.
Contaminant and risk evaluation project. Final report to the
South Florida Natural Resources Center, Everglades National
Park, Homestead, FL.

Overview

- Current study describes probabilistic risk screening work
- Exposure data from CARE project
- Compared levels in the environment to existing ecotoxicity data
- Databases for effects from sources used to establish water quality for ecological purposes
- Identification of chemicals and regions of potential concern for management and monitoring efforts for the restoration of South Florida ecosystems

Endpoints

Exceedence of the 5th or 10th centile of effect values by exposure concentrations

Effect values are chronic no effect concentrations (NOECs), acute (LC/EC50s), critical body residues (CBRs) for various taxa

Exposure values are median for chronic; 90th centile for acute, CBR

Methods- contaminant sampling

Fish tissue,
sediment/soil,
surface waters



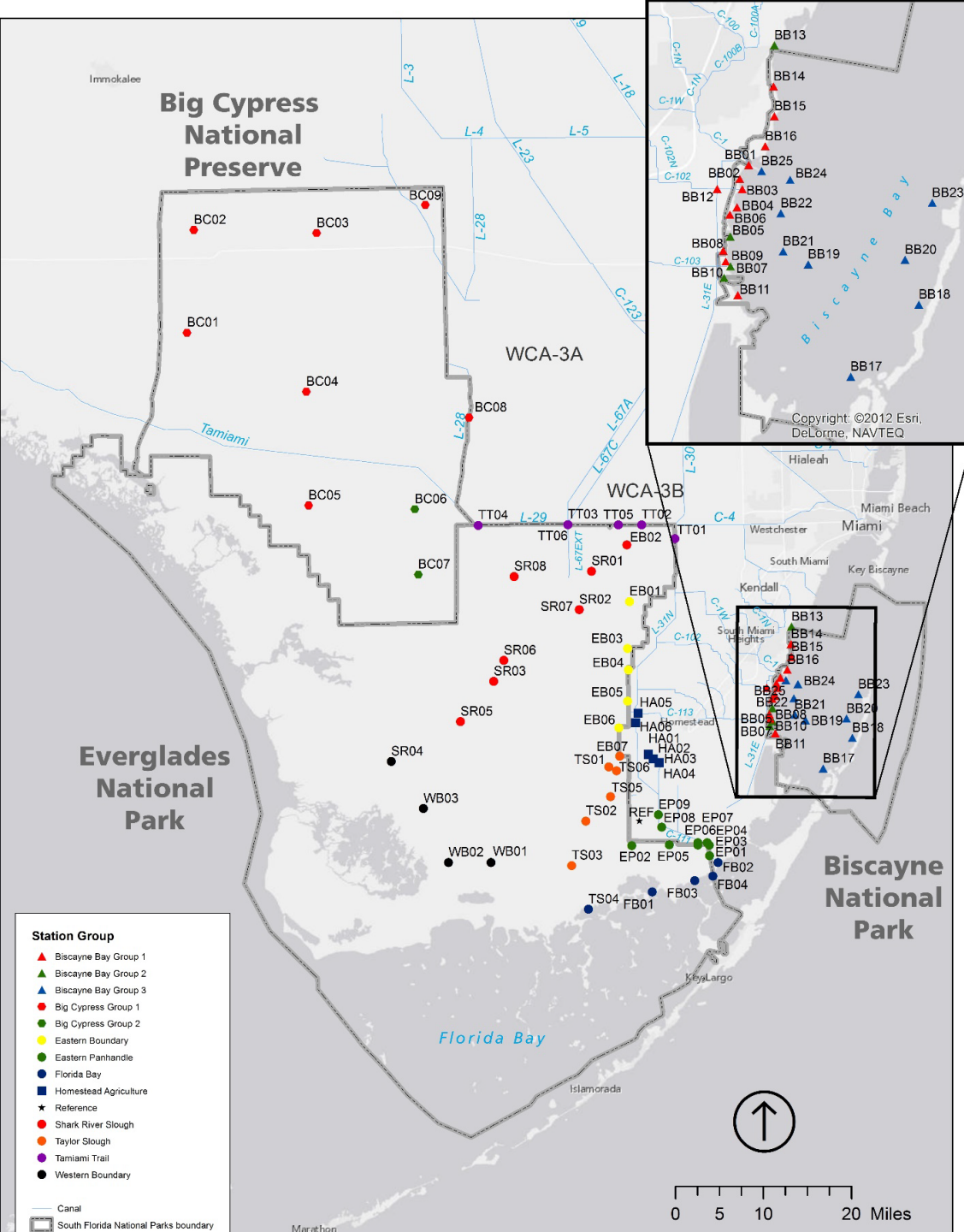
Samples
collected from
2006 to 2009

30 stations for Everglades National Park (ENP)
9 sites in Big Cypress National Park (BCNP)
11 sites in Biscayne National Park (BNP)
9 sites at or near canal locations close to the ENP



Further details
in CARE report

Gardinali, P., J. Castro, N. Quinete, and G. Rand. 2015. Contaminant and risk evaluation project. Final report to the South Florida Natural Resources Center, Everglades National Park, Homestead, FL.



Sampling map

- BB = Biscayne Bay
- BC = Big Cypress
- EB = Eastern boundary
- EP = Eastern Panhandle
- FB = Florida Bay
- HA = Homestead agriculture
- SR = Shark River
- TS = Taylor Slough
- TT = Tamiami Trail
- WB = Western boundary



Field technician collecting a "grab" sample of canal water. FIU photo.

Gardinali, P., J. Castro, N. Quinete, and G. Rand. 2015. Contaminant and risk evaluation project. Final report to the South Florida Natural Resources Center, Everglades National Park, Homestead, FL.

