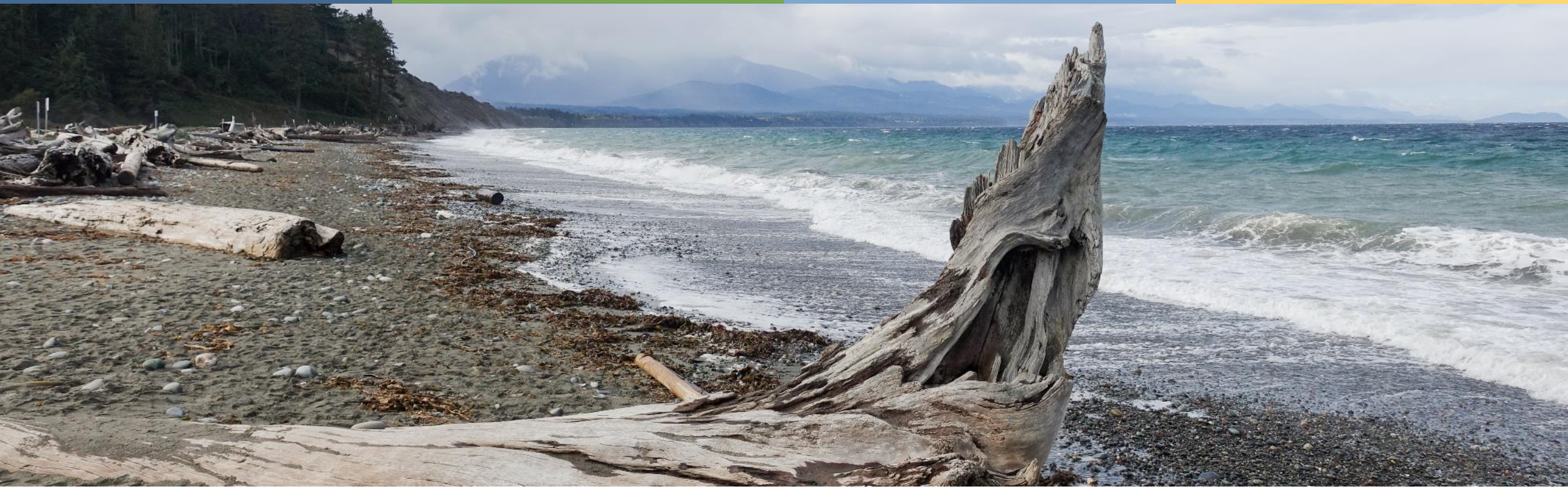
Welcome to the September 28 Nutrient Forum Meeting!

Thank you for joining us today!

- ✓ Please make sure you are muted upon entering the webinar
- ✓ We will be starting shortly

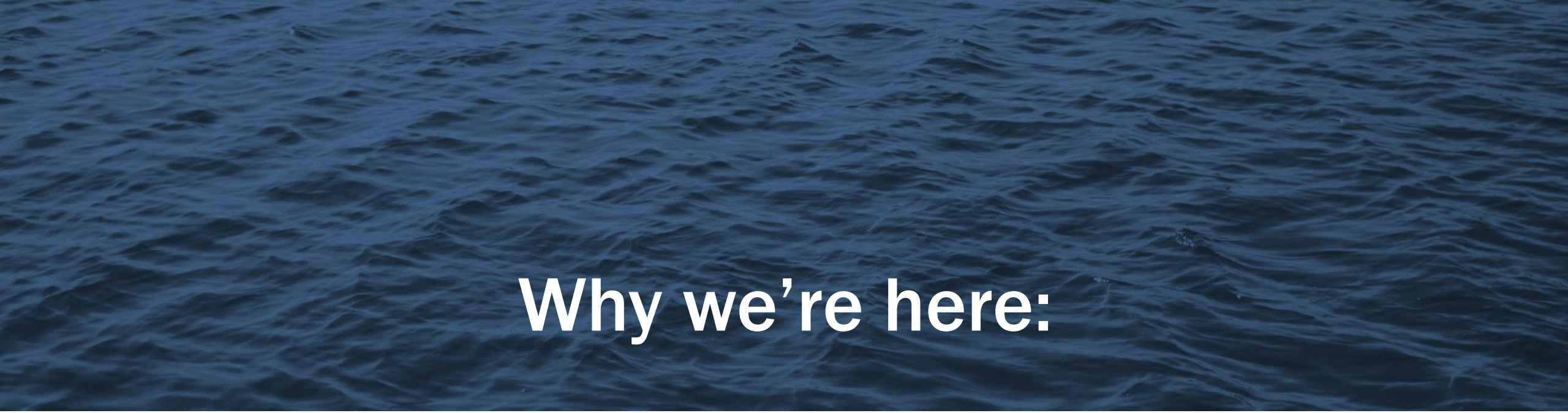


Puget Sound Nutrient Forum

Optimization Tech Memo Results

September 28, 2021

DEPARTMENT OF ECOLOGY
State of Washington

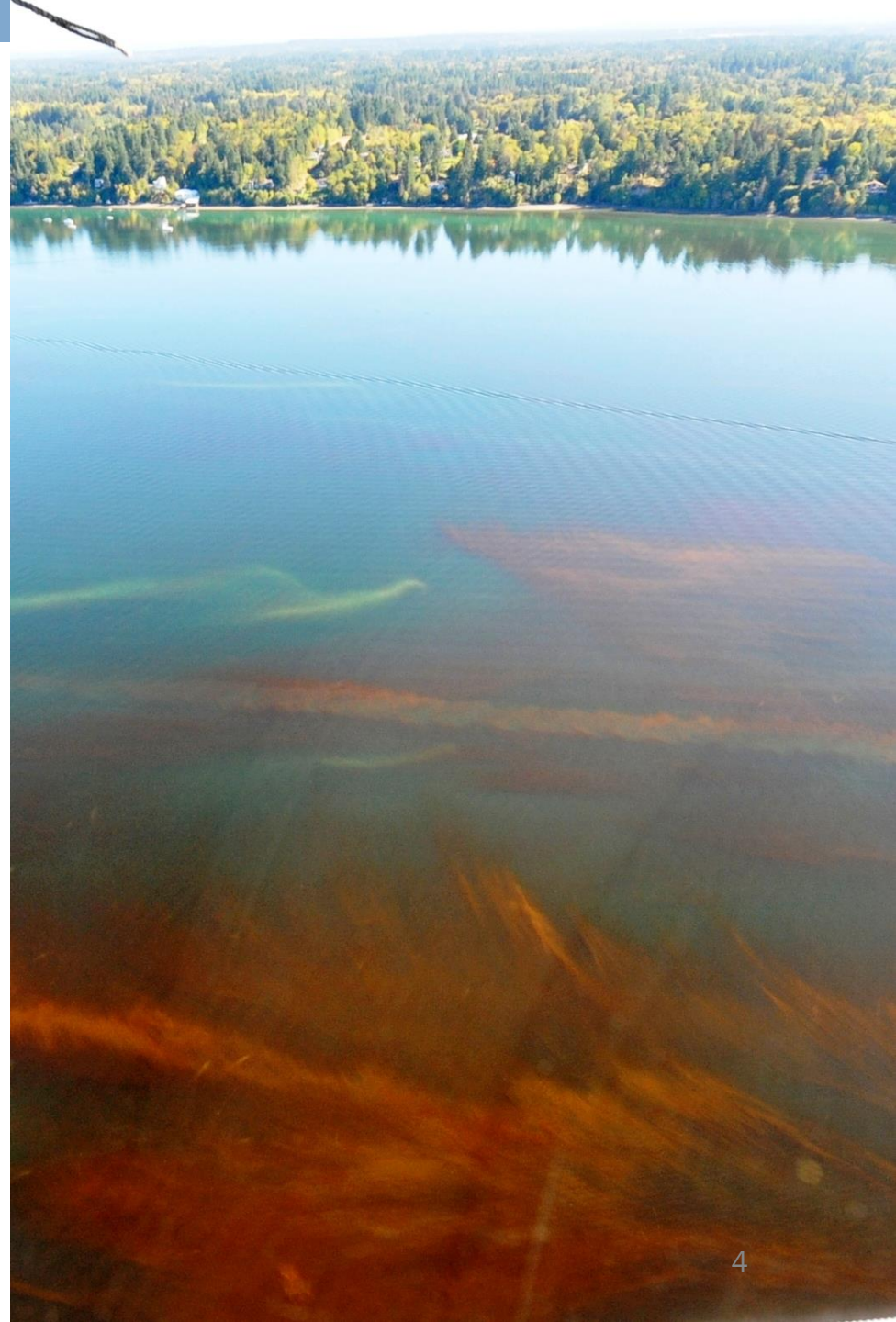


Why we're here:

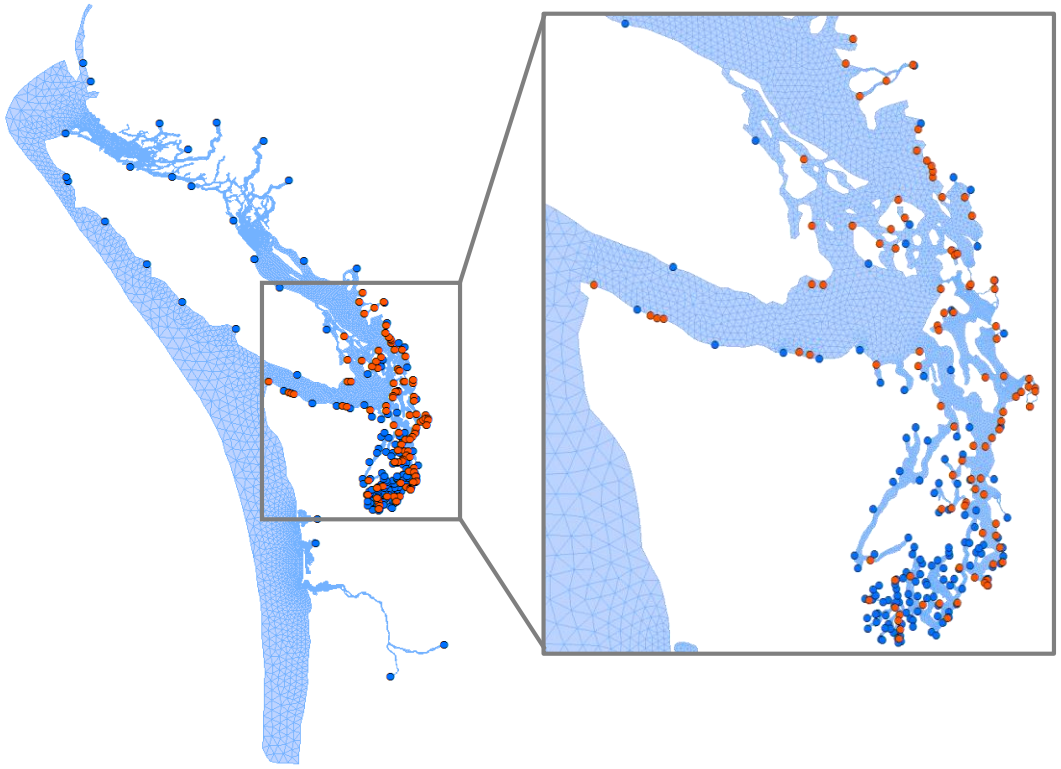
to restore Puget Sound.

Our strategy: reduce human sources of nutrients

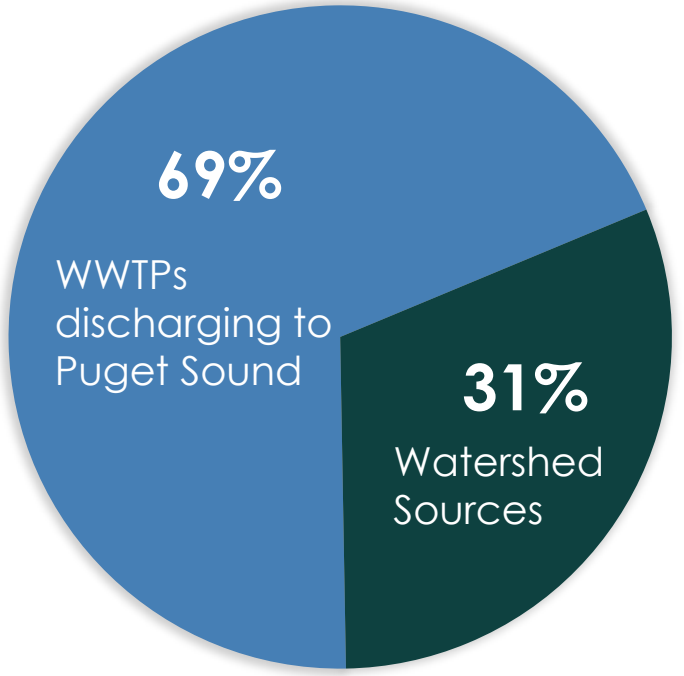
- Focus on where we can make biggest and fastest impact
- Identify other areas where we need answers and evaluate with model
- Define levels of reductions needed



Focus on where we can make biggest and fastest impact



- **Point-Sources (incl. WWTPs)**
- **Rivers (Watersheds)**



Focus on where we can make biggest and fastest impact

What we learned from Bounding Scenarios Report (2019):

- Confirmed human sources of nutrients exacerbate low DO
- WWTP discharges contribute most to low DO
- Watershed nutrient loads also contribute to low DO

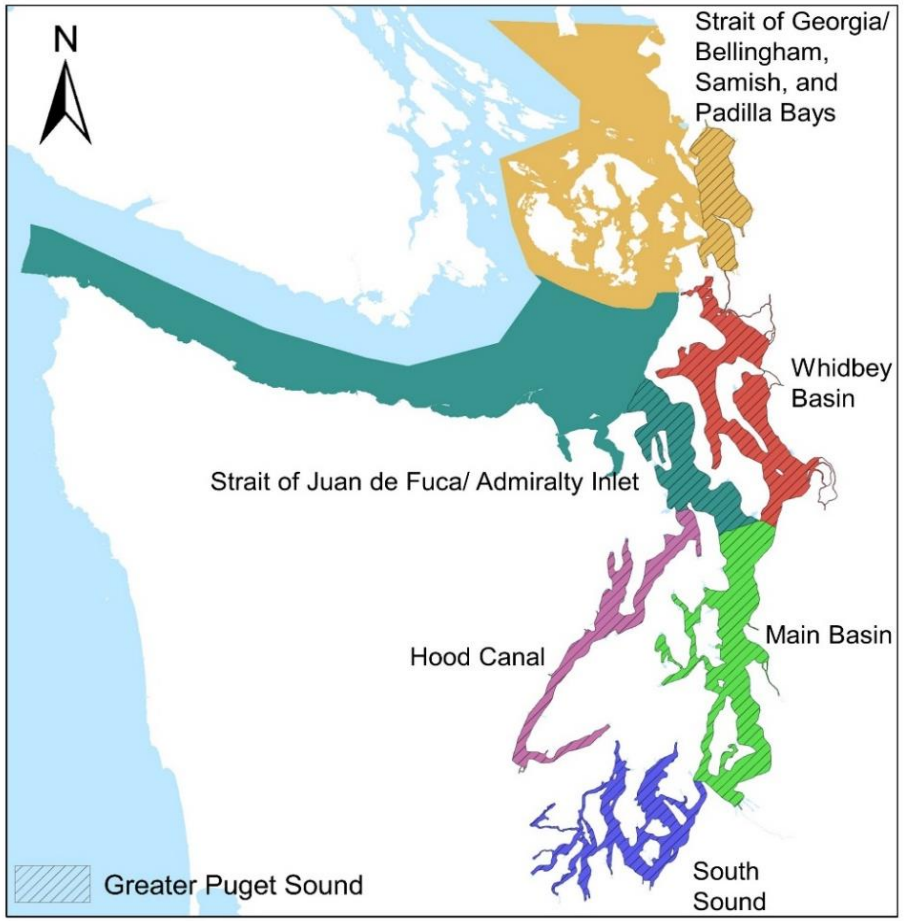
Clean Water Act Responsibility

Action: Develop a Nutrient General Permit for Puget Sound

Identify other areas where we need answers and evaluate with model

Evaluate different combinations of marine and watershed source reductions

Continue modeling to better understand which combinations of reductions will lead to the most improvement



Why we're here today: new results

Developed 5 "scenarios" with Forum in 2019

We evaluated nutrient reduction scenarios

We confirmed reductions in nutrients lead to significant improvement in water quality

Where we're going

Next phase of modeling: **defining the level of reduction needed** from all sources

2018 - 2019

Bounding Scenarios Report

2019 - 2021

Year 1 SSM tech memo

-Combinations of source reductions to find total reduction target range

2021 - 2023

Next phase of modeling

More nutrient reduction combinations to develop reduction targets

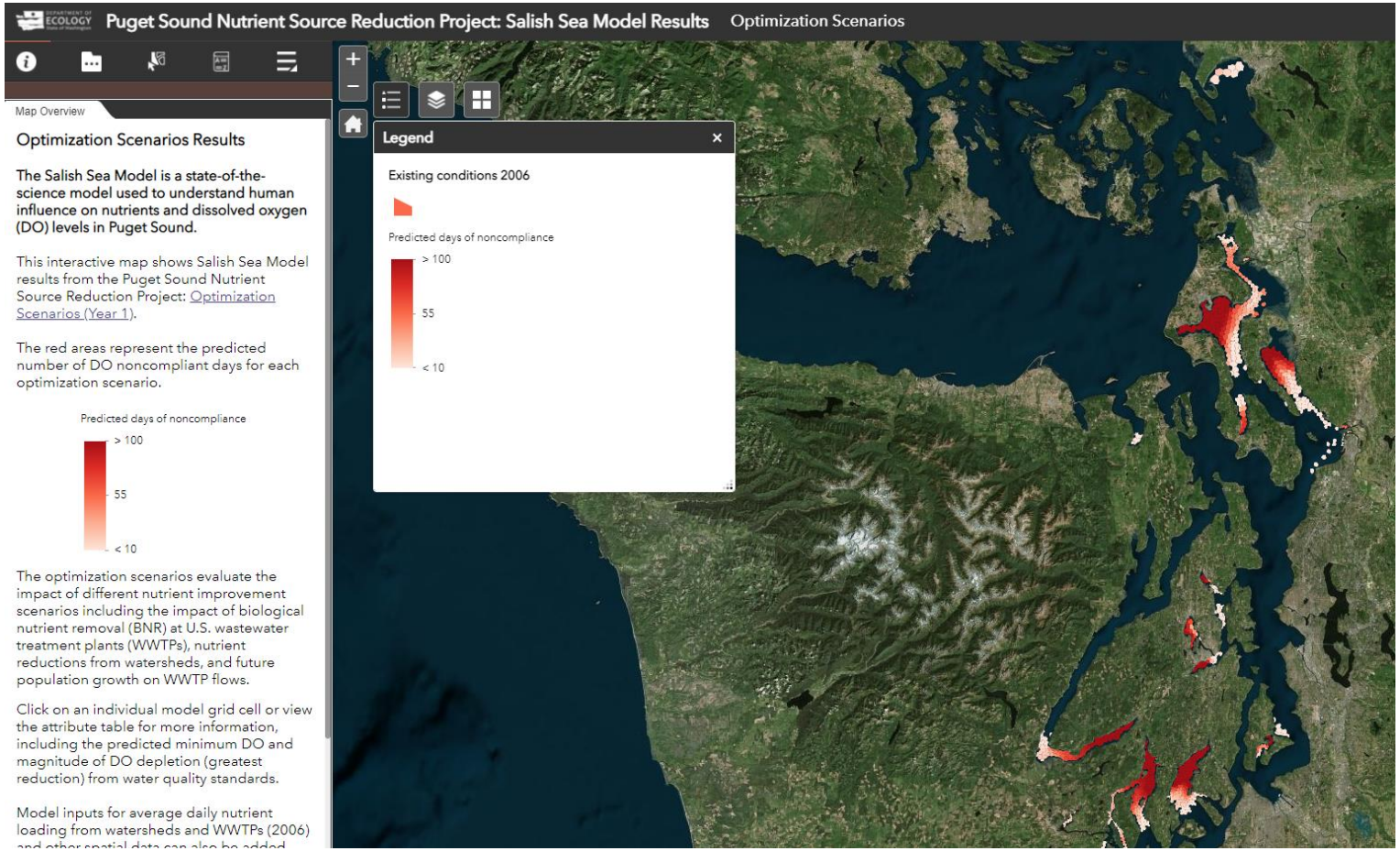
2023

Volume 2: Salish Sea Modeling Report

+

Puget Sound Nutrient Reduction Plan

Model Information Available Online

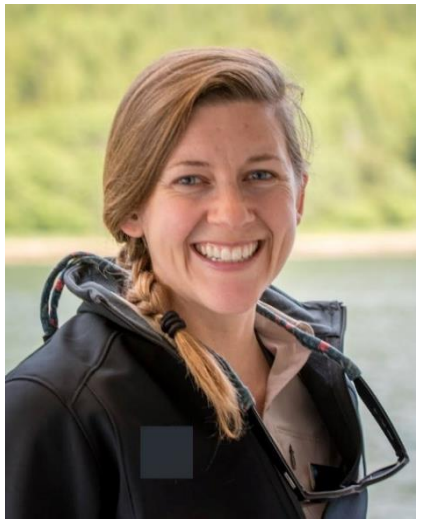


www.ecology.wa.gov/SalishSeaModel

Today's Agenda

1. Comparing modeling results to water quality standards
2. Overview: model scenarios & results
3. Detailed look at model results
4. Highlights of Salish Sea Model application updates
5. Next set of modeling scenarios
6. Puget Sound Nutrient Grant Update

Meet today's presenters

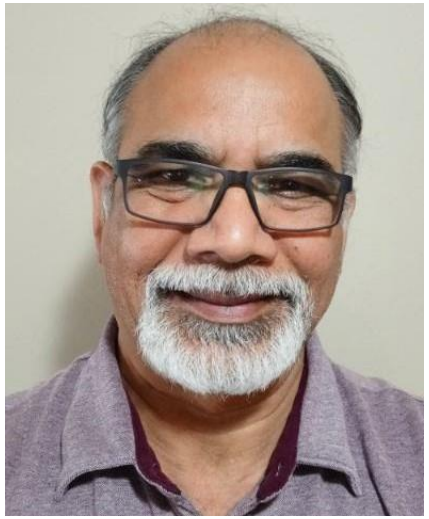


Kelly Ferron

Teizeen Mohamedali

John Gala

Dustin Bilhimer



Anise Ahmed

Cristiana Figueroa-Kaminsky

Today's Agenda

1. Comparing modeling results to water quality standards
2. Overview: model scenarios & results

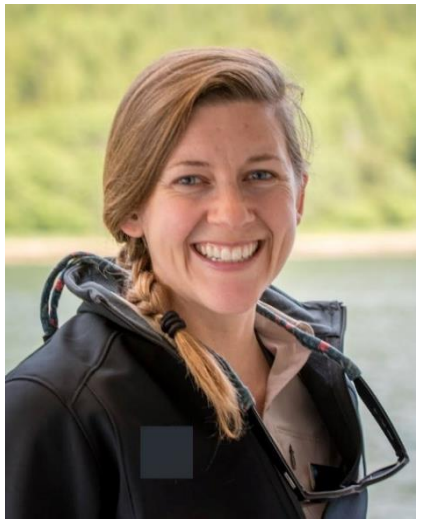
5 minute break

3. Detailed look at model results
4. Highlights of Salish Sea Model application updates

30 minute Q/A

5. Next set of modeling scenarios
6. Puget Sound Nutrient Grant Update

Meet today's presenters



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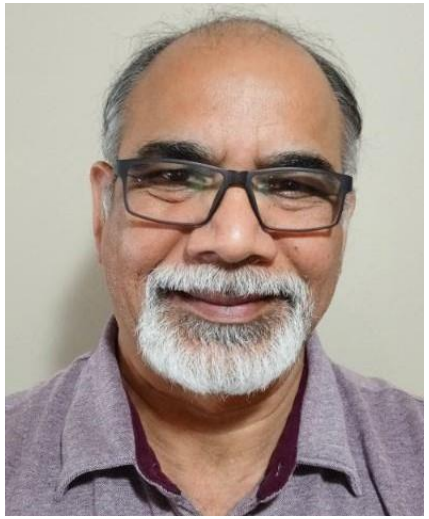

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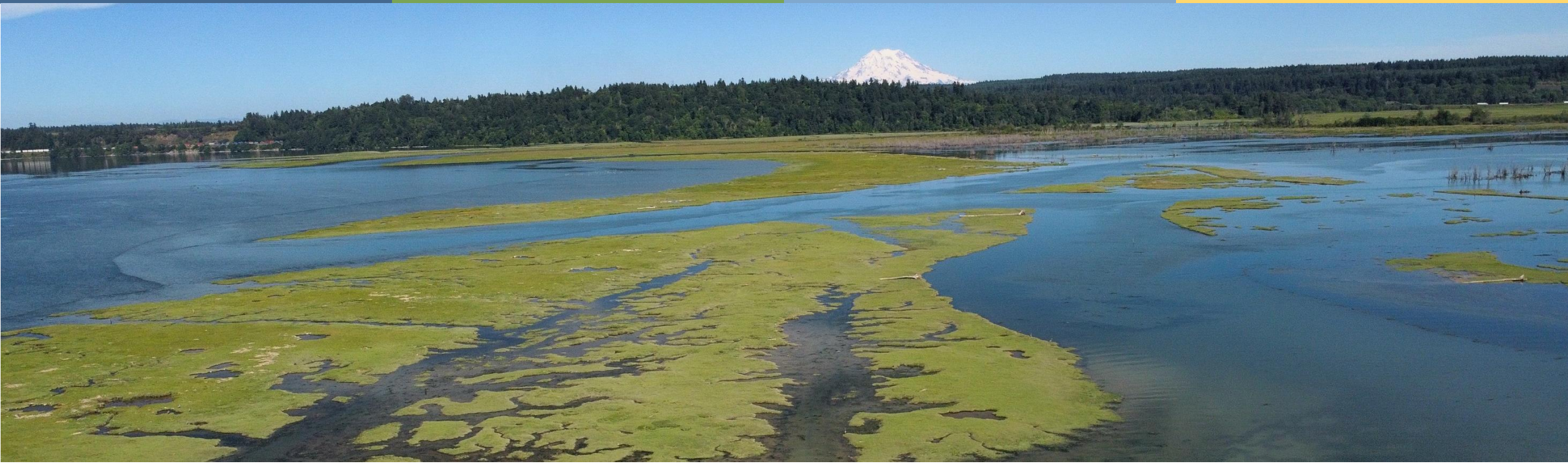
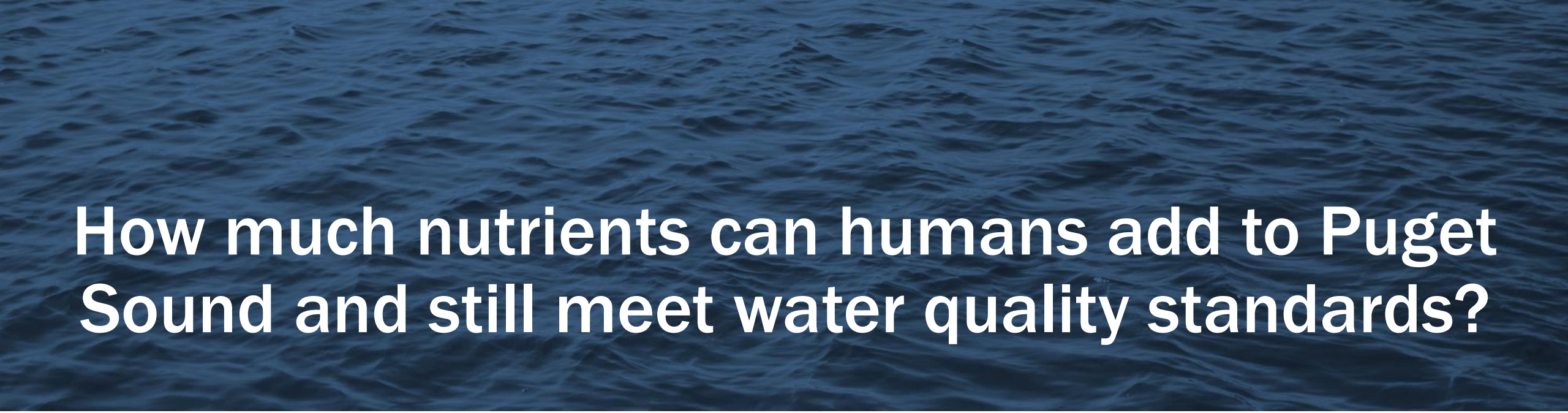


Comparing Model Predictions to DO Standards

Dustin Bilhimer, PSNSRP Project Manager, Water Quality Program

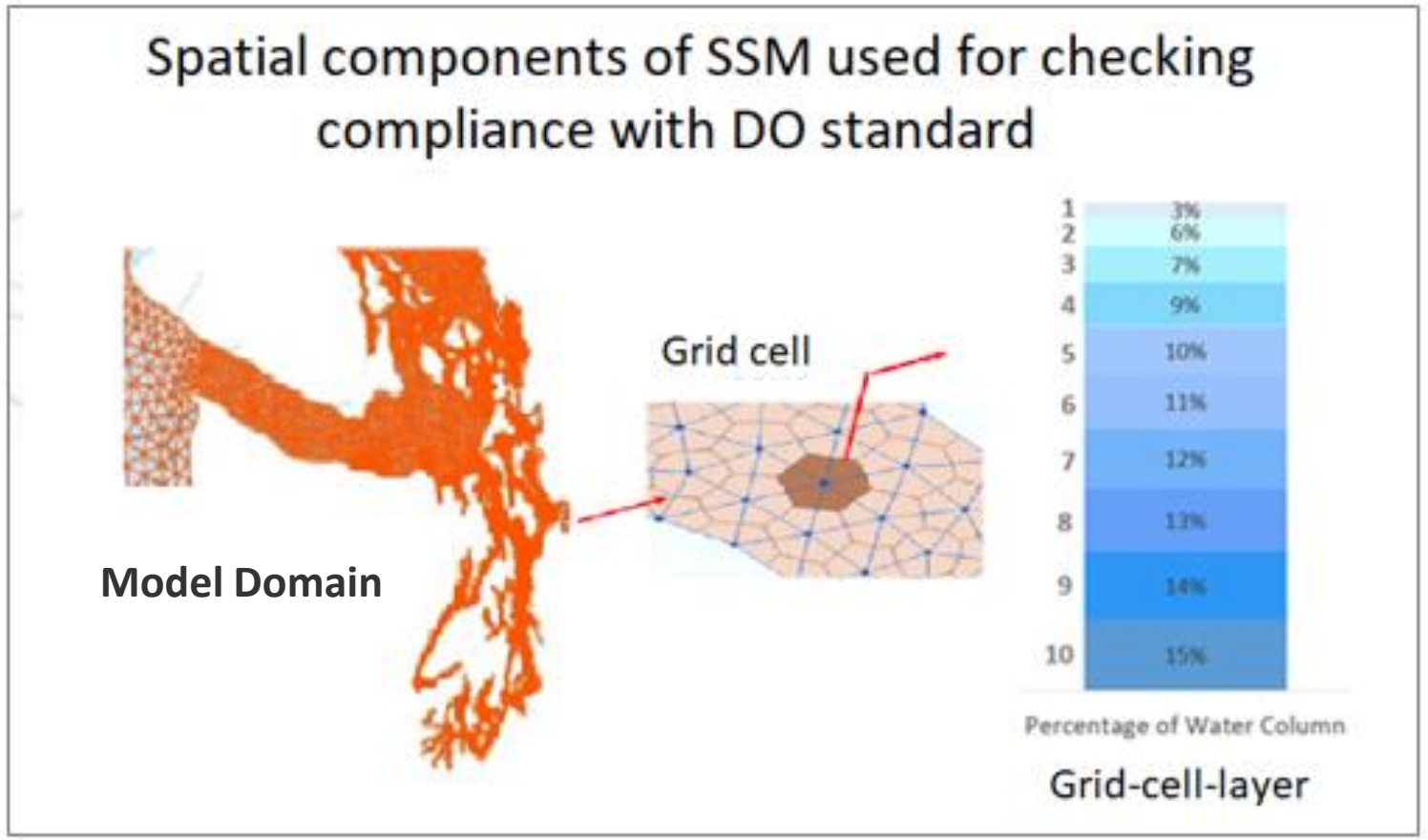
Dustin.Bilhimer@ecy.wa.gov



How much nutrients can humans add to Puget Sound and still meet water quality standards?

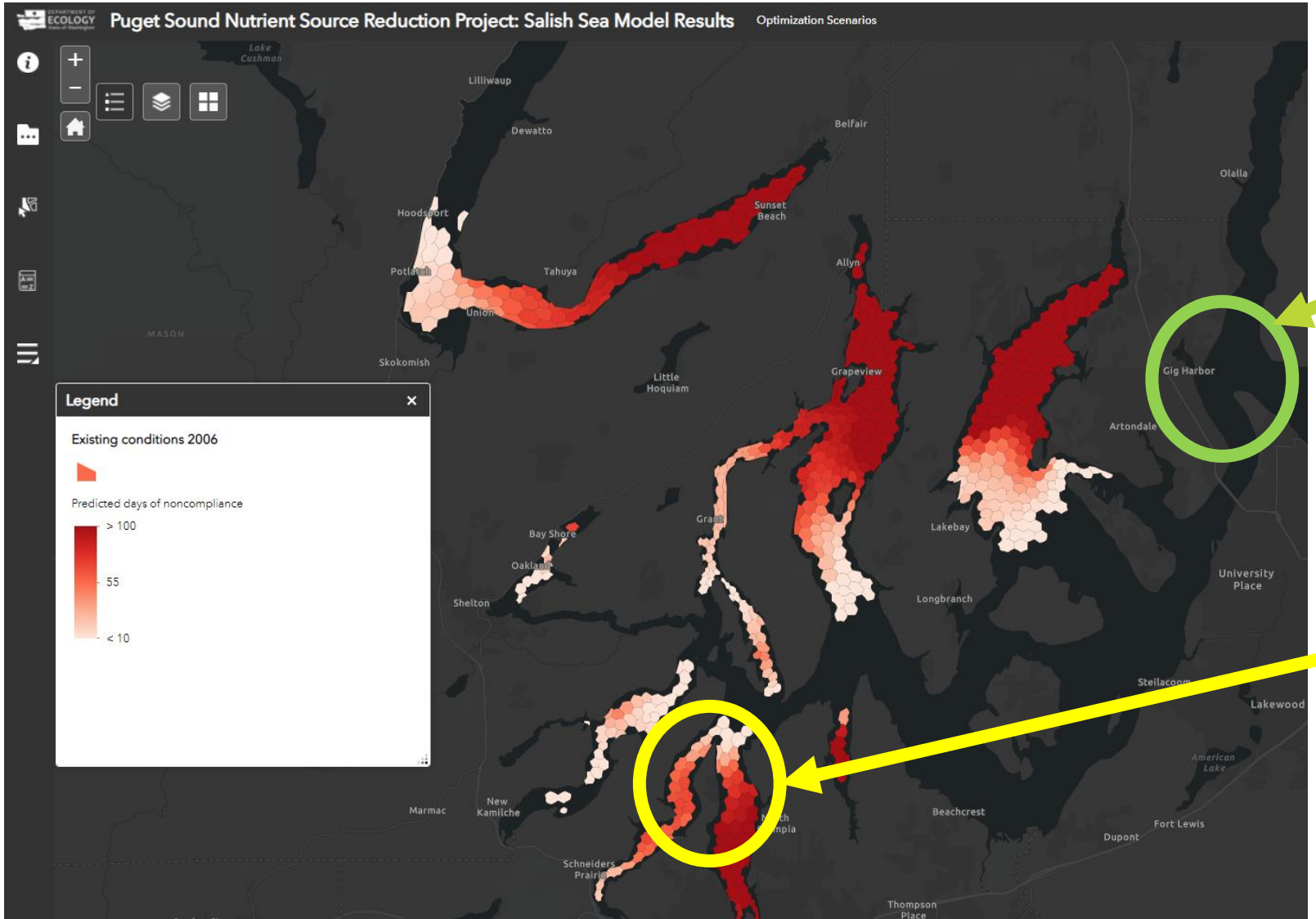
Are marine DO standards met or not?