Methods- contaminants

DDT (sum of 2,4-DDT, 4,4-DDT, DDD, DDE)



Endosulfan (sum of alpha, beta, and sulfate)



Metals

Arsenic

Chromium

Copper

Lead

Zinc

Methods- metals exposure

Sediment, water

Partition coefficients from EPA (2005)
for sediment pore water estimation

Cr (VI) used for partition coefficient
for chromium

EPA. 2005. Partition coefficients for metals in surface waters, soil, and waste. EPA/600/R-05/074, U.S. Environmental Protection Agency, Washington, DC.

Methods- DDT and endosulfan exposure

Sediment, water, fish tissue

Sediment partition coefficients from USDA ARS pesticide properties database

Organic carbon normalized partition coefficients used

Fish tissue groupings made with regional, species, and environment (saltwater, freshwater)

Methods- exposure distributions

- For data with non-detects- robust ROS regression (Helsel 2012)
- For data without non-detects- multiple distributions tested if fit was poor for log-logistic or log-normal (Minitab distribution ID function)
- At least four points used for exposure groupings in regions
- For acute risks-
 - 10 or more data points- 90th centile concentration used
 - Less than 10 data points- maximum concentration was used
- For chronic risks-
 - 50th centile concentration used

Methods- effects

Metals groupings

- All species
- Fish
- Arthropods
- Plants/algae
- Mollusks

Pesticide groupings

- All species
- Fish
- Arthropods

Methods- species sensitivity distributions (SSDs)

- Distributions created with SSDMaster (Rodney & Moore 2008)
- Log-logistic favored (longer tails)
- Goodness of fit and normality of residuals checked
- Distributions summarized with HC5 or HC10 (i.e., 5th or 10th centile concentrations, respectively)
- Toxicity data were NOECs for metals from RIVM datasets
- Chromium III and Chromium VI effects had separate distribution

Rodney, S., & Moore, D., 2008. Development of an Excel-based tool for fitting and evaluating species sensitivity distributions. Final Report, Intrinsic Environmental Services, Inc.

Methods- SSDs (organics)

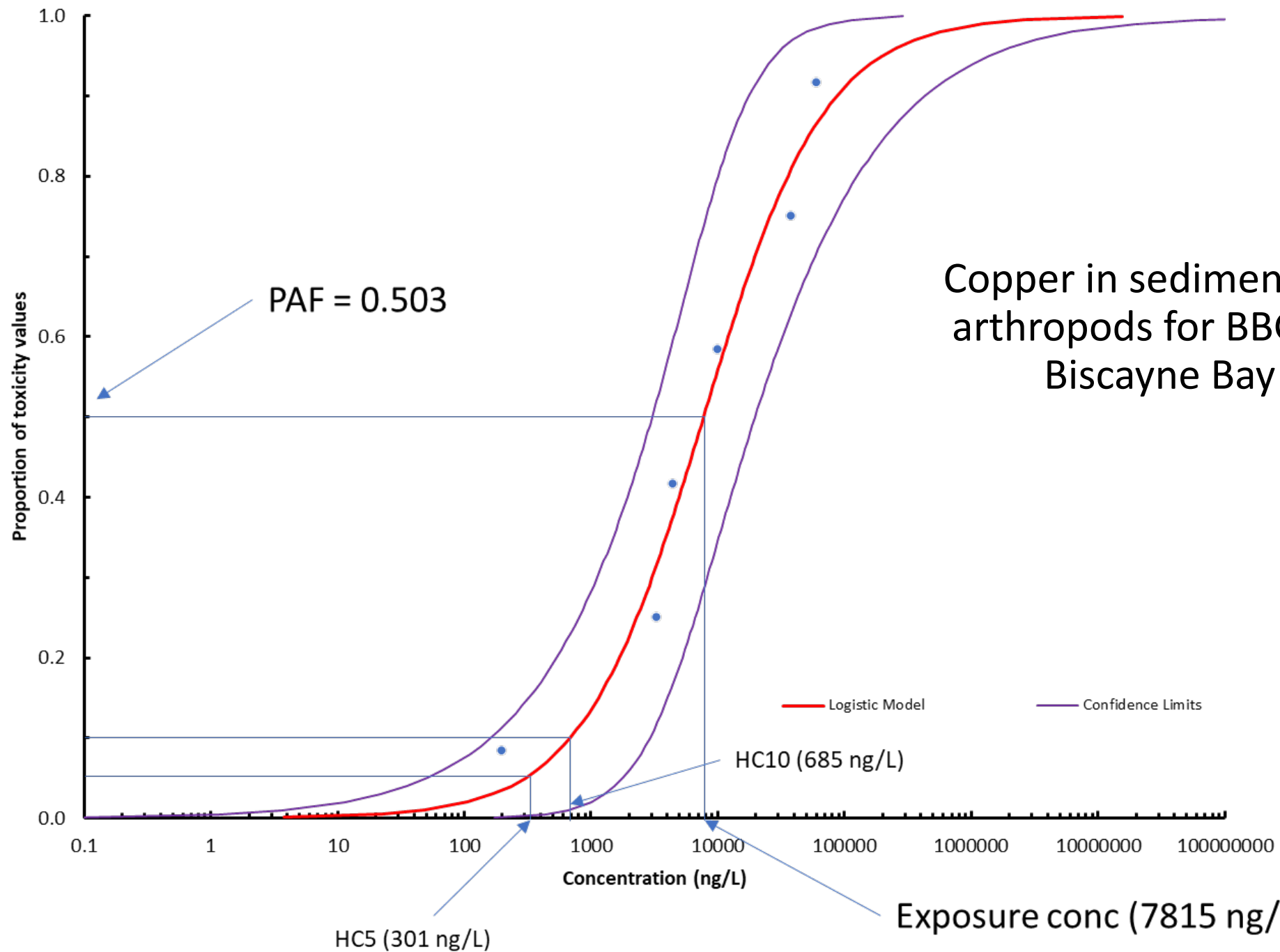
- Aquatic effects data came from EPA Ecotox database
- Acute and chronic data used
- Acceptance/rejection criteria used and prioritization of better tests
- Testing durations followed suggestions in Giddings et al. (2005)
- Fish tissue came from the U.S. ACE's ERED database for DDT but expanded from primary sources. Endosulfan data came from field and lab described in Rand et al. (2010)

Giddings, J.M., 2005. *Atrazine in North American Surface Waters: A Probabilistic Aquatic Ecological Risk Assessment*. SETAC Press.

Rand, G.M., Carriger, J.F., Gardinali, P.R. and Castro, J., 2010. Endosulfan and its metabolite, endosulfan sulfate, in freshwater ecosystems of South Florida: a probabilistic aquatic ecological risk assessment. *Ecotoxicology*, 19, pp.879-900.

Methods- PAF approach

- Potentially affected fraction of toxicity values (PAF) for individual chemicals
- 90th centile exposure concentration applied to SSDs
- Multiple substance potentially affected of toxicity values (msPAF) for multiple chemicals (Traas et al. 2002)
- msPAF used response addition to combine probabilities
- Chromium included in msPAF and excluded due to conservative assumptions



Results- exposure (arsenic sediment example)

- BB = Biscayne Bay
- BC = Big Cypress
- EB = Eastern boundary
- EP = Eastern Panhandle
- FB = Florida Bay
- HA = Homestead agriculture
- SR = Shark River
- TT = Tamiami Trail
- TS = Taylor Slough
- WB = Western boundary

Environment	Group	50 th centile	Maximum	90 th centile
Freshwater	All data	7564	42996	36387
Freshwater	BC1	3981	17915	16123
Freshwater	BC2	10980	13934	15352
Freshwater	EB	5654	14730	8567
Freshwater	EP	16330	39015	37466
Freshwater	SR	36682	42996	38934
Freshwater	TS	6395	10749	9340
Freshwater	TT	10504	25479	23720
Saltwater	All data	10664	26275	18520
Saltwater	BB1	8547	20304	17065
Saltwater	BB2	13905	26275	26155
Saltwater	FB	11247	16721	20079
Saltwater	WB	10506	15526	16391

Results- effects- DDT

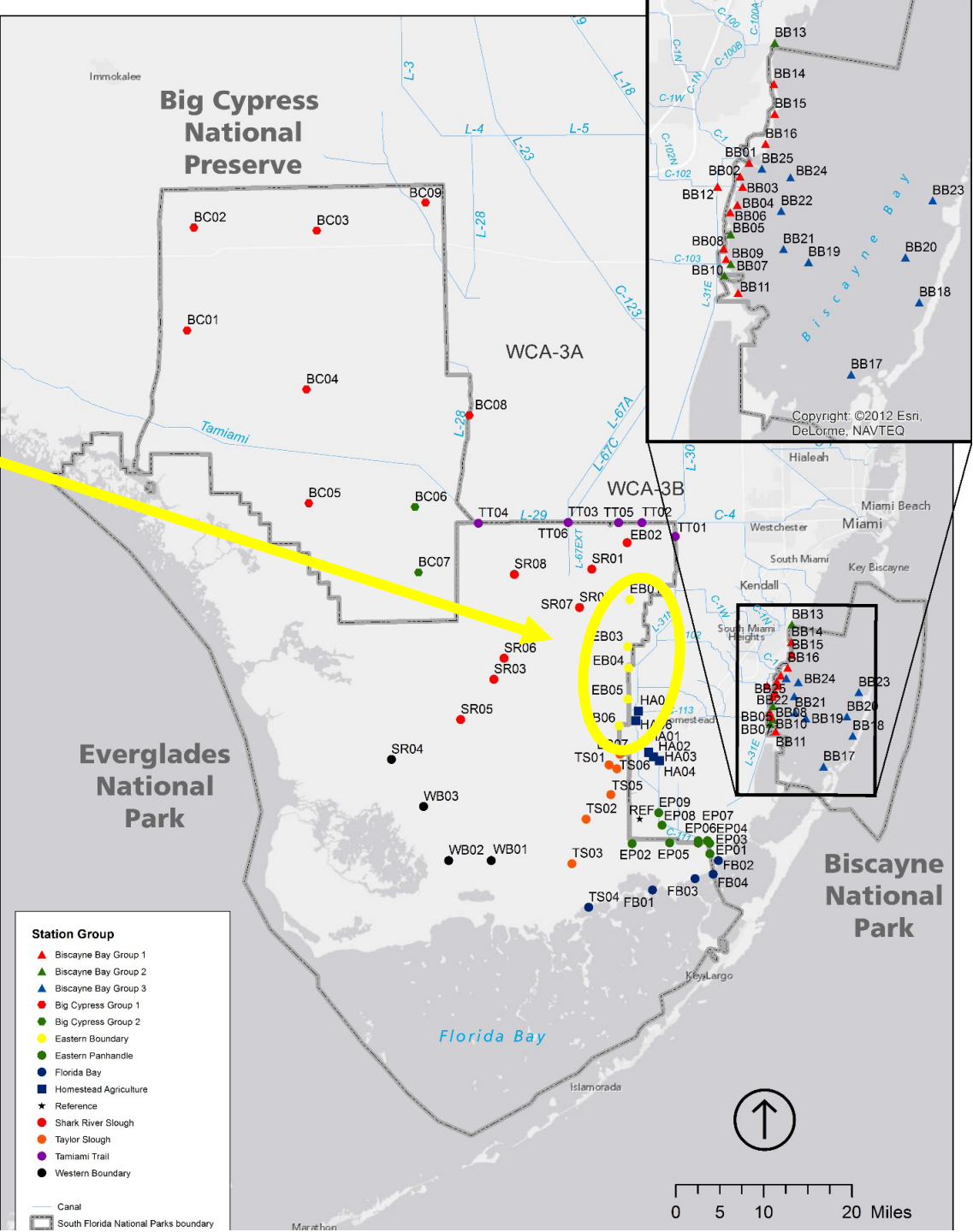
Media	Taxa	Test type	HC5	HC10
FW	All species	Acute	827	1378
FW	Arthropods	Acute	299	748
FW	Fish	Acute	641	1307
SW	All species	Acute	209	383
SW	Arthropods	Acute	128	361
SW	Fish	Acute	61	149
FW	All species	Chronic	11	39
SW	All species	Chronic	95	231
NA	Fish tissue	NER	69	111
NA	Fish tissue	LER	264	401