Salish Sea Model Grid Cells



- Each grid cell has 10 vertical layers
- Average conditions within each grid cell layer
- Each layer compared to DO standards
- Largest depletion is reported

Understanding Maps of Model results



No color means a grid cell meets standards and passes both Part A and B tests

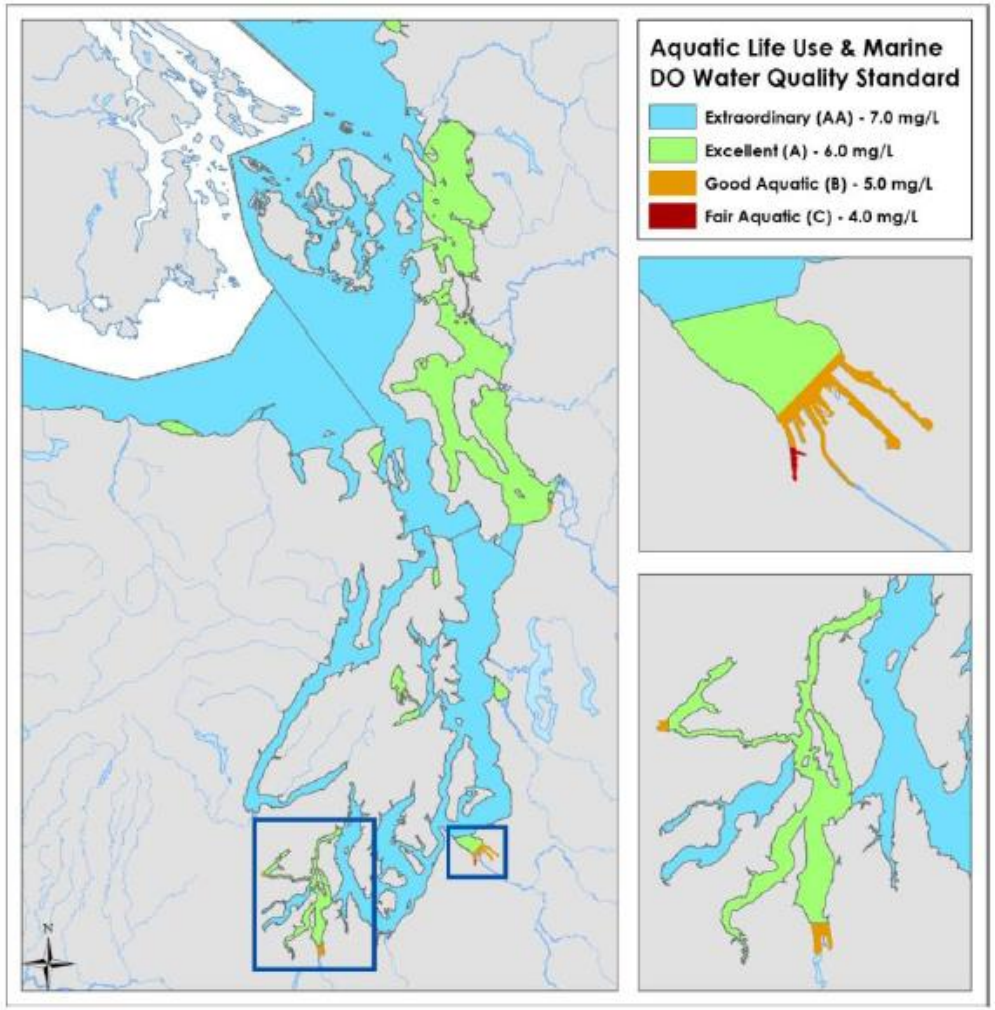
If a grid cell is colored in, then it does not pass either the Part A or Part B tests (or both) and does not meet standards

PART A- Numeric Criteria

Summarizes Table 210 (1)(c) from WAC 173-201A-210

- **7.0** mg/L (Extraordinary)- most of Puget Sound and the Straits
- **6.0** mg/L (Excellent)- Bellingham Bay, Samish Bay, Skagit Bay, most of the Whidbey Basin, parts of Budd Inlet and other parts of South Sound Basin
- **5.0** mg/L (Good)- Commencement Bay, Budd Inlet, and headwaters of some inlets
- **4.0** mg/L (Fair)- finger of Commencement Bay

- Concentrations are measured as 1-day minimum (Dmin)
- Probability frequency < Average of once per ten years



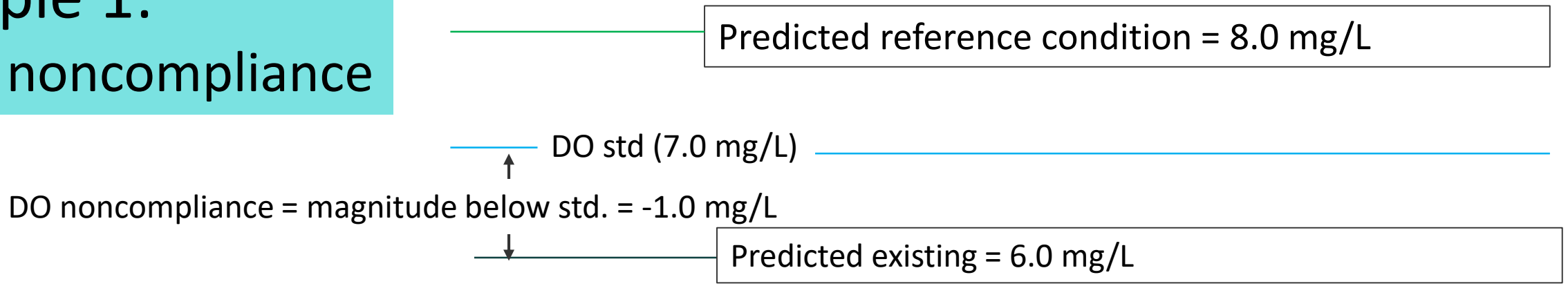
PART B- Limit DO Depletion from the Natural Condition

WAC 173-201A-210(d)(i): *When a water body's DO is lower than the criteria in Table 210(1)(d) (or within 0.2mg/L of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2mg/L.*

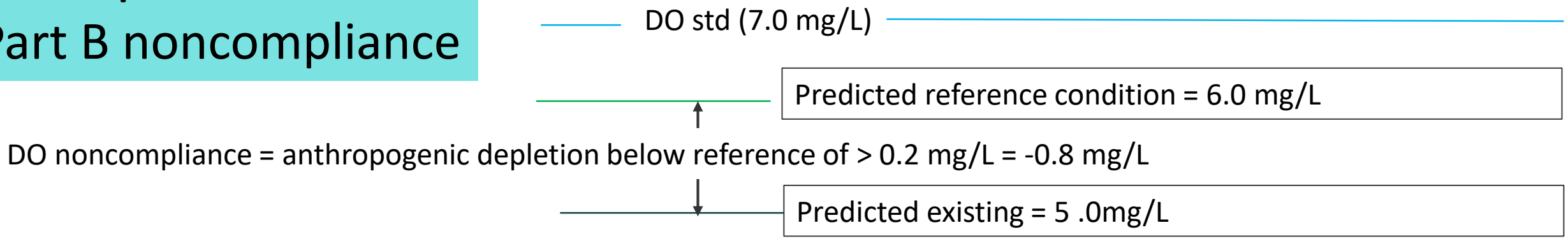
Limits cumulative human actions (nutrient discharges) so as not to degrade water quality further below the reference condition which includes the ocean influence

Comparing DO standards to model predictions

Example 1:
Part A noncompliance



Example 2:
Part B noncompliance

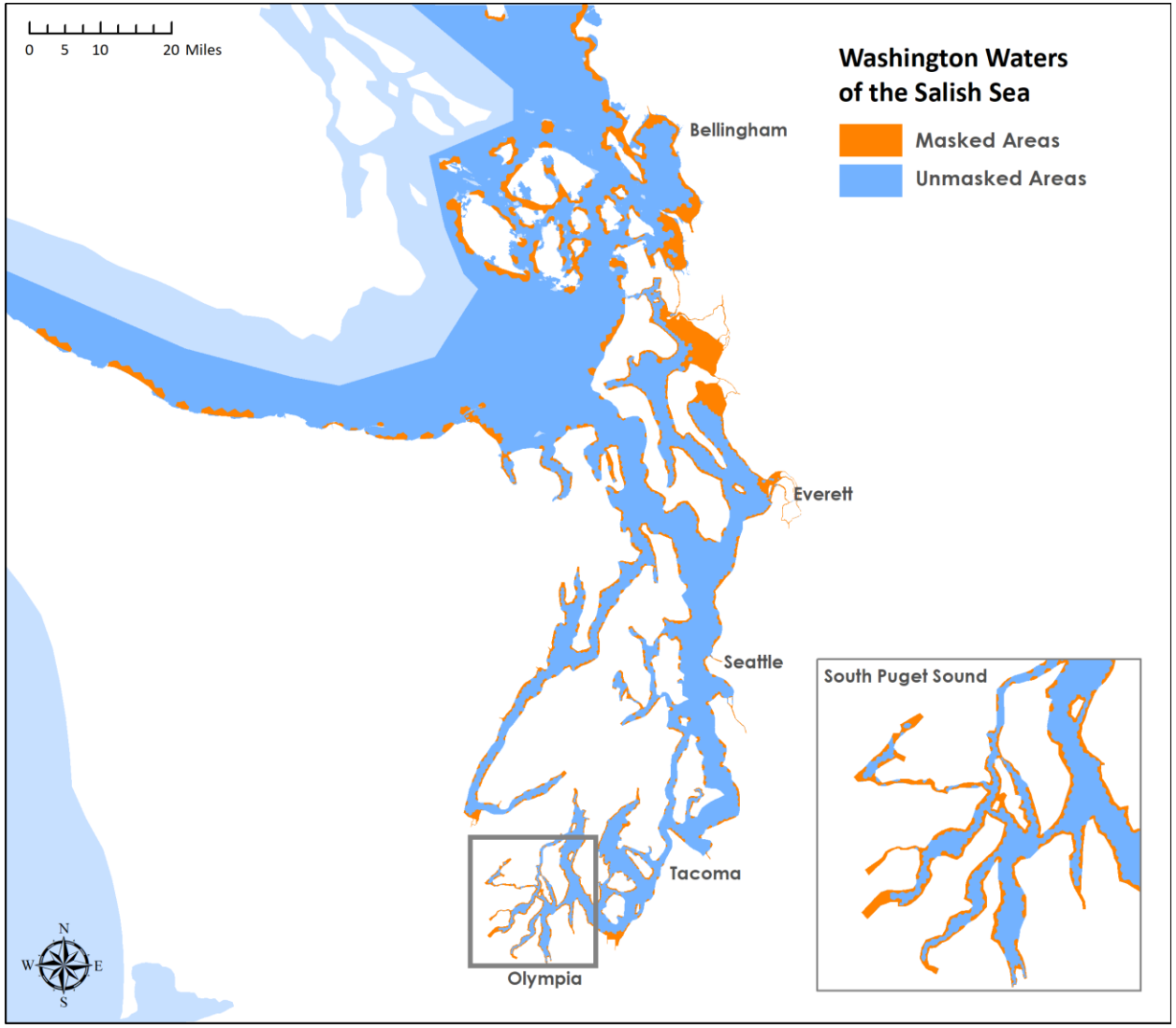


Where we calculate and report compliance

Applied to unmasked WA Waters of the Salish Sea

Masked areas not evaluated for DO standards

For now, we assume that improvement in adjacent unmasked areas will likely also improve masked areas



Questions?

Dustin Bilhimer, PSNSRP Project Manager, Water Quality Program

Dustin.Bilhimer@ecy.wa.gov

Overview: Model Scenarios and Results

Teizeen Mohamedali

Optimization Scenarios – Year 1 Modeling Results

Puget Sound Nutrient Forum

September 28, 2020

Ecology's Salish Sea Modeling Team:
Anise Ahmed, Cristiana Figueroa-Kaminsky, John Gala, Sheelagh McCarthy and Teizeen Mohamedali

Outline

- Overview: Model Scenarios and Results – Teizeen Mohamedali (~20 min)
- Detailed look at model results – Anise Ahmed (~25 min)
  - Summary of 2 Years with multiple scenarios.
- Highlights of SSM Application Updates – John Gala (~10 min)
  - Continuous improvement is part of best practices in modeling.
  - As more data and information becomes available, further enhancements become possible.

Overview: model scenarios and results

Teizeen Mohamedali

DEPARTMENT OF ECOLOGY
State of Washington

Optimization Scenarios

Scenario Number	Scenario Name	Watershed Loads	WWTP Loads
1	Watershed reductions	Watersheds in focus region at reference; all others at existing	Existing Conditions
2	WWTP reductions	Existing Conditions	WWTPs in focus region at reference; all others at existing
3	Annual BNR8	Existing Conditions	Annual BNR8 at all WWTPs
4	Projected future growth	Existing Conditions	Projected high and low WWTP flow estimates
5	Combined watershed and WWTP reductions	15%, 40% or 65% reductions in anthropogenic load	Annual or seasonal BNR8 or BNR3

Optimization Scenarios

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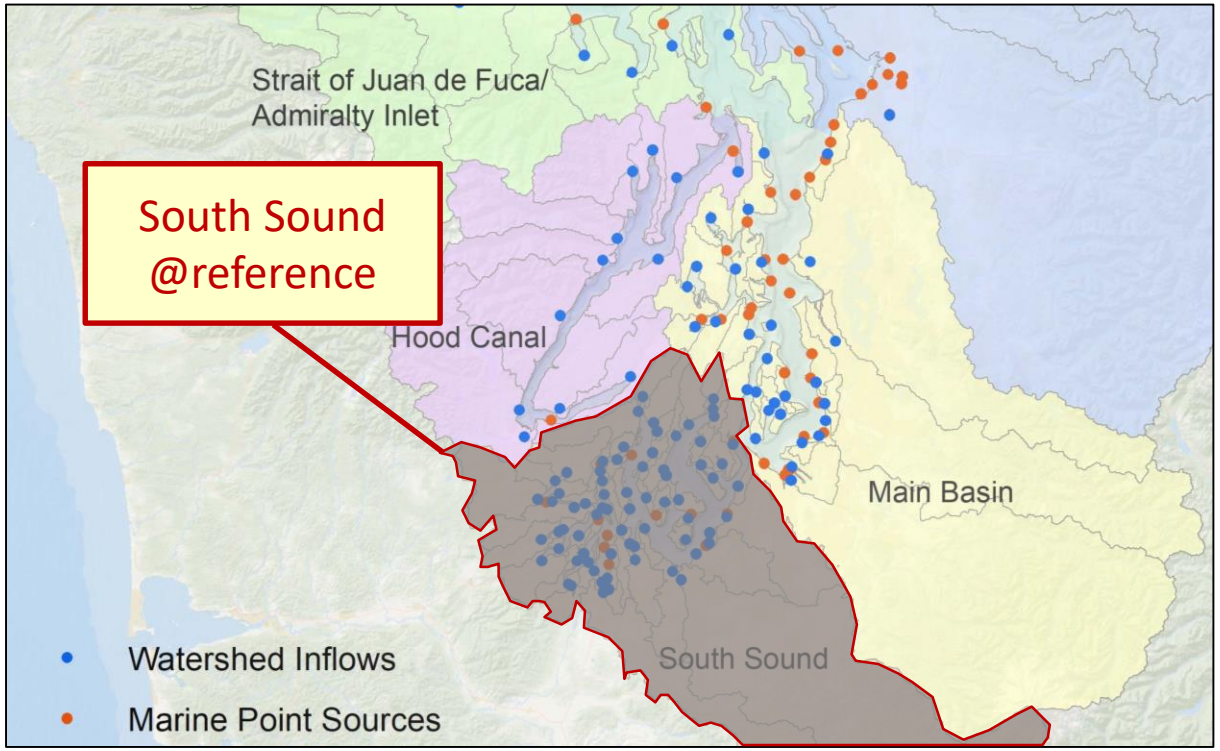
1	Watershed reductions	Watersheds in focus region at reference; all others at existing	Existing Conditions
2	WWTP reductions	Existing Conditions	WWTPs in focus region at reference; all others at existing

- Scenario 1 and 2 evaluate are each associated with **six model runs**
- Watershed and WWTP inputs entering each region are set to reference in turn



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3	**Annual BNR8**	**Existing Conditions**	**Annual BNR8 at all WWTPs**

BNR = Biological Nitrogen Removal

BNR8: DIN = 8 mg/L, CBOD = 8 mg/L

BNR3: DIN = 3 mg/L, CBOD = 8 mg/L

Additional Seasonal BNR Scenarios
(re-runs from Bounding Scenarios)

- **BNR8-All** – all WWTPs set to BNR8
- **BNR8-1000** – at mid-sized WWTPs with an existing DIN load >1000 kg/day
- **BNR8-8000** – at large WWTPs with an existing DIN load >8000 kg/day