Results- effects- copper

Media	Taxa	HC5	HC10
FW	All species	2765	4371
FW	Arthropods	1667	2620
FW	Fish	3892	5876
FW	Plants/algae	3185	5405
FW/SW	Fish	3804	5905
FW/SW	Mollusks	3402	4290
SW	All species	534	1267
SW	Arthropods	301	685
SW	Mollusks	2404	3224
SW	Plants/algae	463	1586

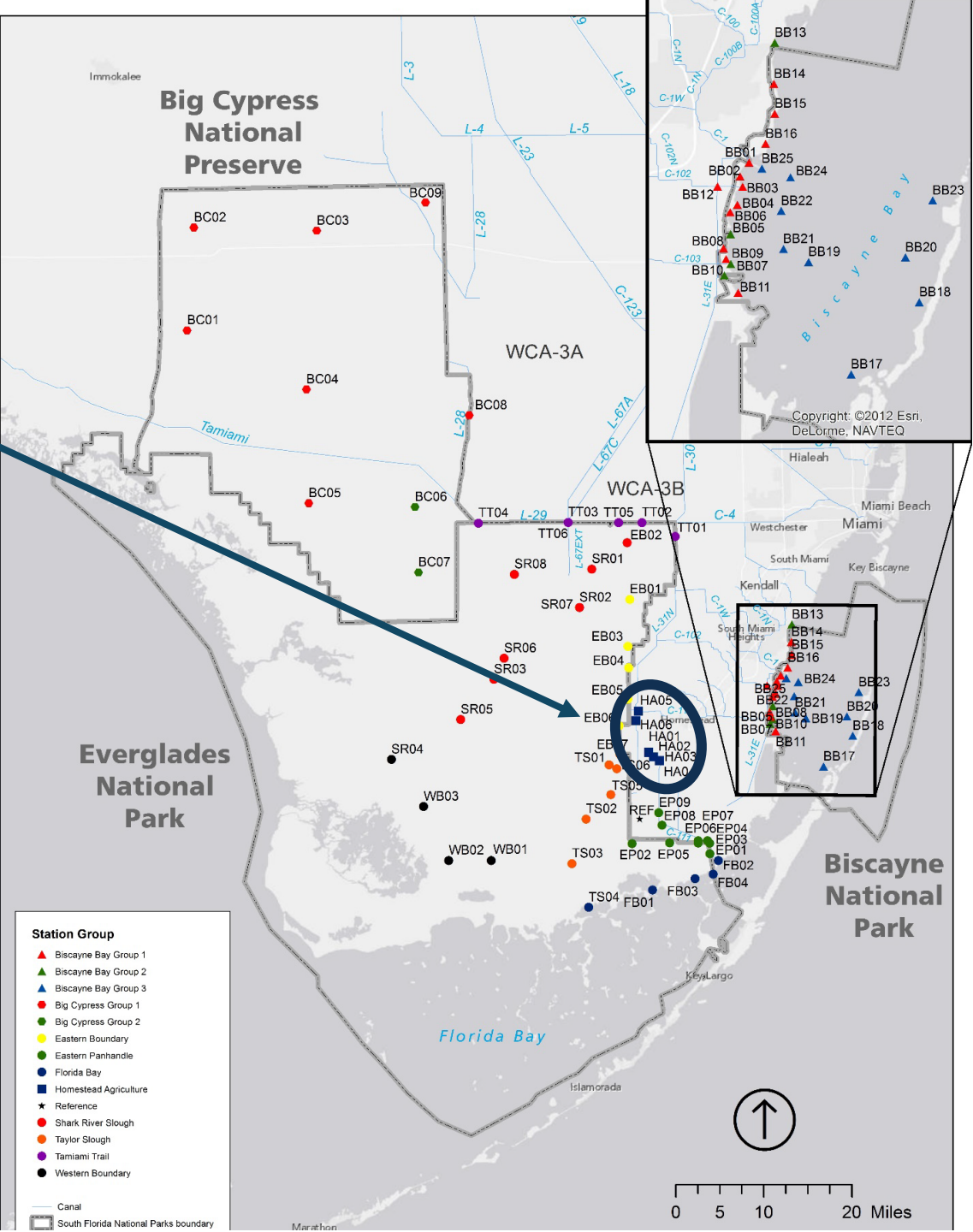
Results- Fish tissue, EB

Compound	PAF (%)	Maximum concentration (ng/kg ww)
DDT-LER	0.0	6886
DDT-NER	0.2	6886
Endosulfan	6.0	42877