Optimization Scenarios

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Optimization Scenarios

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Optimization Scenarios

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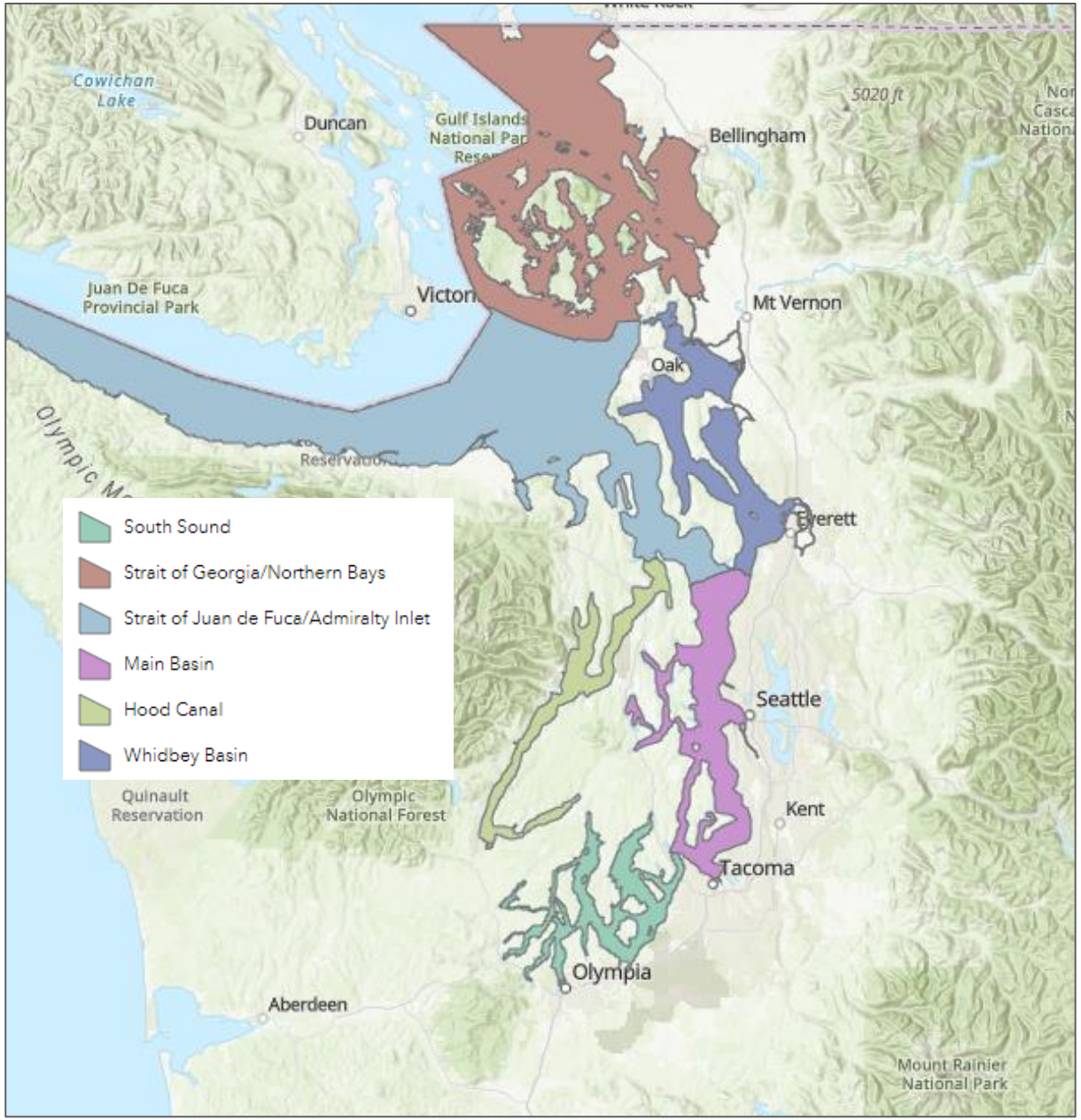
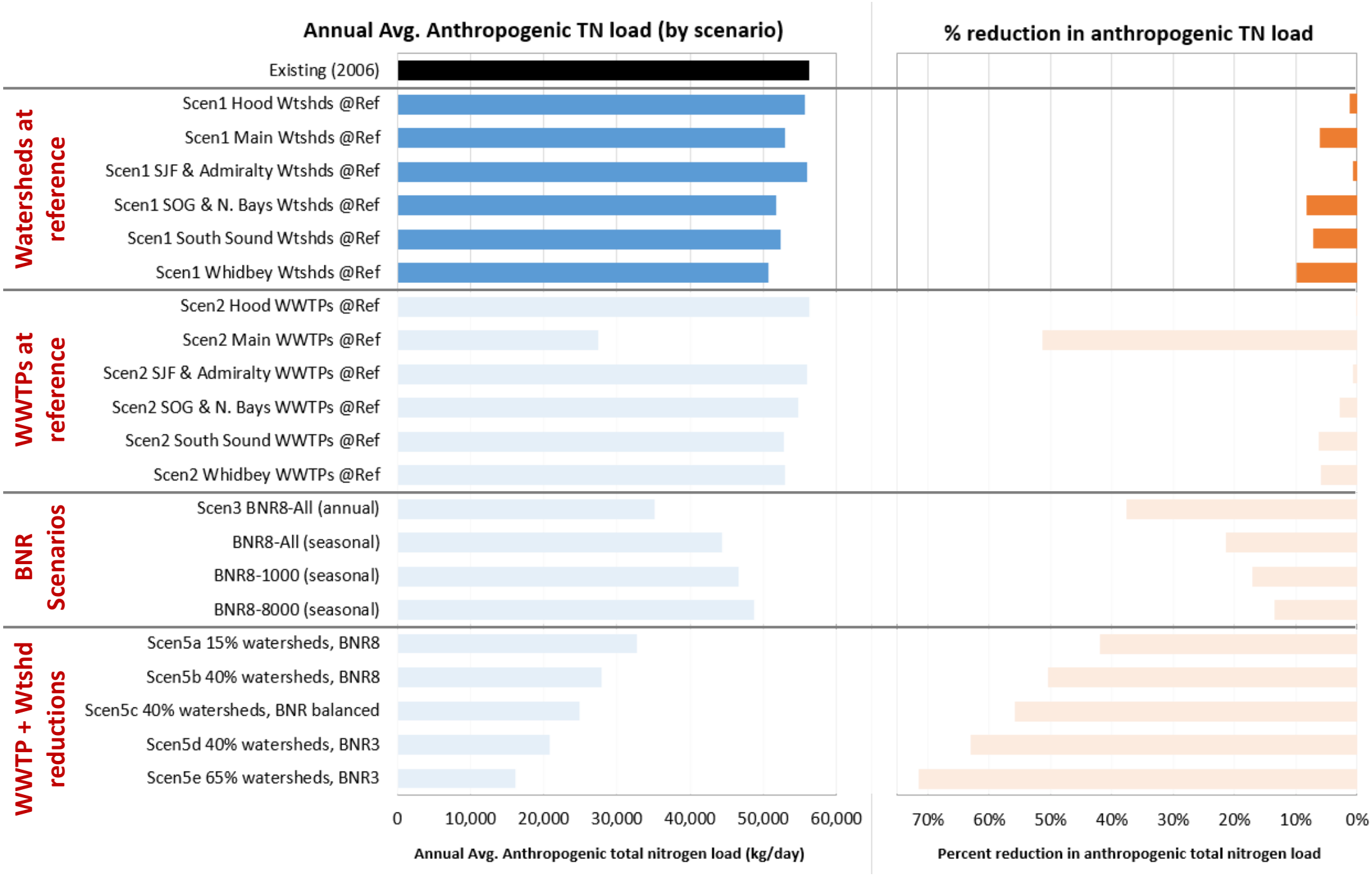
5	Combined watershed and WWTP reductions	15%, 40% or 65% reductions in anthropogenic load	Annual or seasonal BNR8 or BNR3

- Existing/baseline and reference model runs also run for each model year (2006 and 2014)

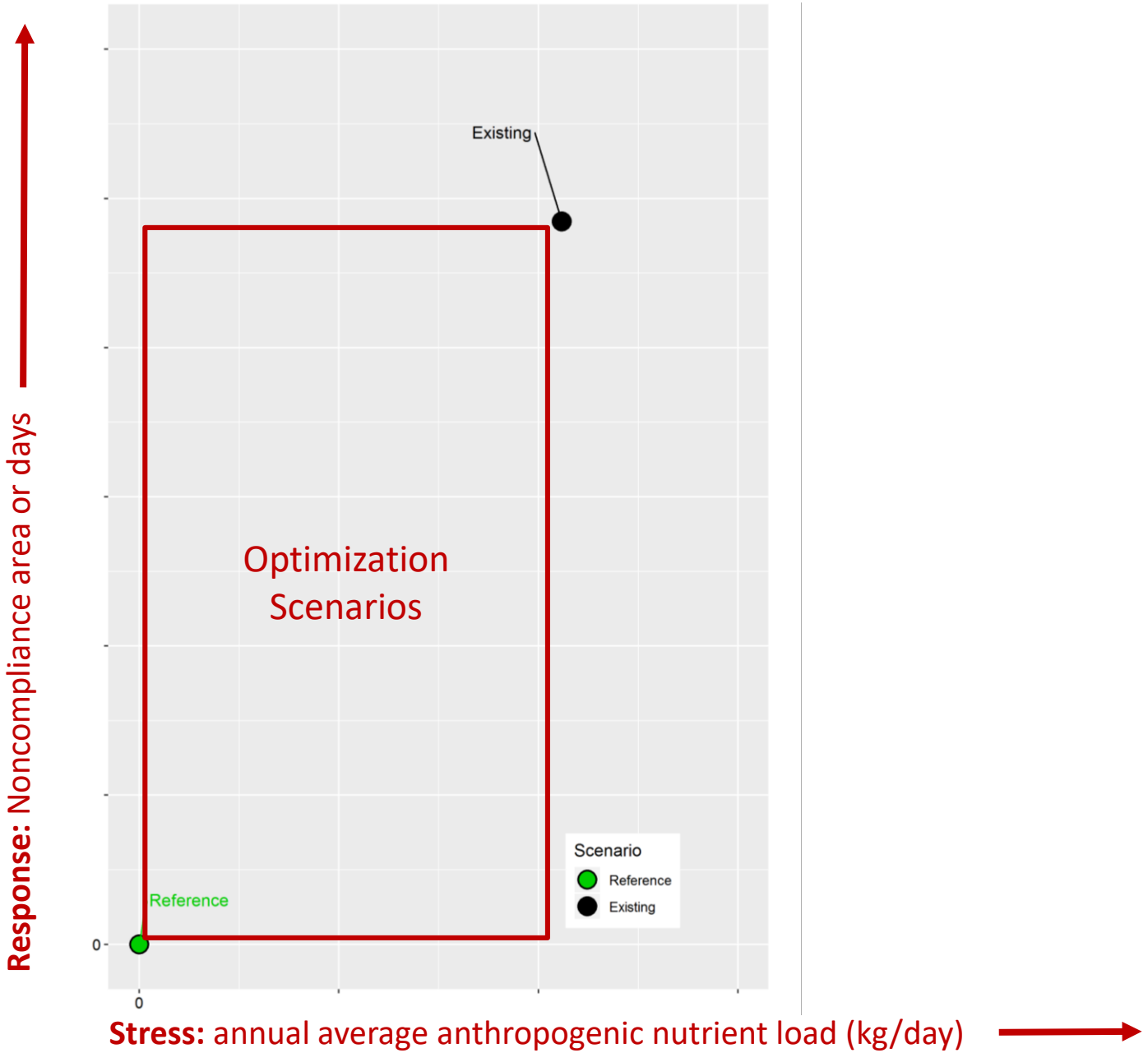
How results are presented

- DO depletion vs. DO noncompliance
- DO noncompliance expressed as:
  1. Predicted noncompliant **area**
  2. Predicted cumulative noncompliant **days**
  3. Predicted **maximum magnitude** of DO noncompliance
- Some results are presented in terms of improvements in DO within the waters associated with these regions
- Most other results are presented in terms of DO improvements in 'WA waters of the Salish Sea' – which includes all regions combined



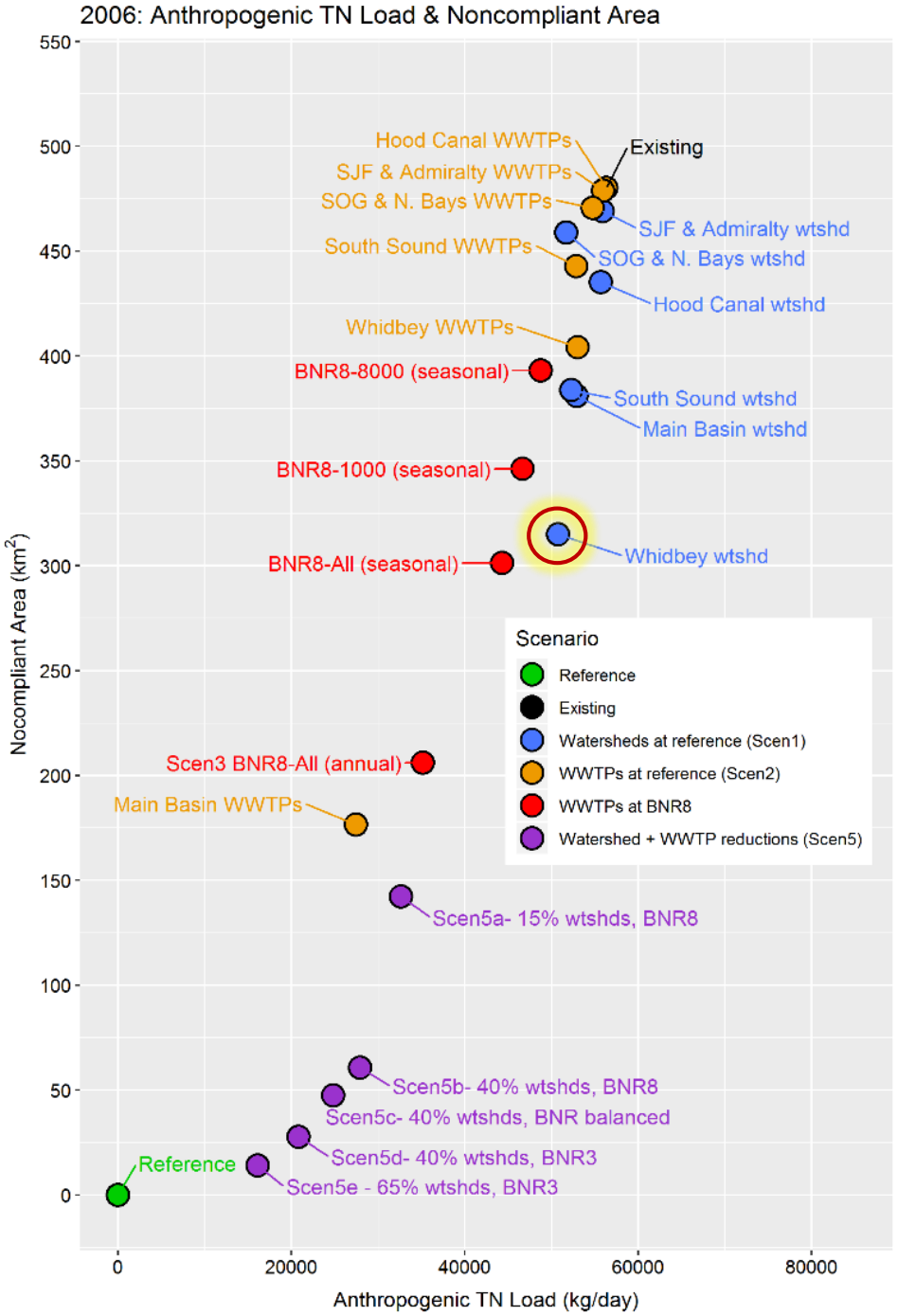

Annual Avg. Anthropogenic TN load (by scenario)
% reduction in anthropogenic TN load
Existing (2006)
Watersheds at reference
Scen1 Hood Wtshds @Ref
Scen1 Main Wtshds @Ref
Scen1 SJF & Admiralty Wtshds @Ref
Scen1 SOG & N. Bays Wtshds @Ref
Scen1 South Sound Wtshds @Ref
Scen1 Whidbey Wtshds @Ref
WWTPs at reference
Scen2 Hood WWTPs @Ref
Scen2 Main WWTPs @Ref
Scen2 SJF & Admiralty WWTPs @Ref
Scen2 SOG & N. Bays WWTPs @Ref
Scen2 South Sound WWTPs @Ref
Scen2 Whidbey WWTPs @Ref
BNR Scenarios
Scen3 BNR8-All (annual)
BNR8-All (seasonal)
BNR8-1000 (seasonal)
BNR8-8000 (seasonal)
WWTP + Wtshd reductions
Scen5a 15% watersheds, BNR8
Scen5b 40% watersheds, BNR8
Scen5c 40% watersheds, BNR balanced
Scen5d 40% watersheds, BNR3
Scen5e 65% watersheds, BNR3
0
10,000
20,000
30,000
40,000
50,000
60,000
70%
60%
50%
40%
30%
20%
10%
0%
Annual Avg. Anthropogenic total nitrogen load (kg/day)
Percent reduction in anthropogenic total nitrogen load

Scenario scatter plots comparing all scenarios

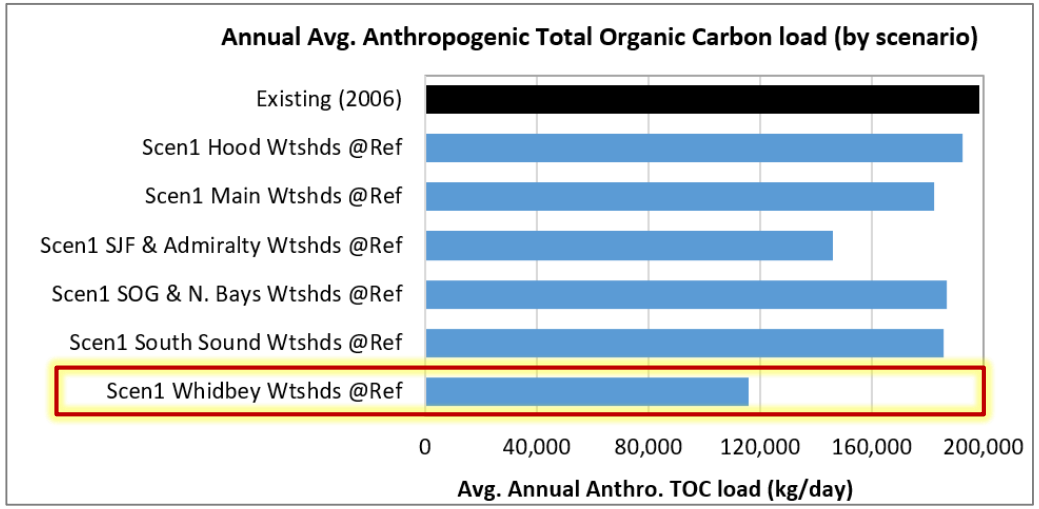


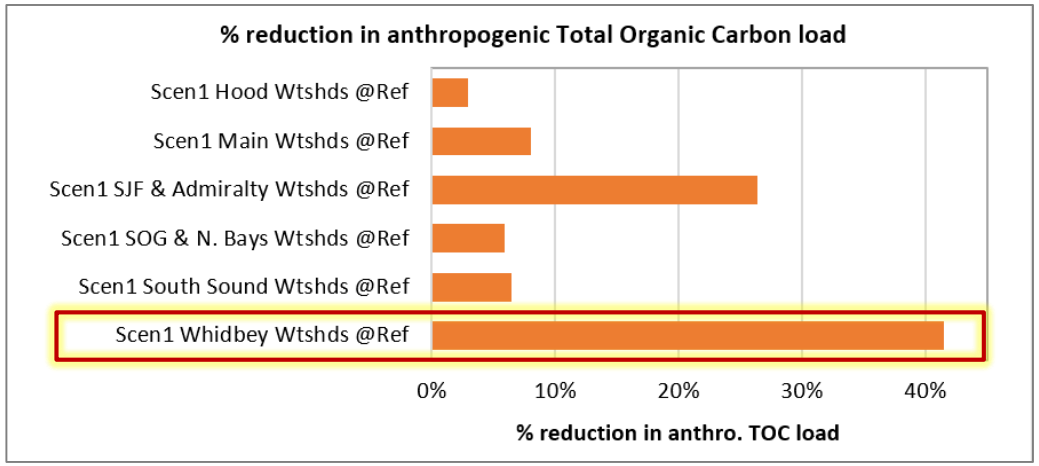
Predicted noncompliant area across all scenarios

- Total nitrogen and total organic carbon reductions are done at the same time
- Anthropogenic TN load is similar across watersheds, but predicted impact on DO is not – TOC loads influence noncompliance



Scenario 1 – watershed TOC loads & reductions





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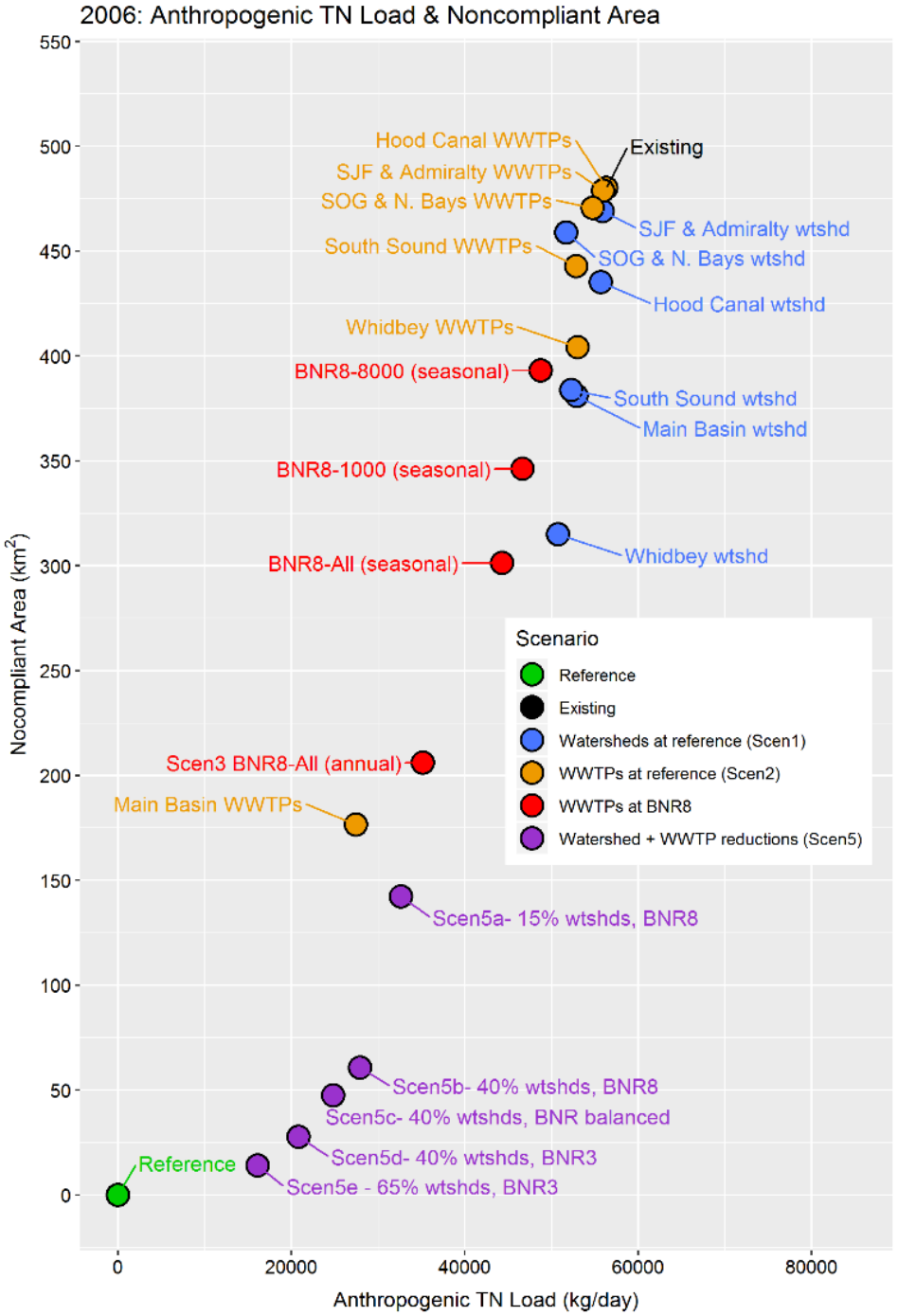
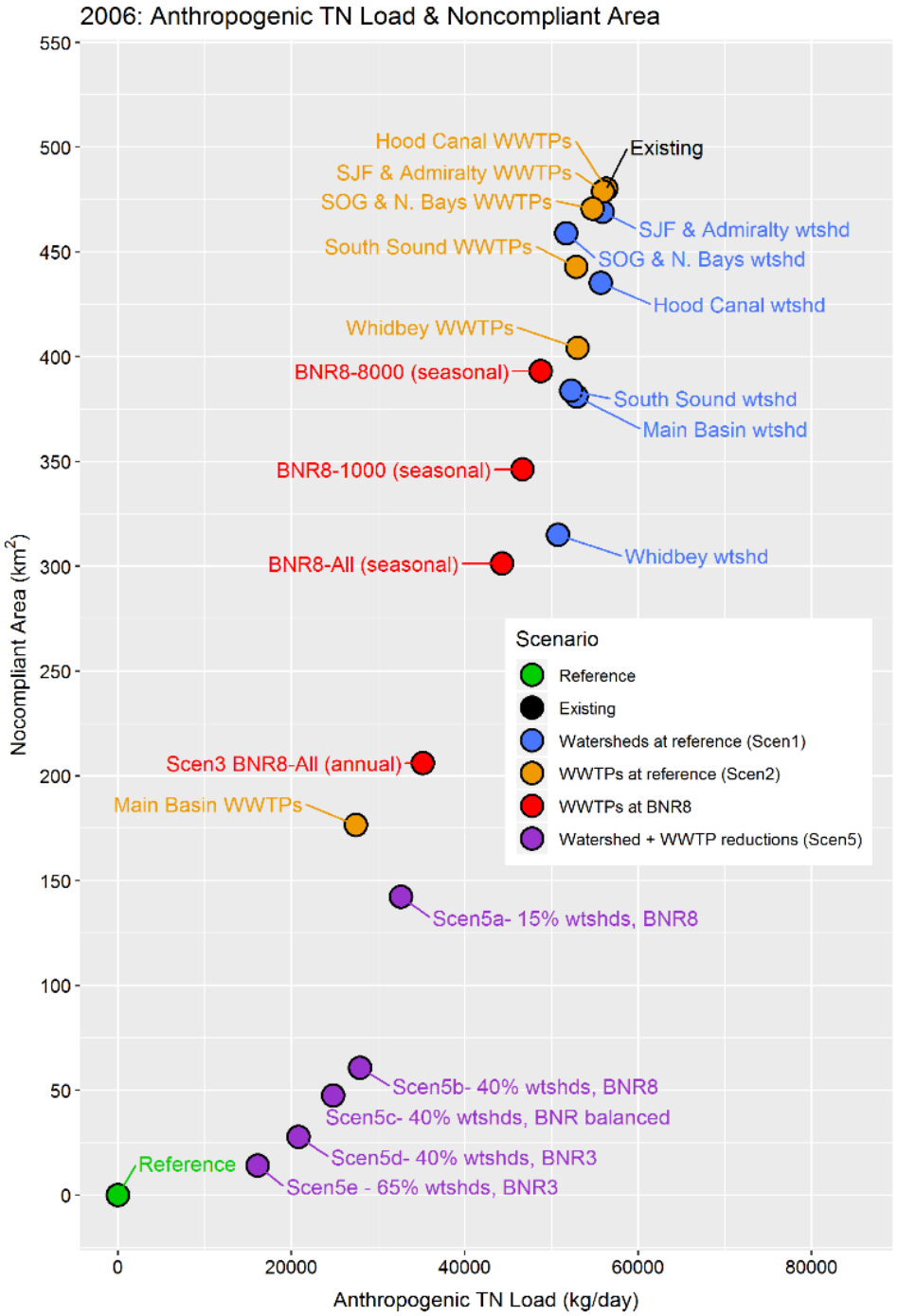
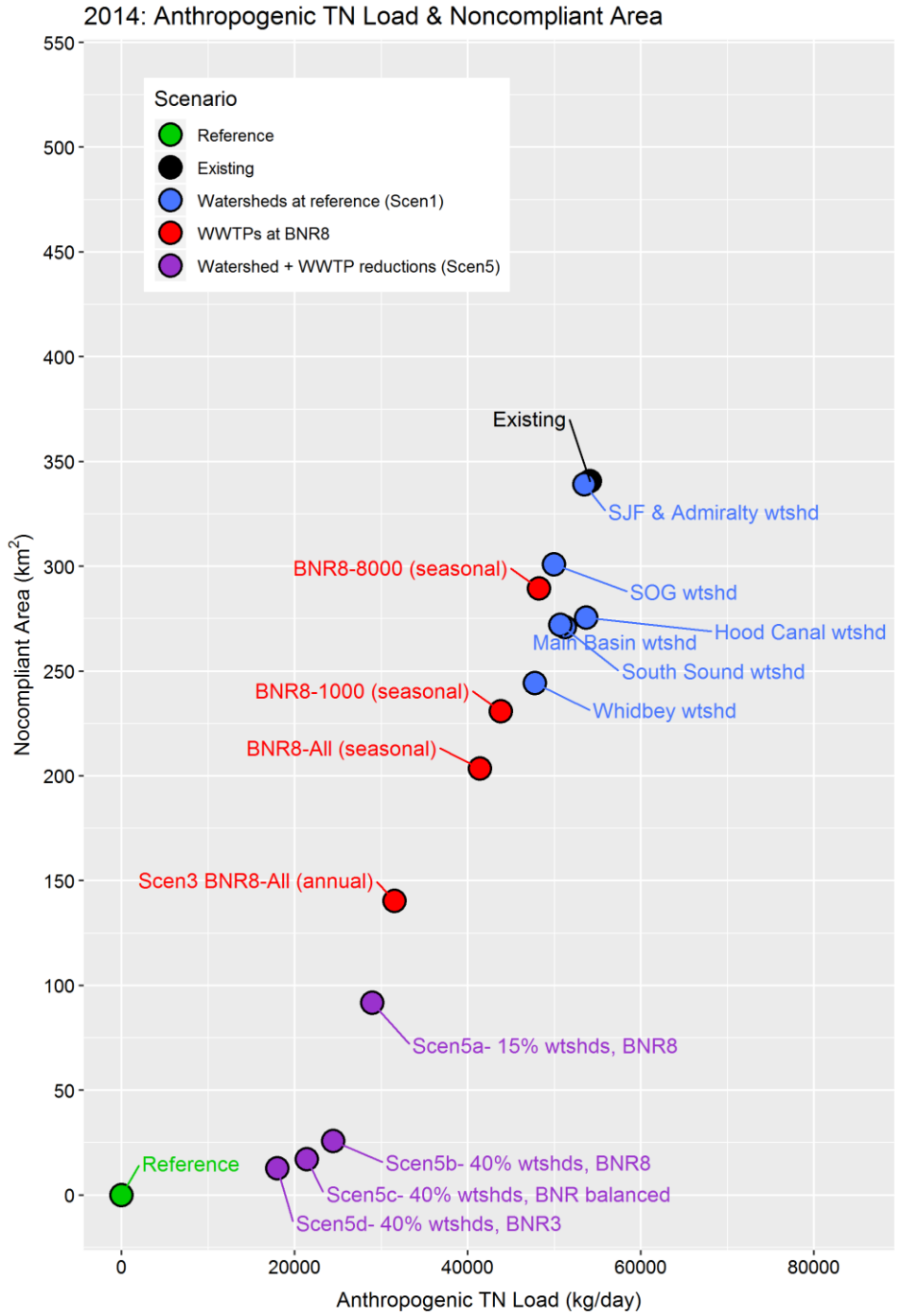
- Improvements from Main Basin WWTP @Ref are > BNR and Scenario 5 runs
- BNR scenarios reflect reductions at WWTPs based on treatment
- Combined reductions achieve the greatest improvements in predicted noncompliant area



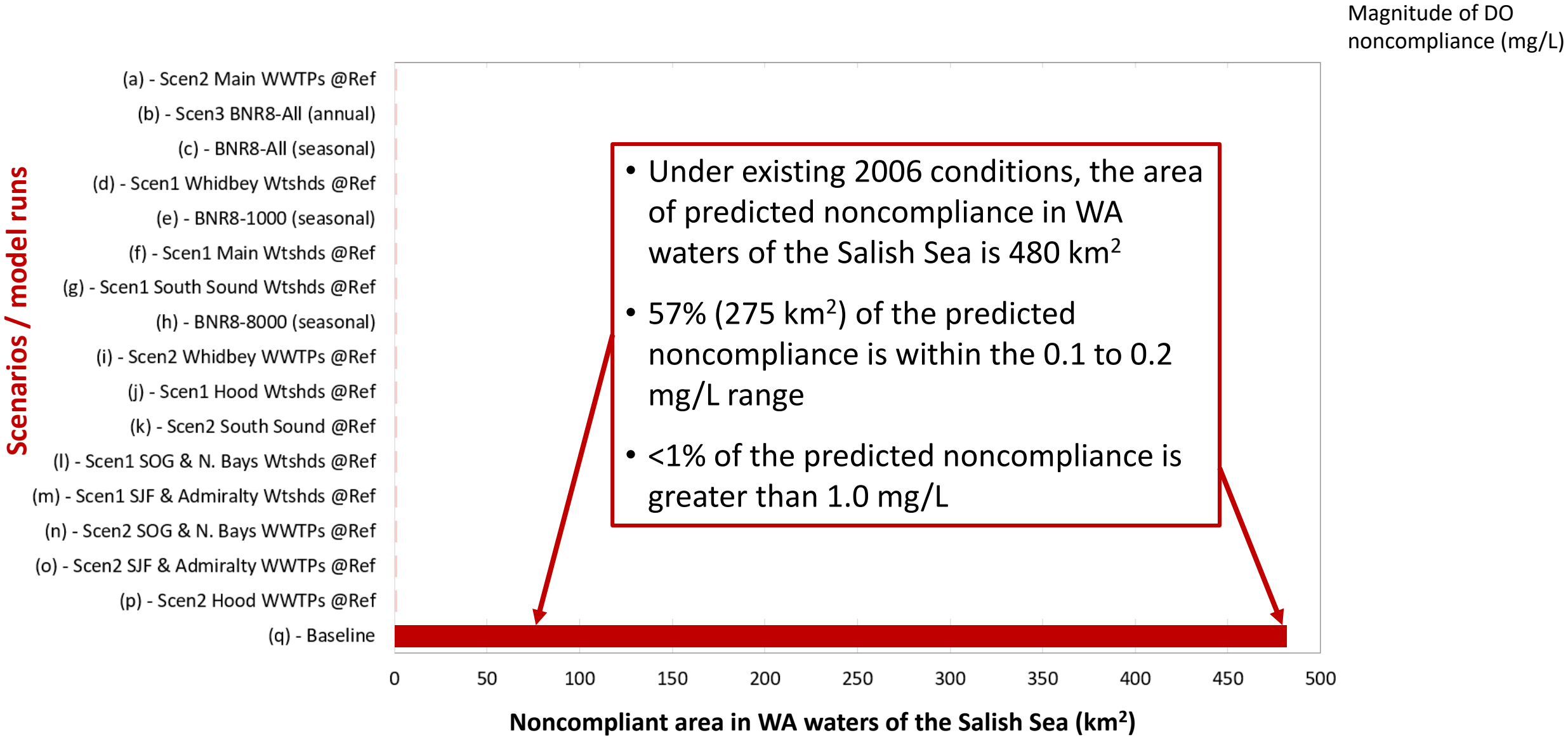
Predicted noncompliant area across all scenarios

- Total nitrogen and total organic carbon reductions are done at the same time
- Anthropogenic TN load is similar across watersheds, but predicted impact on DO is not – TOC loads influence noncompliance
- BNR scenarios reflect reductions at WWTPs based on treatment
- Improvements from Main Basin WWTP @Ref are > BNR and Scenario 5 runs
- Combined reductions achieve the greatest improvements in predicted noncompliant area
- Predicted noncompliance varies between years (2006 vs. 2014)





Range in magnitude of predicted DO noncompliance



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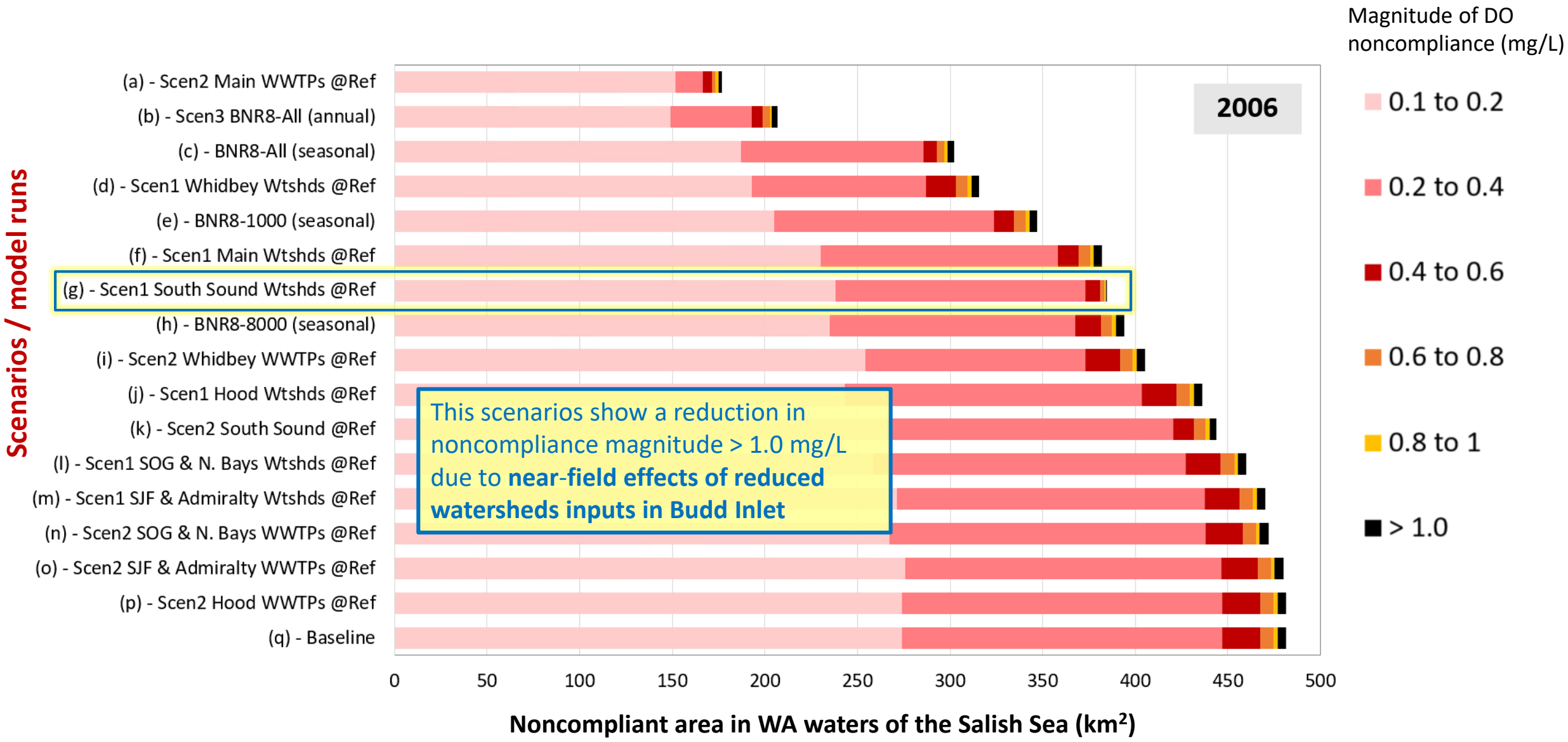
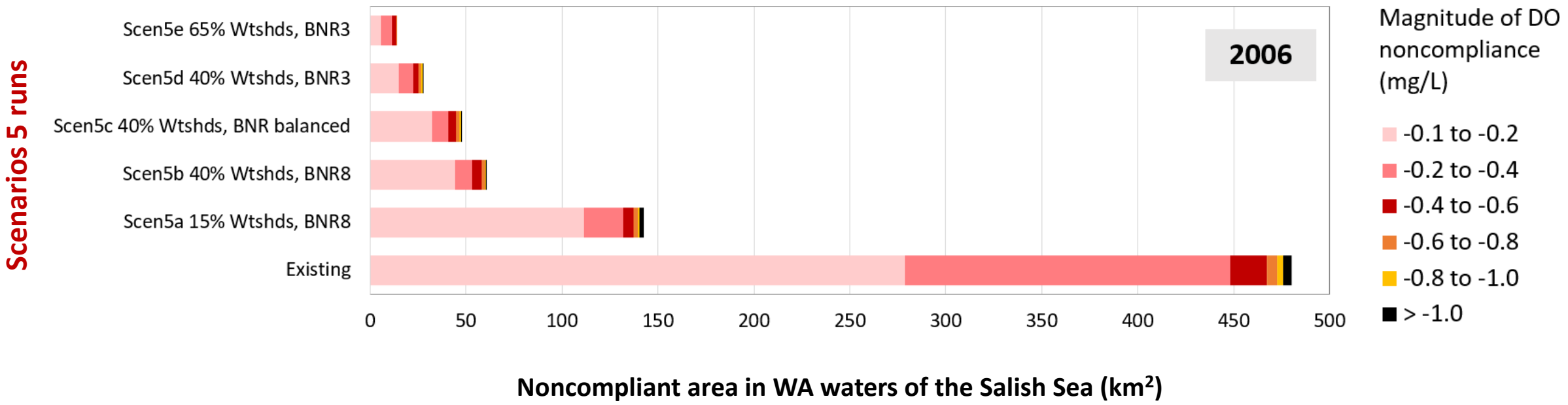