Results- Fish tissue, HA

Compound	PAF (%)	Maximum concentration (ng/kg ww)
DDT-LER	0.4	58851
DDT-NER	4.0	58851
Endosulfan	51.5	397848



Results- freshwater, sediment

Compound	All species	Arthropods	Fish	Plants/Algae	Mollusks	50th centile concentration (ng/L)
Arsenic	2.4	-	-	12.4	-	7564
Chromium (III)	41.6	-	-	-	-	147649
Chromium (VI)	39.5	34.3	26.3	76.1	-	147649
Copper	0.7	1.6	0.3	0.8	0.1	822
Lead	0.2	0.0	0.0	0.0	-	171
Zinc	0.1	0.4	0.2	0.0	-	564
DDT	0.1	-	-	-	-	0.006
Endosulfan	0.4	0.0	-	-	-	0.097
-	-	-	-	-	-	-
msPAF (Cr) ¹	41.8	35.6	26.7	79.3	-	-
msPAF (noCr) ²	3.8	2.0	0.5	13.1	-	-

Results- freshwater, surface water

Compound	All species	Arthropods	Fish	Plants/Algae	Mollusks	50th centile concentration (ng/L)
Arsenic	0.5	-	-	5.2	-	883
Chromium (III)	0.0	-	-	-	-	164
Chromium (VI)	0.3	0.1	0.1	0.0	-	164
Copper	0.1	0.2	0.0	0.1	0.0	246
Lead	0.1	0.0	0.0	0.0	-	80
Zinc	1.8	3.3	1.1	0.2	-	2862
DDT	1.7	-	-	-	-	1.75
Endosulfan	3.7	0.0	-	-	-	11.0
-	-	-	-	-	-	-
msPAF (Cr) ¹	8.0	3.6	1.3	5.5	-	-
msPAF (noCr) ²	7.7	3.5	1.2	5.5	-	-

Results- saltwater, sediment

Compound	All species	Arthropods	Fish	Plants/Algae	Mollusks	50th centile concentration (ng/L)
Arsenic	3.9	-	-	14.2	-	10664
Chromium (III)	47.7	-	-	-	-	170025
Chromium (VI)	34.5	10.4	28.7	75.0	-	170025
Copper	14.5	23.8	1.9	11.8	3.7	2136
Lead	0.2	0.0	0.0	0.0	-	157
Zinc	0.8	0.8	0.3	1.2	-	989
DDT	0.0	-	-	-	-	0.0159
-	-	-	-	-	-	-
msPAF (all) ¹	46.7	32.2	30.3	81.3	-	-
msPAF (noCr) ²	18.7	24.4	2.3	25.2	-	-
-	-	-	-	-	-	-