Range in magnitude of predicted DO noncompliance

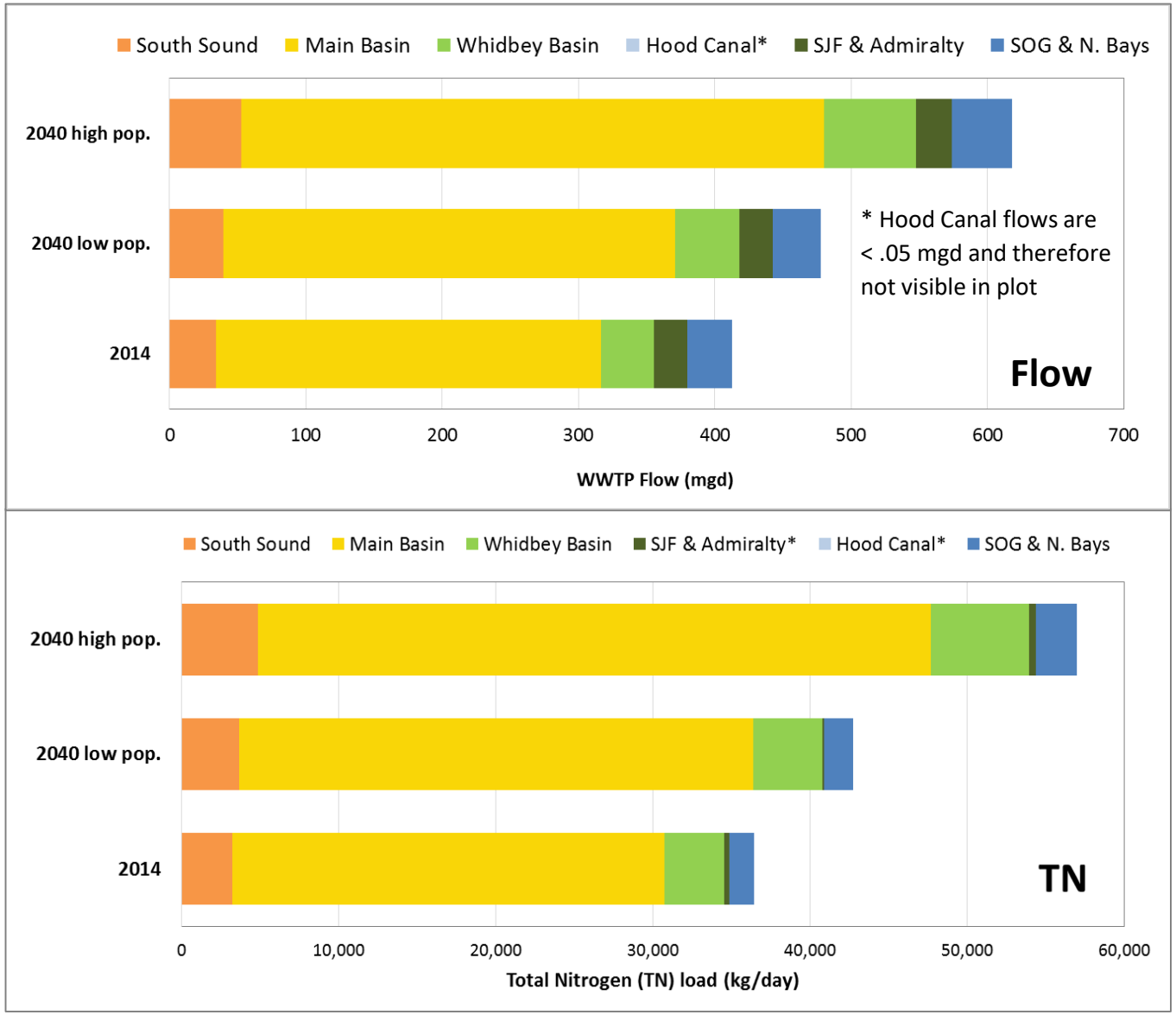


Scenario 5 Combined Reductions result in the greatest decrease in:

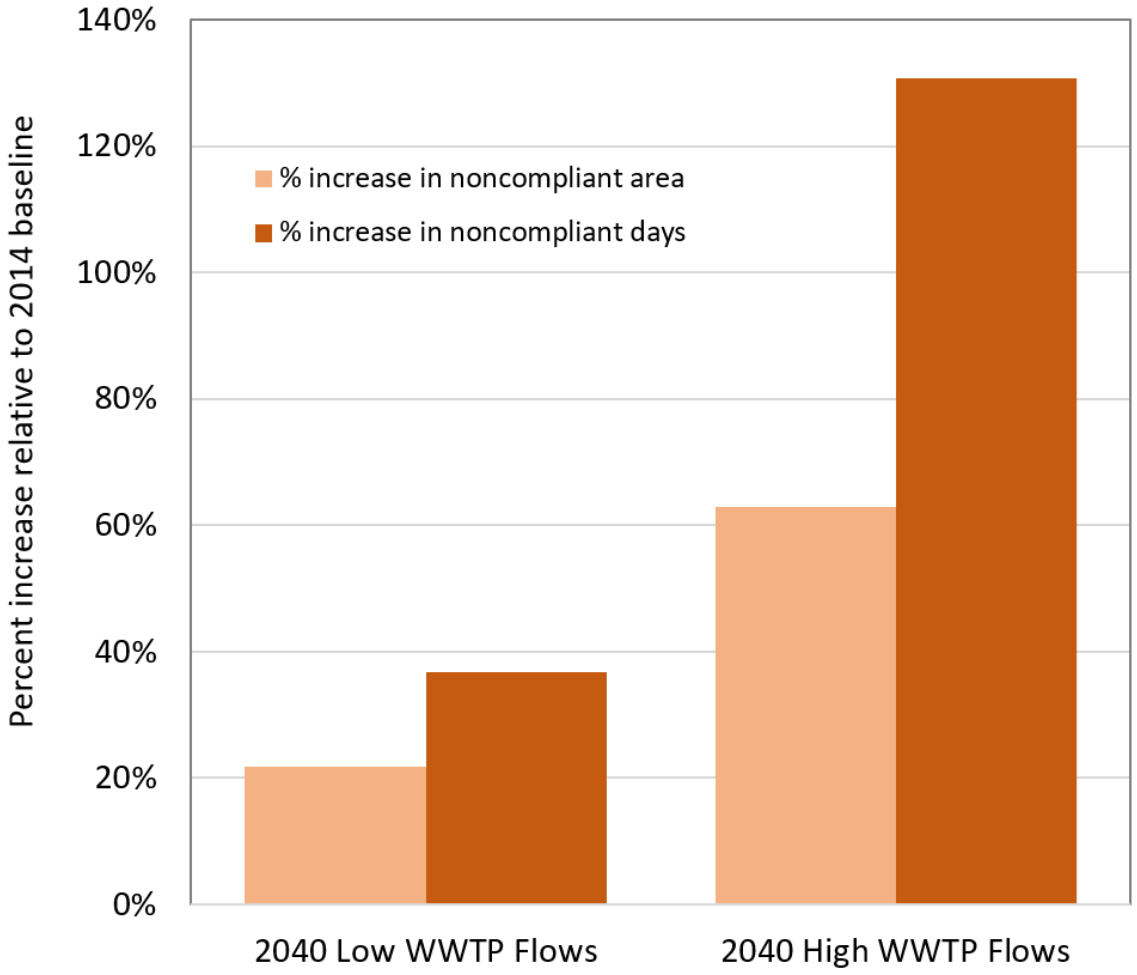
- Overall predicted area of noncompliance
- The magnitude of predicted noncompliance across all ranges

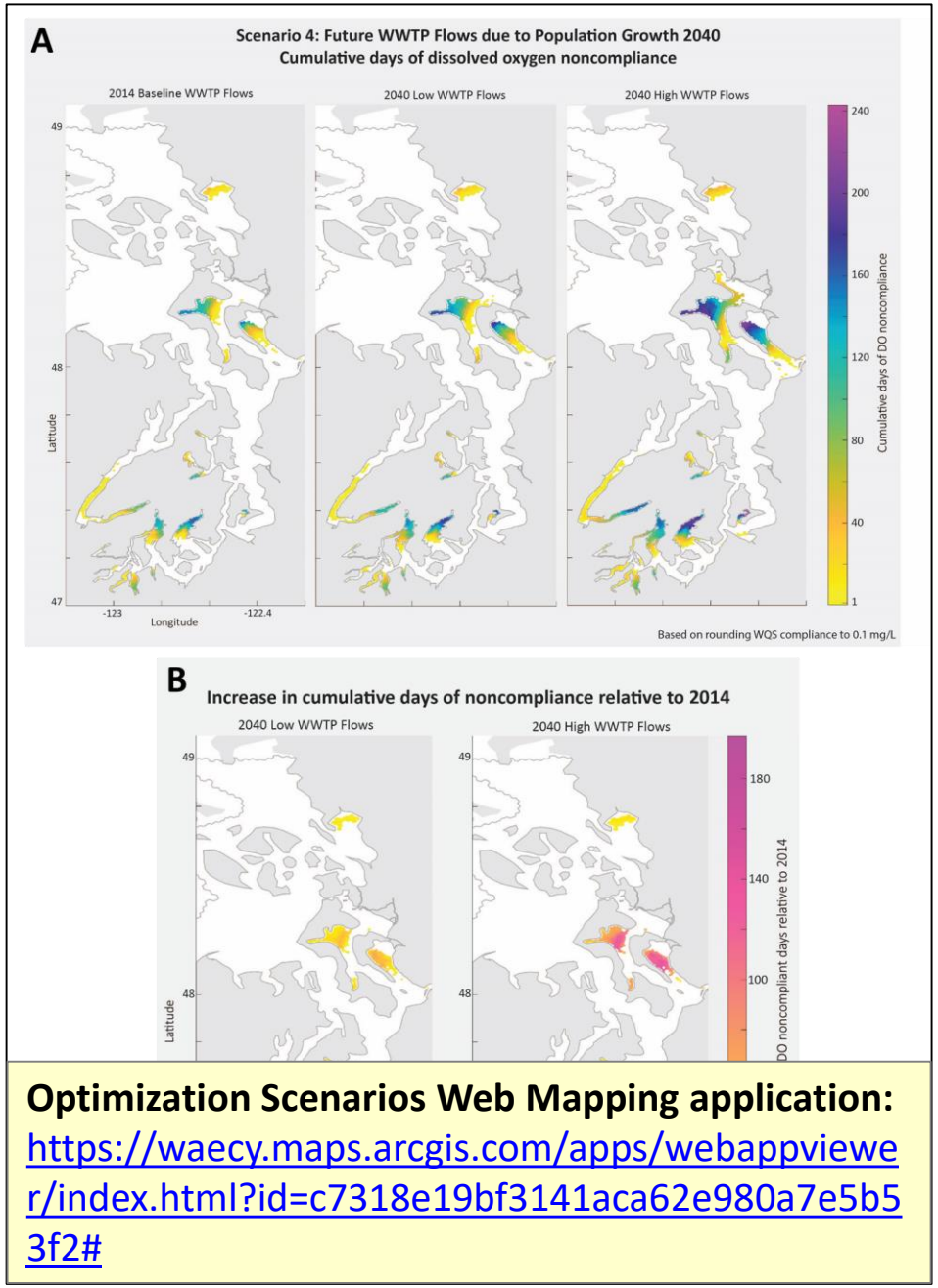
Scenario 4 - Future 2040 WWTP flows

- **2014 conditions (river, meteorology, ocean conditions, circulation, etc.)**
- **Only change is WWTP inputs**
- Used future population projections in 2040
- Scaled WWTP flows up by estimated population growth by county
- Perturbed WWTP inputs to reflect the increase in nutrient loads associated with this increase in flow



Predicted impact of future WWTP flows in oxygen





Optimization Scenarios Web Mapping application:
https://waecy.maps.arcgis.com/apps/webappviewer/index.html?id=c7318e19bf3141aca62e980a7e5b53f2#

Detailed look at model results

Anise Ahmed

DEPARTMENT OF ECOLOGY
State of Washington

Scenario 1 : What is the relative influence of watershed nutrient loads entering individual regions?

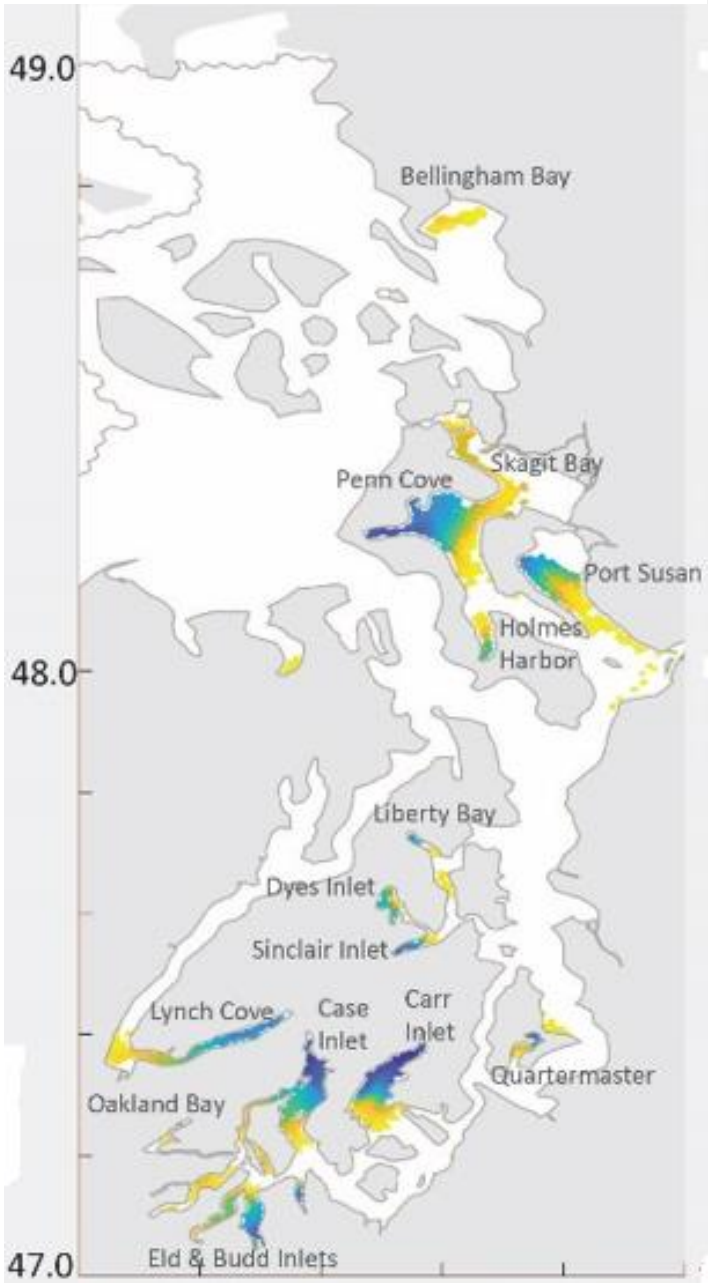
Approach:

1. All watersheds in focus regions at reference condition
2. Watersheds in all other regions at existing conditions
3. All WWTP in all regions at existing conditions

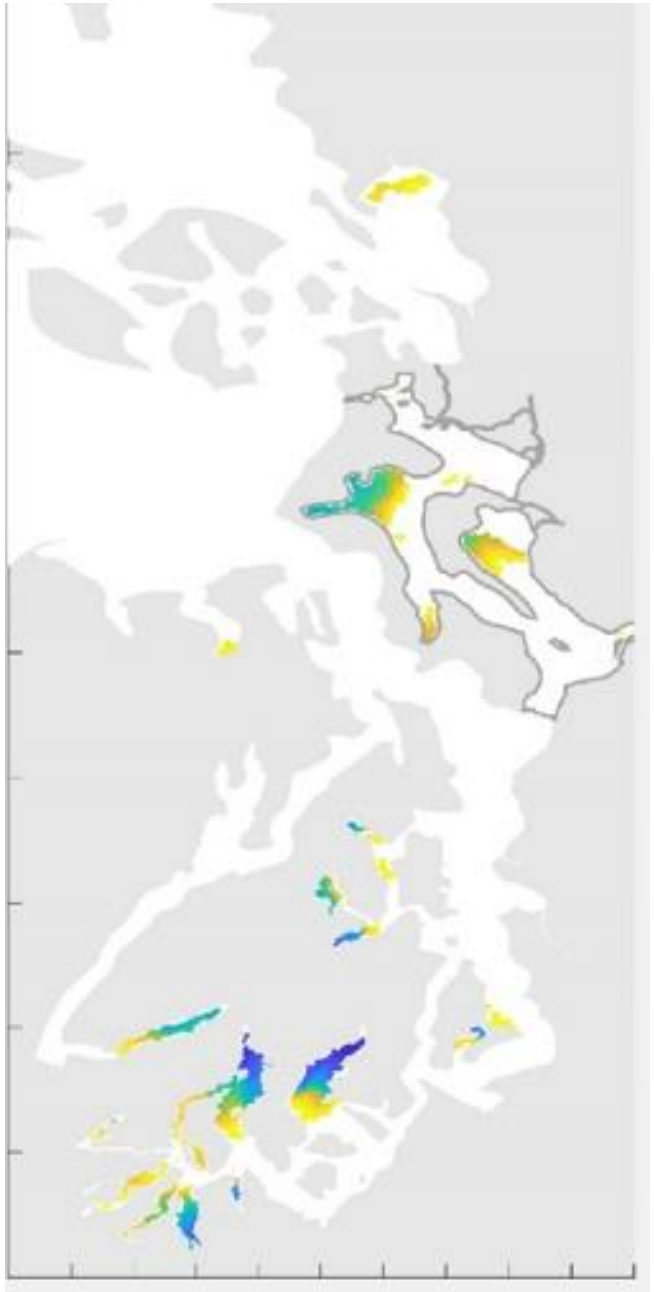
Scenario 1 loads 2006	**TN Load (Kg/d)**	**TN Reduction**	**TOC Load (Kg/d)**	**TOC Reduction**
Existing	56,323	n/a	198,341	0.0%
Scen1 Hood Wtshds	55,695	1.1%	192,474	3.0%
Scen1 Main Wtshds	52,920	6.0%	182,340	8.1%
Scen1 SJF & Admiralty Wtshds	55,917	0.7%	146,018	26.4%
Scen1 SOG & N. Bays Wtshds	51,696	8.2%	186,668	5.9%
Scen1 South Sound Wtshds	52,295	7.2%	185,572	6.4%
Scen1 Whidbey Wtshds	50,743	9.9%	116,015	41.5%

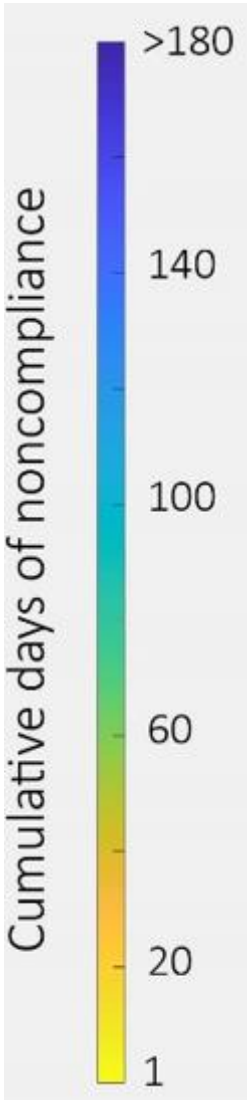
Scenario 1

2006 Existing



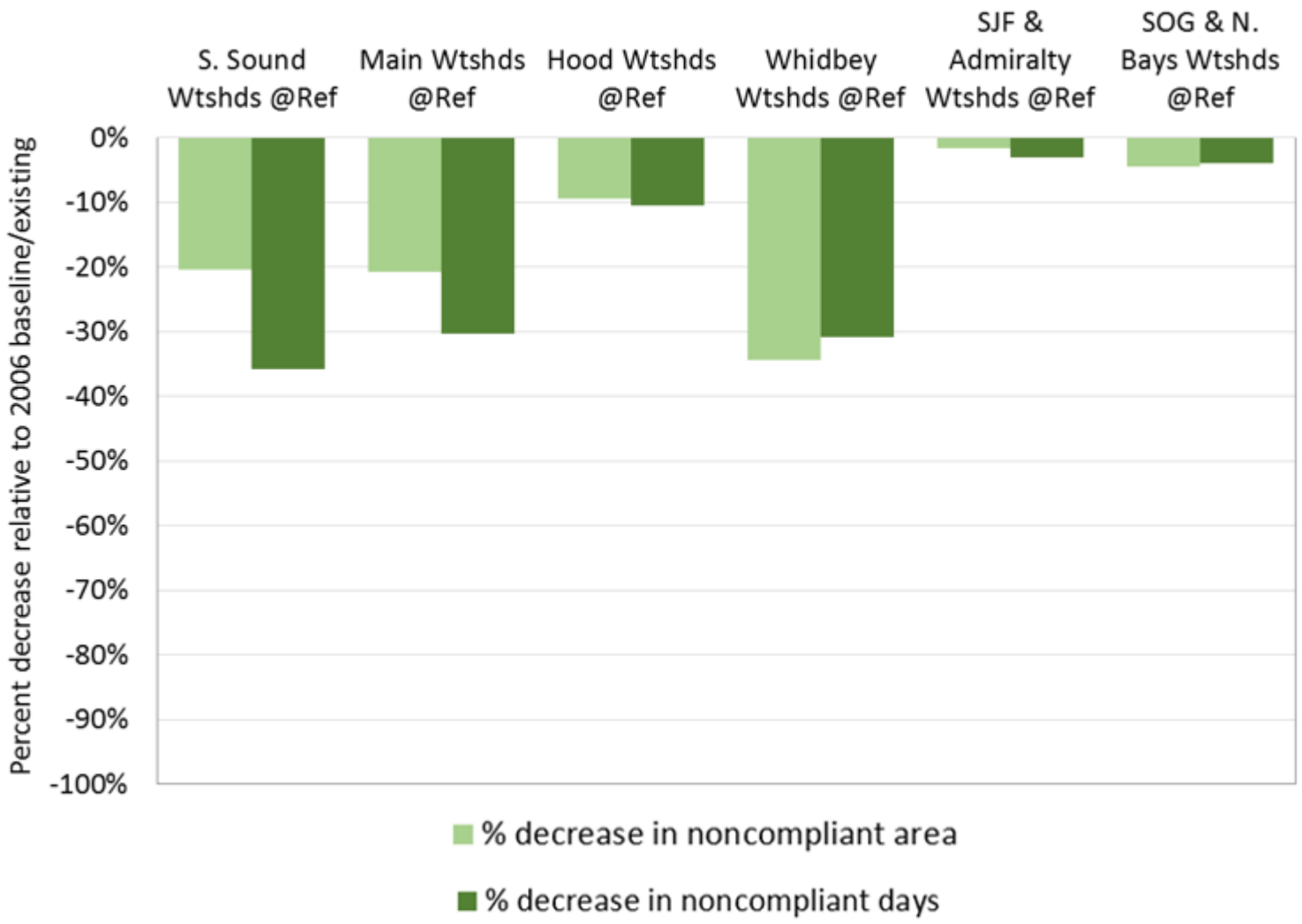
Whidbey Basin Watershed at Reference





Scenario 1 model runs (contd): Percent reduction in domain noncompliance (2006)

Domain = Washington waters



Estuaries and Coasts (2015) 38:735–753
DOI 10.1007/s12237-014-9853-y

Patterns of River Influence and Connectivity Among Subbasins of Puget Sound, with Application to Bacterial and Nutrient Loading

N. S. Banas · L. Conway-Cranos · D. A. Sutherland · P. MacCready · P. Kiffney · M. Plummer

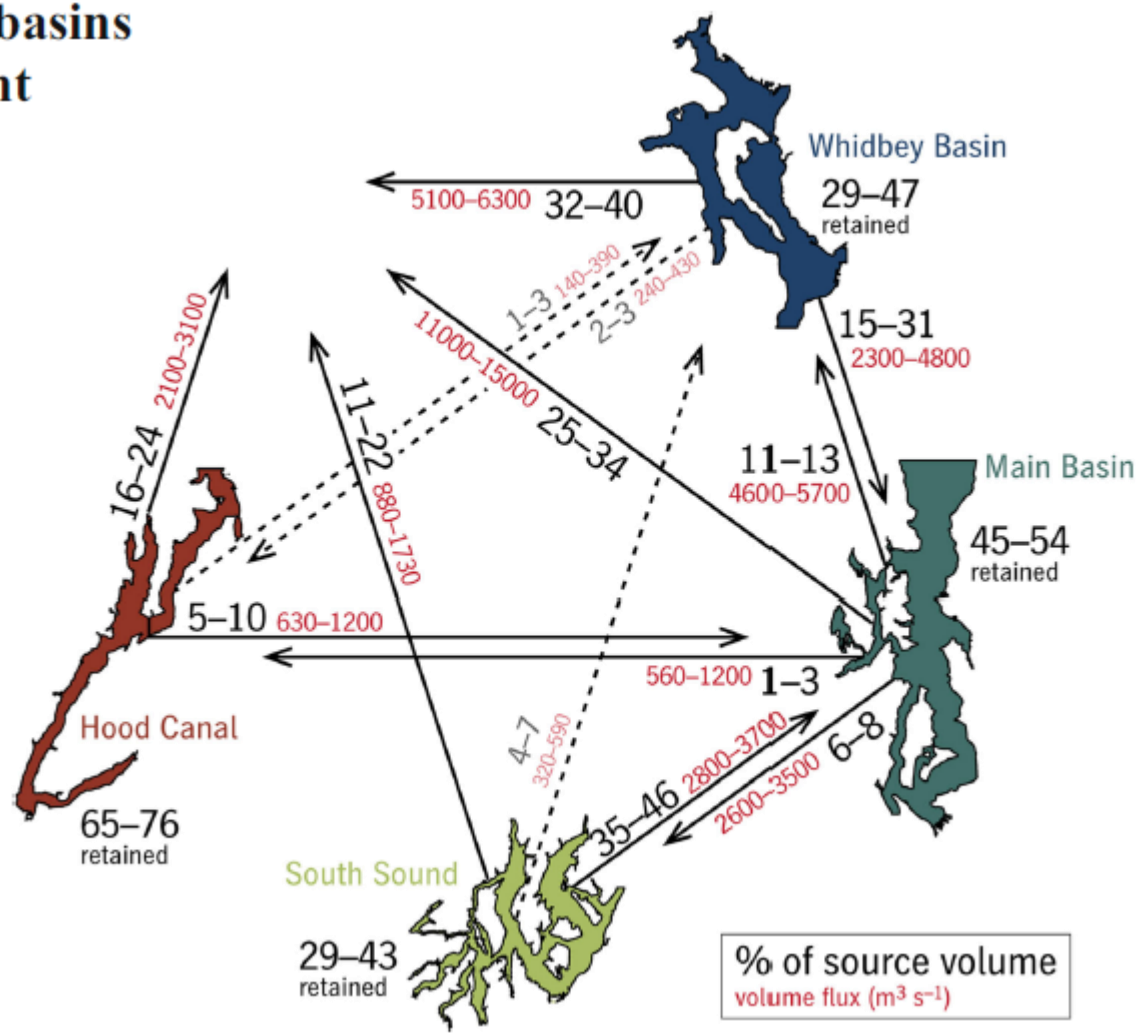
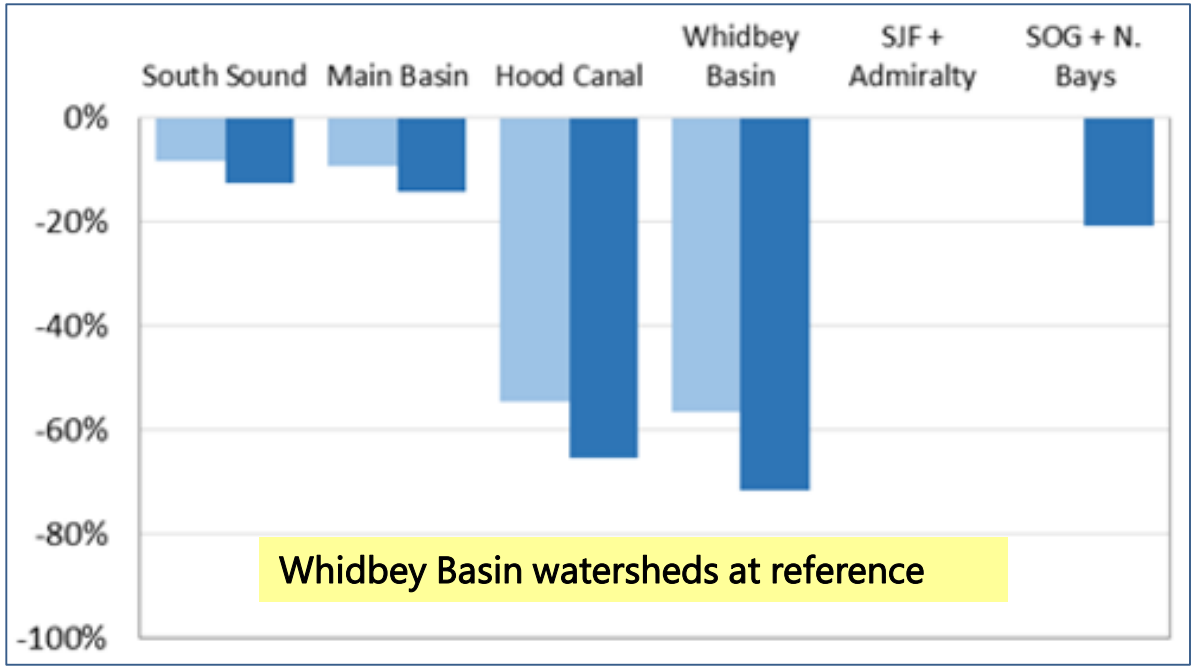
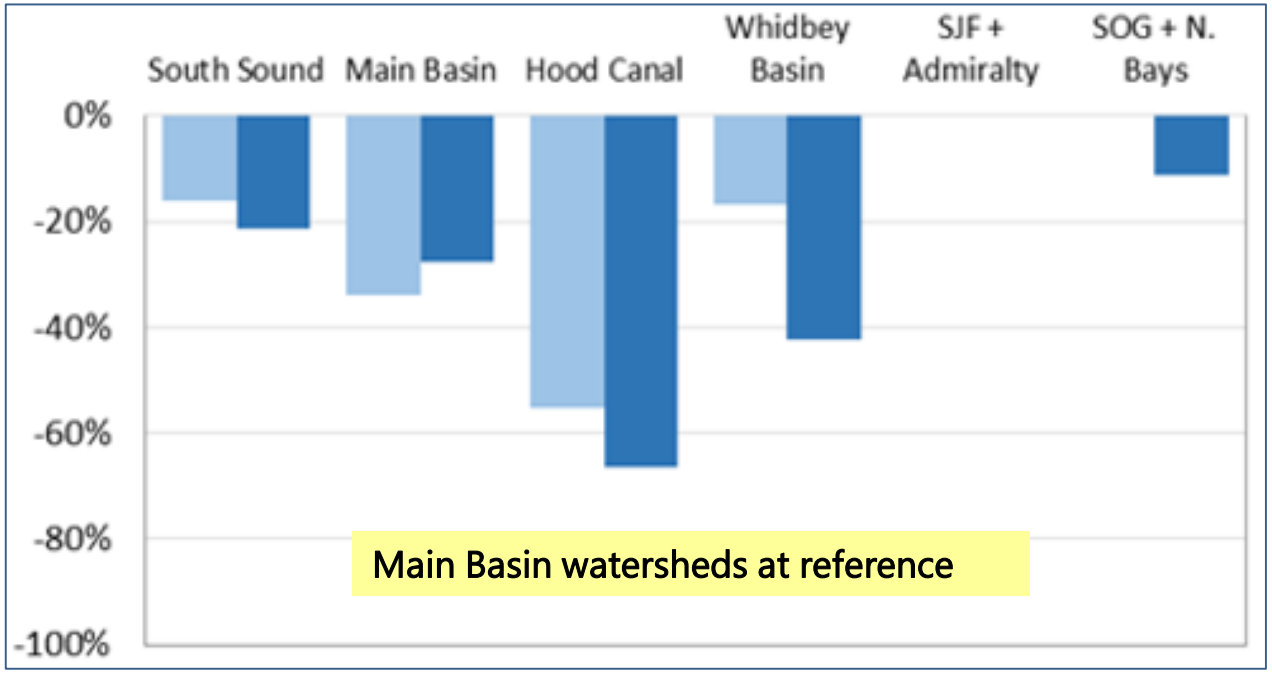
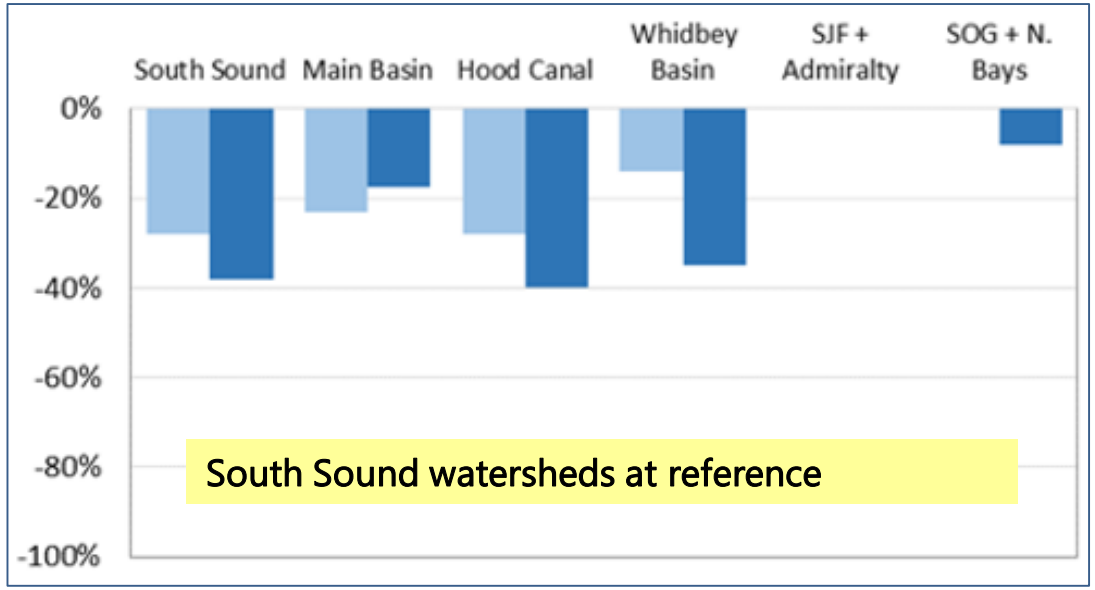


Fig. 4 Overall connectivity among four subbasins of Puget Sound. Percentages of the volume of each subbasin transported to each other subbasin over 20 days are shown in *black*; the same transports converted to volume flux in cubic meters per second are shown in *red*. Ranges show the maximum and minimum among monthly mean transports for 2006. Transports below 200 $m^3\ s^{-1}$ are omitted for clarity; transports below 800 $m^3\ s^{-1}$ are *grayed* and *dashed*. *Arrows* pointing outward (not toward a subbasin) represent the volume fraction found outside Puget Sound after 20 days

Scenario 1 model runs (contd): Percent reduction in regional noncompliance (2006)







% decrease in noncompliant area

% decrease in noncompliant days

Scenario 2: What is the relative influence of marine point source nutrient loads entering individual regions?