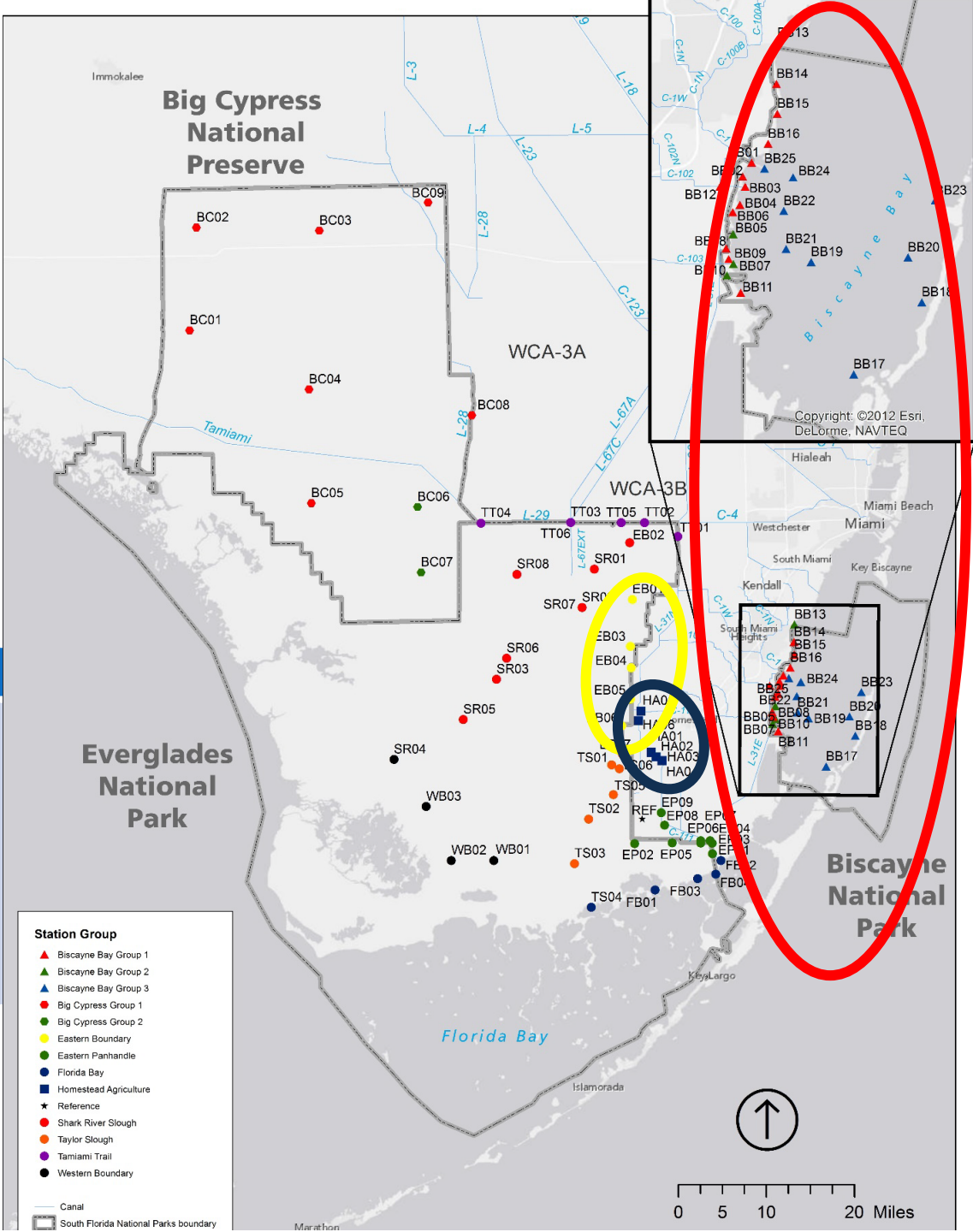
Results- saltwater, surface water

Compound	All species	Arthropods	Fish	Plants/Algae	Mollusks	50th centile concentration (ng/L)
Arsenic	0.4	-	-	3.8	-	418
Chromium (III)	0.0	-	-	-	-	503
Chromium (VI)	0.1	0.0	0.3	0.0	-	503
Copper	2.2	3.9	0.0	3.3	0.0	226
Lead	0.1	0.0	0.0	0.0	-	80
Zinc	2.2	2.6	0.9	3.0	-	2400
DDT	0.2	0.0	-	-	-	5.58
-	-	-	-	-	-	-
msPAF (all) ¹	5.2	6.5	1.2	9.8	-	-
msPAF (noCr) ²	5.1	6.5	1.0	9.8	-	-

Risk rankings-pesticides

- BB- DDT (arthropods in sediment)
- EB- Endosulfan (surface water)
- HA- DDT (fish tissue), endosulfan (surface water, fish tissue)

Chemical	Species grouping	1 st	2 nd	3 rd
DDT	All species	All data, SuW, C (FW)	HA, sed, C (FW)	Multiple
DDT	Arthropods	All data, SuW, A (FW)	BBG2, sed, C (SW) ²	*
DDT	Fish	*	*	*
DDT	Fish tissue- NER	HA	Mosquitofish	Pike killifish
DDT	Fish tissue- LER	HA	Mosquitofish	*
Endosulfan	All species	HA, SuW, A (FW)	All data, SuW, A (FW)	EB, SuW, A (FW)
Endosulfan	Arthropods	All data, SuW, A (SW)	HA, SuW, A (FW)	All data, SuW, A (FW)
Endosulfan	Fish	HA, SuW, A (FW)	All data, SuW, A (FW)	EB, SuW, A (FW)
Endosulfan	Fish tissue	HA	Golden topminnow	Mosquitofish



Risk rankings- copper, lead, zinc

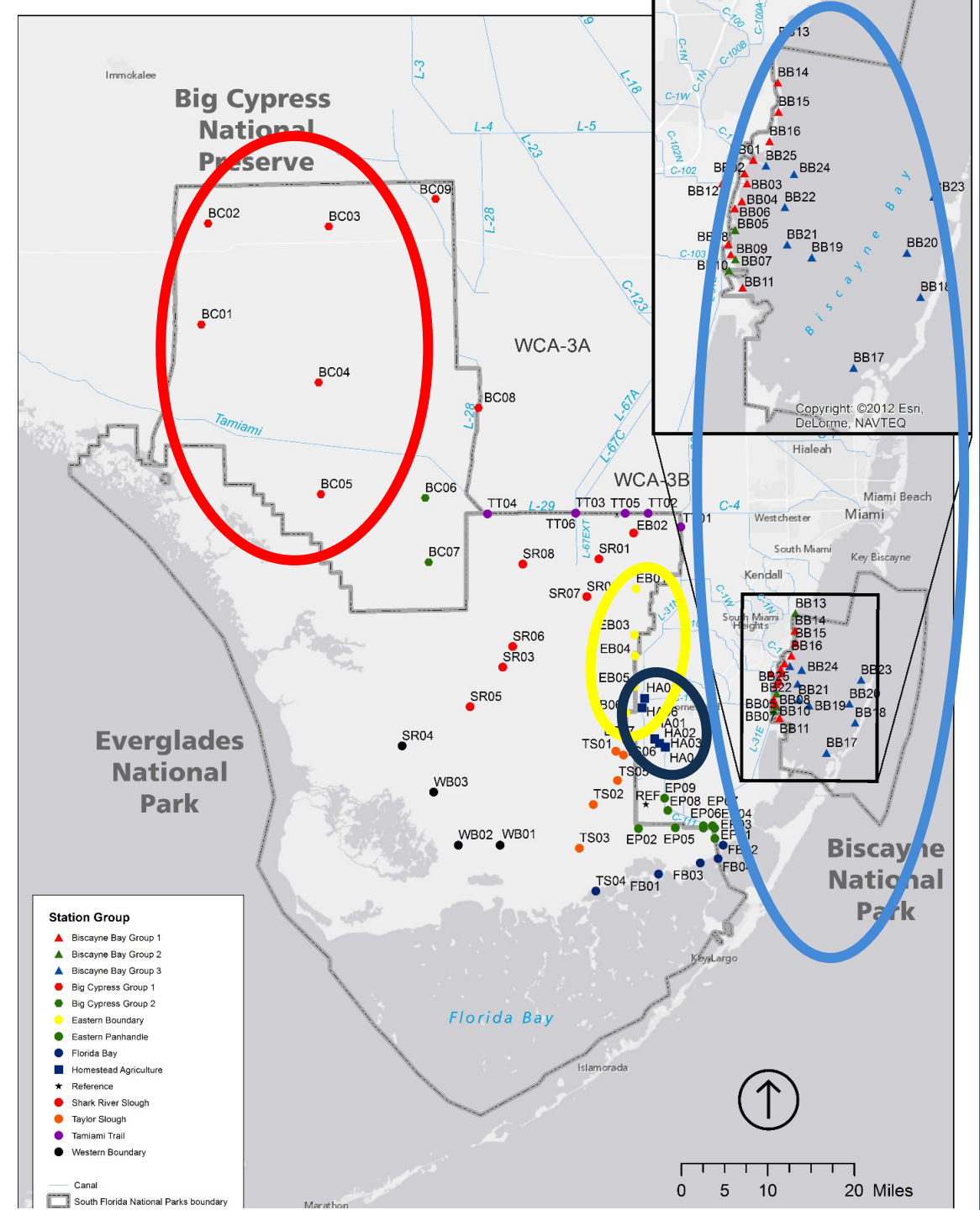
Chemical	Species grouping	1 st	2 nd	3 rd
Copper	All species	BBG2, sed (SW)	BBG1, sed (SW)	All data, sed (SW)
Copper	Arthropods	BBG2, sed (SW)	BBG1, sed (SW)	All data, sed (SW)
Copper	Fish	BBG2, sed (SW)	BBG1, sed (SW)	All data, sed (SW)
Copper	Plants/algae	BBG2, sed (SW)	BBG1, sed (SW)	All data, sed (SW)
Copper	Mollusks	BBG2, sed (SW)	BBG1, sed (SW)	All data, sed (SW)
Lead	All species	EB, sed (FW)	Multiple	Multiple
Lead	Arthropods	EB, sed (FW)	*	*
Lead	Fish	*	*	*
Lead	Plants/algae	*	*	*
Zinc	All species	EB, SuW (FW)	BBG2, SuW (SW)	BCG1, SuW (FW)
Zinc	Arthropods	EB, SuW (FW)	BBG2, SuW (SW)	BCG1, SuW (FW)
Zinc	Fish	EB, SuW (FW)	BBG2, SuW (SW)	BCG1, SuW (FW)
Zinc	Plants/algae	BBG2, SuW (SW)	BBG2, sed (SW)	BBG1, SuW (SW)

Risk rankings map- copper, lead, zinc

Big Cypress- zinc

Eastern Boundary- lead, zinc

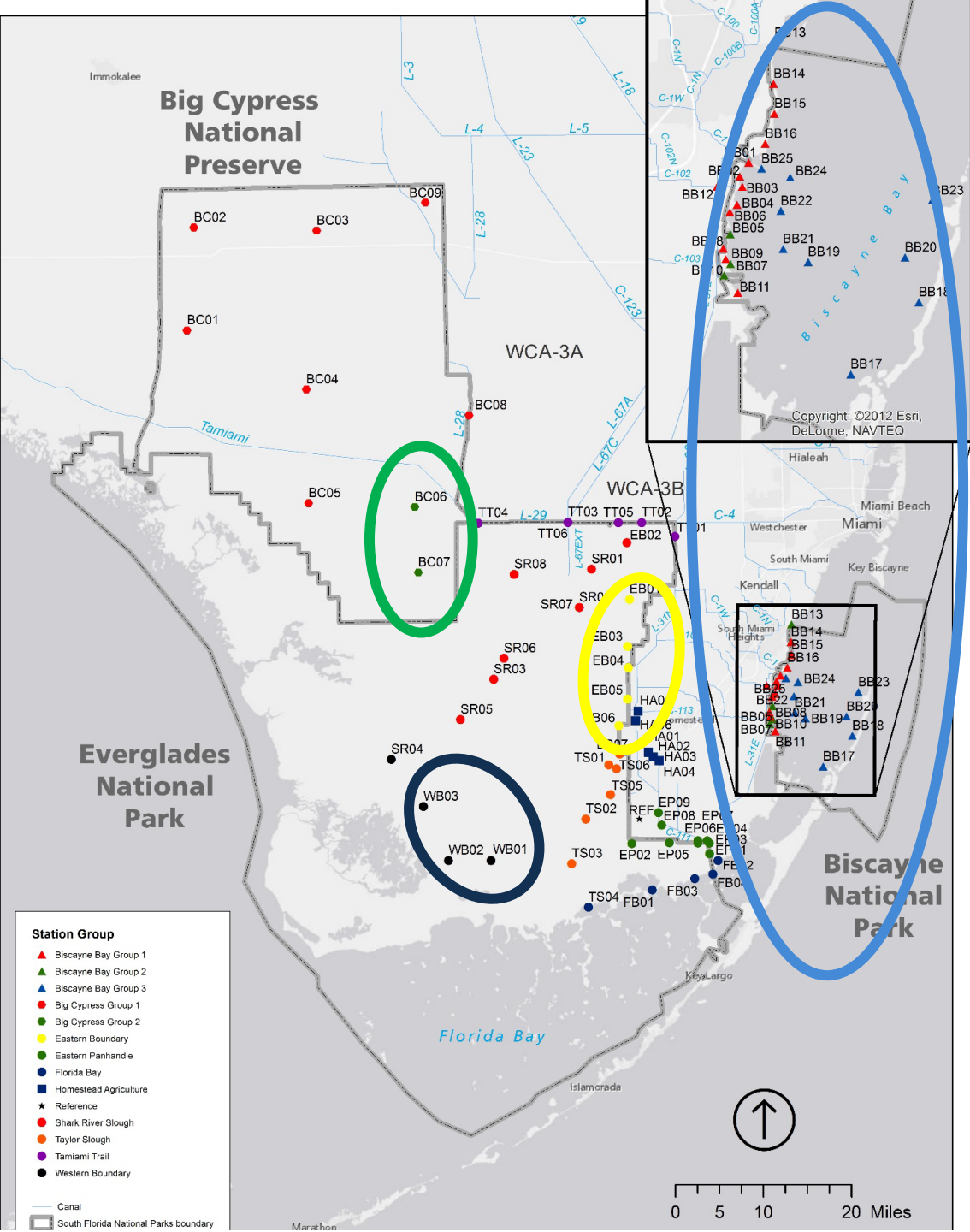
Biscayne Bay- copper, zinc



Risk rankings- msPAF with chromium

EB- all species, arthropods, fish, plants/algae (sediment)
BC- all species, arthropods, fish, plants/algae (sediment)
BB- all species, arthropods, fish (sediment)

Chemical	Species grouping	1 st	2 nd	3 rd
msPAF ⁴	All species	EB, sed (FW)	BCG2, sed (FW)	BBG2, sed (SW)
msPAF ⁴	Arthropods	EB, sed (FW)	BBG2, sed (SW)	BCG2, sed (FW)
msPAF ⁴	Fish	EB, sed (FW)	BCG2, sed (FW)	BBG2, sed (SW)
msPAF ⁴	Plants/algae	EB, sed (FW)	BCG2, sed (FW)	WB, sed (SW)



Risk communication

NPS/FIU. 2016. Contaminant Assessment and Risk Evaluation Project Everglades National Park, Biscayne National Park, & Big Cypress National Preserve. Summary Report. Prepared by the National Park Service and Florida International University.

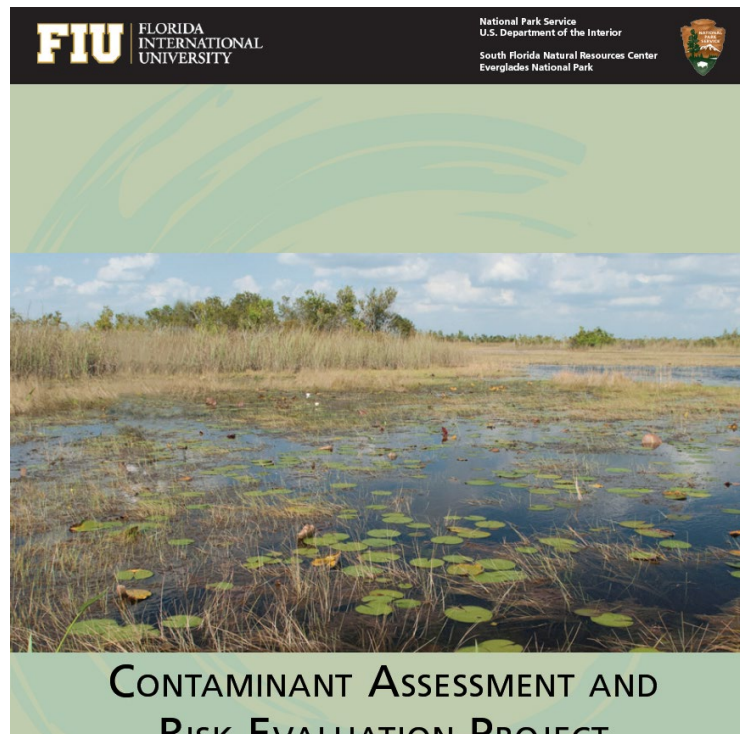


Table 6. Summarized rank of importance of chemicals that represent contaminant risk based on the assessment of multiple lines of evidence produced during the CARE project and supplemented by available literature/studies (see legend below).

Line of Evidence		Inorganic					Organic	
		Cu	As	Cr	Pb	Zn	DDD/DDE	EndoS
Source	Anthropogenic	Yes	No	?	No	No	No	Yes
	Bioavailable	Yes	Yes	?	No	No	No	Yes
Exposure	Concentrations	Yes	Yes	?	Yes	No	No	Yes
	Exceedances	?	Yes	Yes	Yes	Yes	No	Yes
Fate	Transport	No	?	No	No	Yes	No	Yes
	Bioaccumulates	Yes	Yes	No	No	No	Yes	Yes
Risk	Risk Assessment Results	No	No	Yes	No	No	No	Yes
	Keystone Species	?	Yes	?	No	No	No	Yes
Overall Risk		Yellow	Yellow	Yellow	Green	Green	Green	Red

Conclusions

- Higher risks found near boundary areas of protected regions next to urban and agricultural land use
 - Eastern boundary of ENP had some of the higher relative risks for chromium, endosulfan and zinc
 - Agricultural areas had highest risks for DDT and endosulfan
 - Arsenic had higher risks in Shark River Slough
 - Big Cypress had some higher risks for zinc and chromium at edges of park (closer to Tamiami Trail)
 - For saltwater, Biscayne Bay had some of the higher relative risks for zinc, DDT, copper and arsenic
 - Western boundary near Florida Bay had higher saltwater risks for chromium
-
- As restoration efforts progress, need for monitoring and interpreting monitoring data will grow
 - Screening level risk assessments can be refined with more information on the effects and exposure side
 - Importance of background levels in future research



Thank you!

Questions?