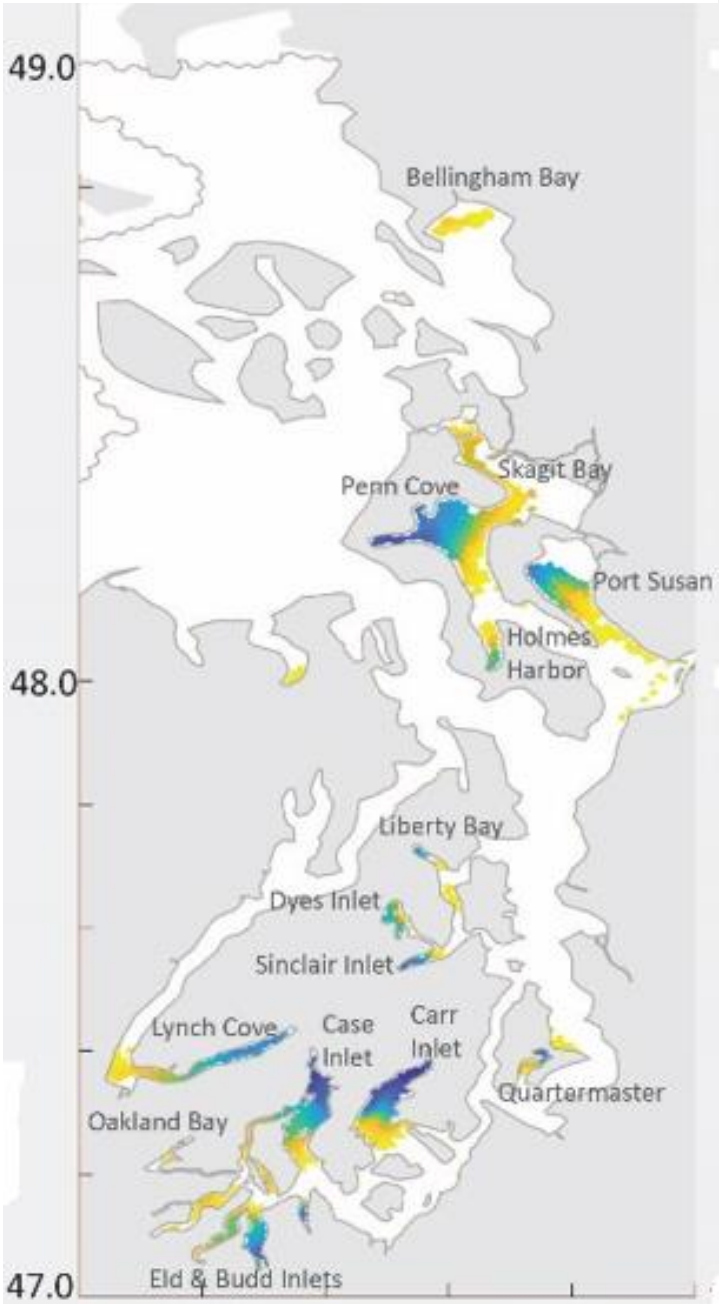
Approach:

1. All WWTPs in focus regions at reference conditions
2. WWTPs in all other regions at existing conditions
3. All watersheds in all regions at existing conditions

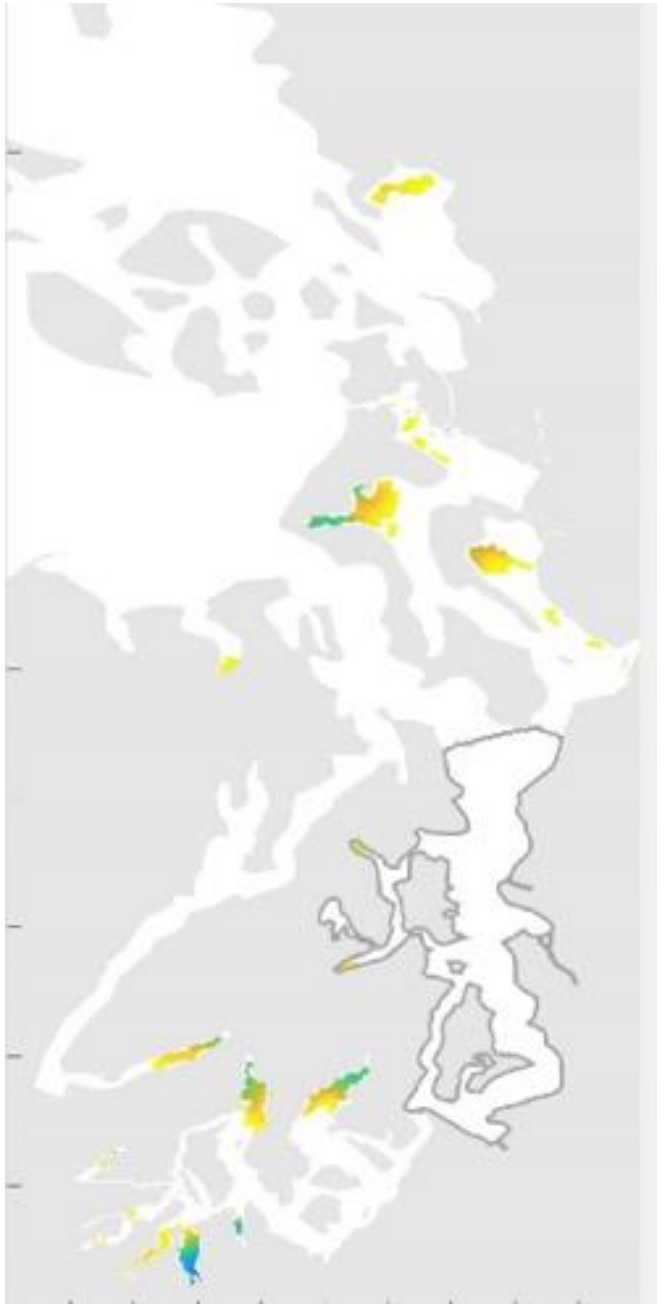
Scenario 2 loads 2006	TN Load (Kg/d)	TN Reduction	TOC Load (Kg/d)	TOC Reduction
Existing	56,323	n/a	198,341	0.0%
Scen2 Hood WWTPs	56,322	<0.01%	198,341	<0.01%
Scen2 Main WWTPs	27,437	51.3%	188,248	5.1%
Scen2 SJF & Admiralty WWTPs	55,973	0.6%	196,465	0.9%
Scen2 SOG & N. Bays WWTPs	54,718	2.8%	197,735	0.3%
Scen2 South Sound WWTPs	52,845	6.2%	197,853	0.2%
Scen2 Whidbey WWTPs	52,991	5.9%	194,023	2.2%

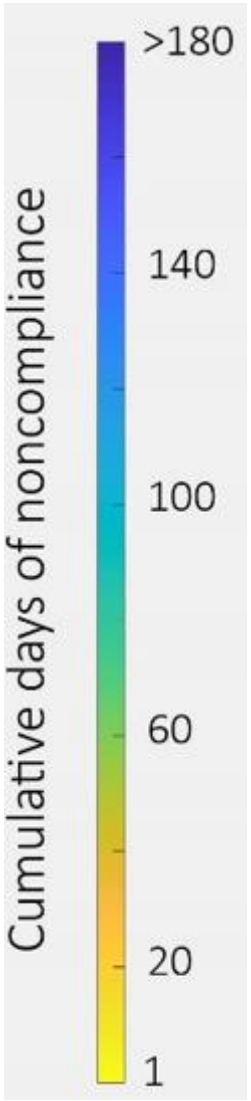
Scenario 2

2006 Existing



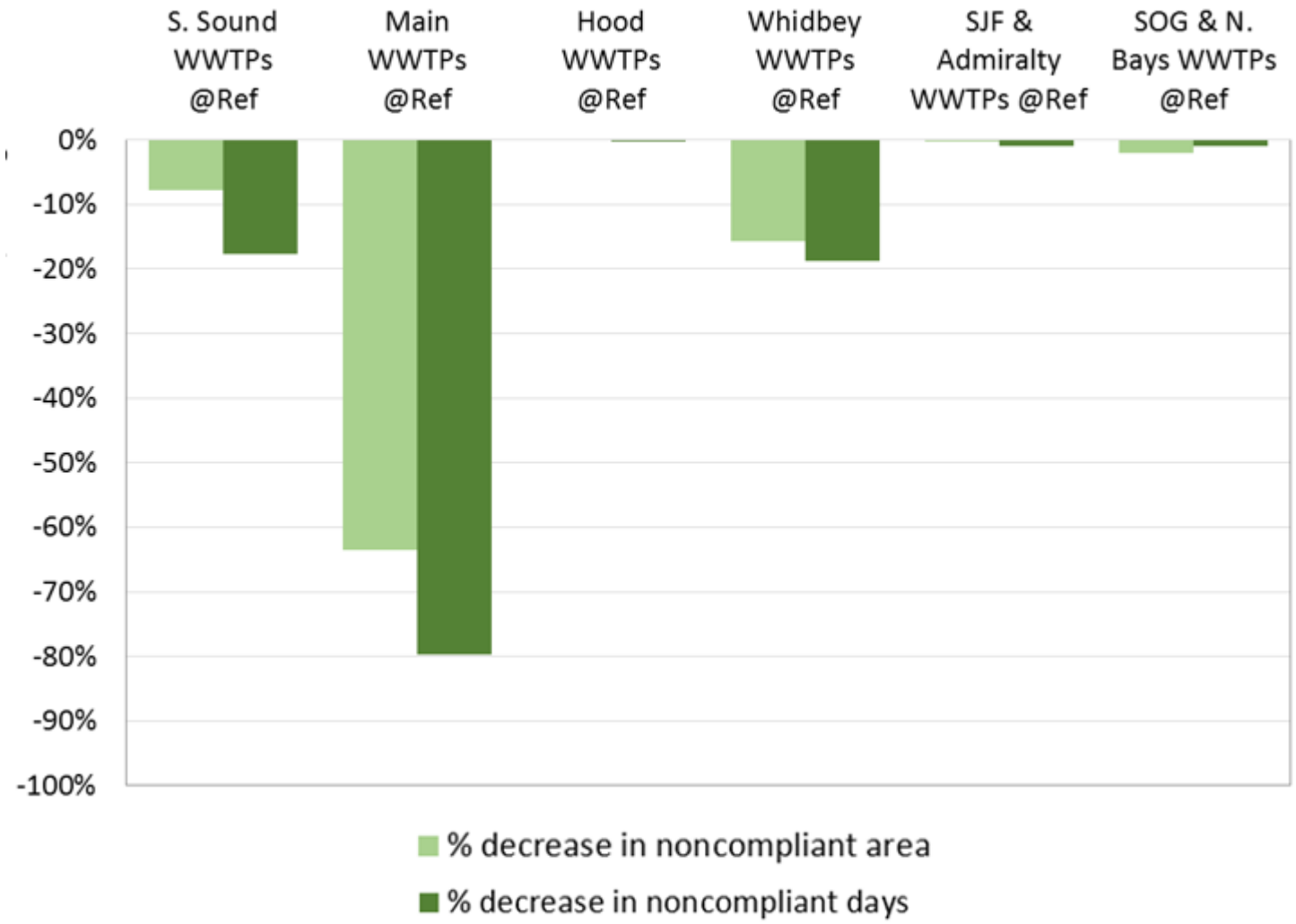
Main Basin WWTPs at Reference



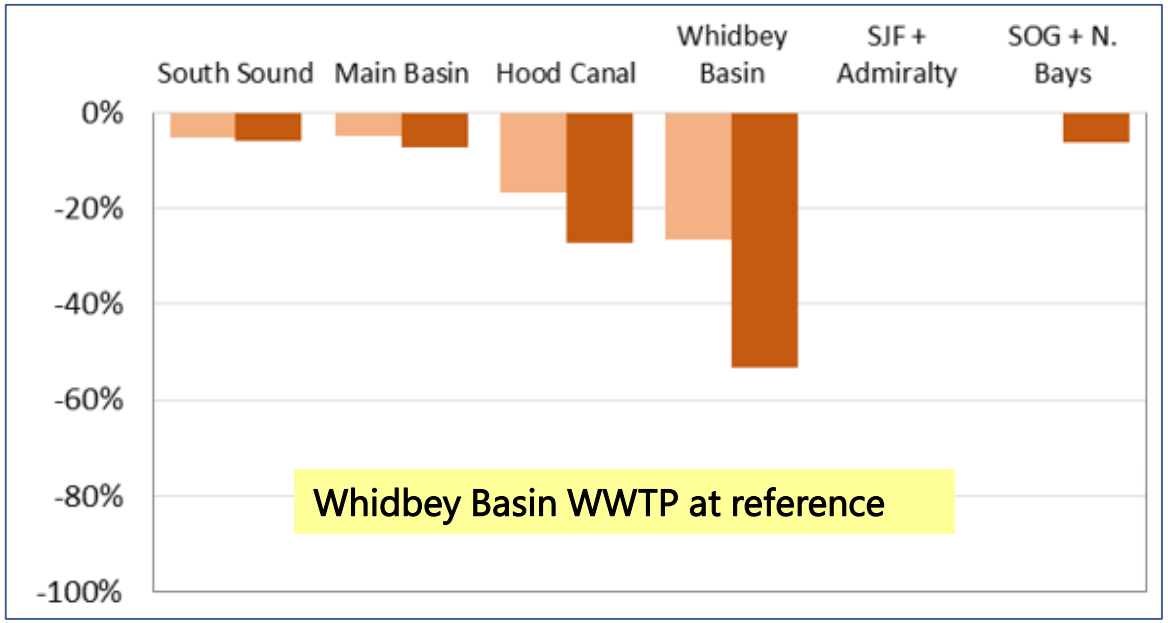


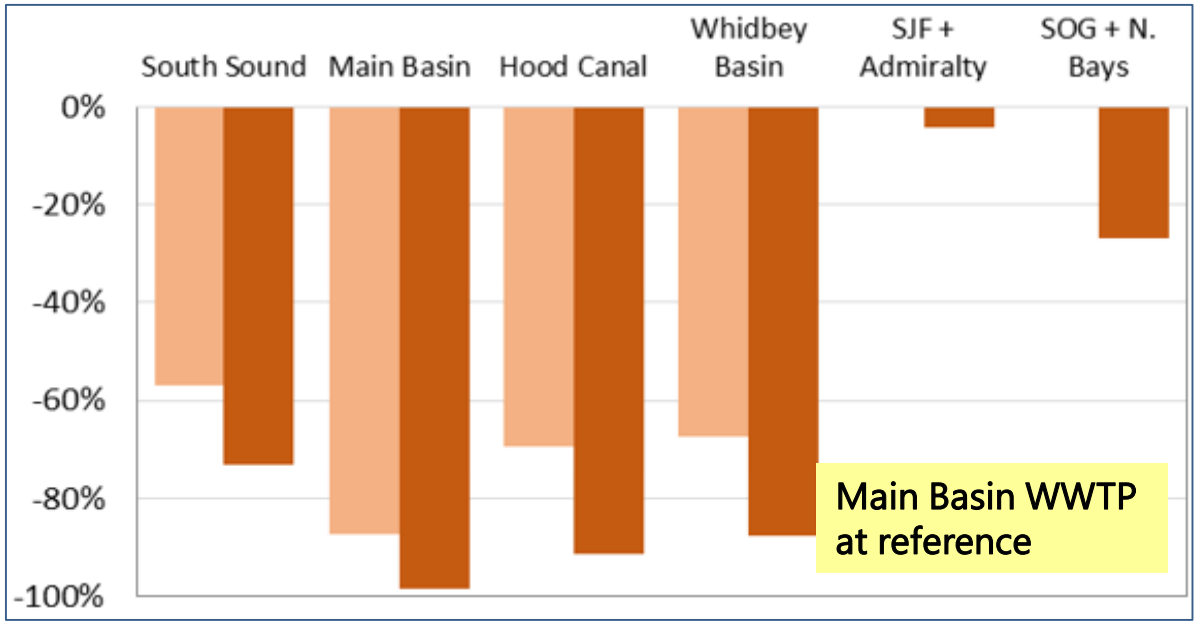
Scenario 2 model runs (contd): Percent reduction in domain noncompliance (2006)

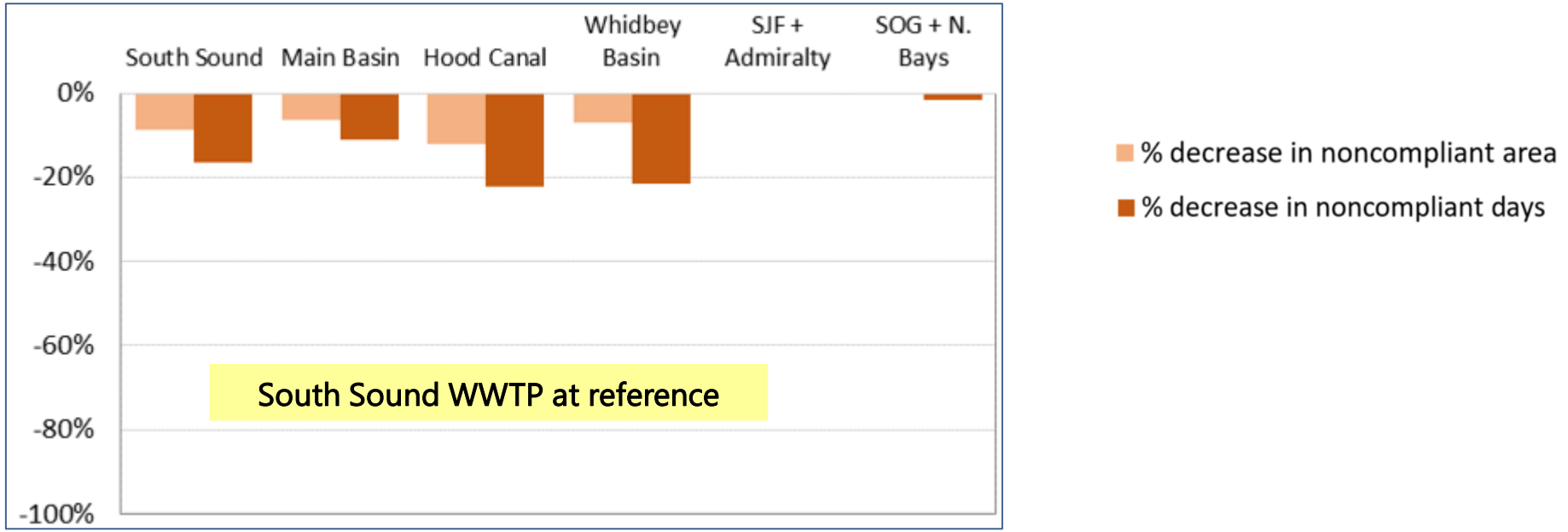
Domain = Washington waters



Scenario 2 model runs (contd): Percent reduction in regional noncompliance (2006)







Scenario 3: How do annual nutrient load reductions at WWTPs influence potential water quality improvements? How does it compare with seasonal nutrient reductions (Bounding Scenarios)

Approach:

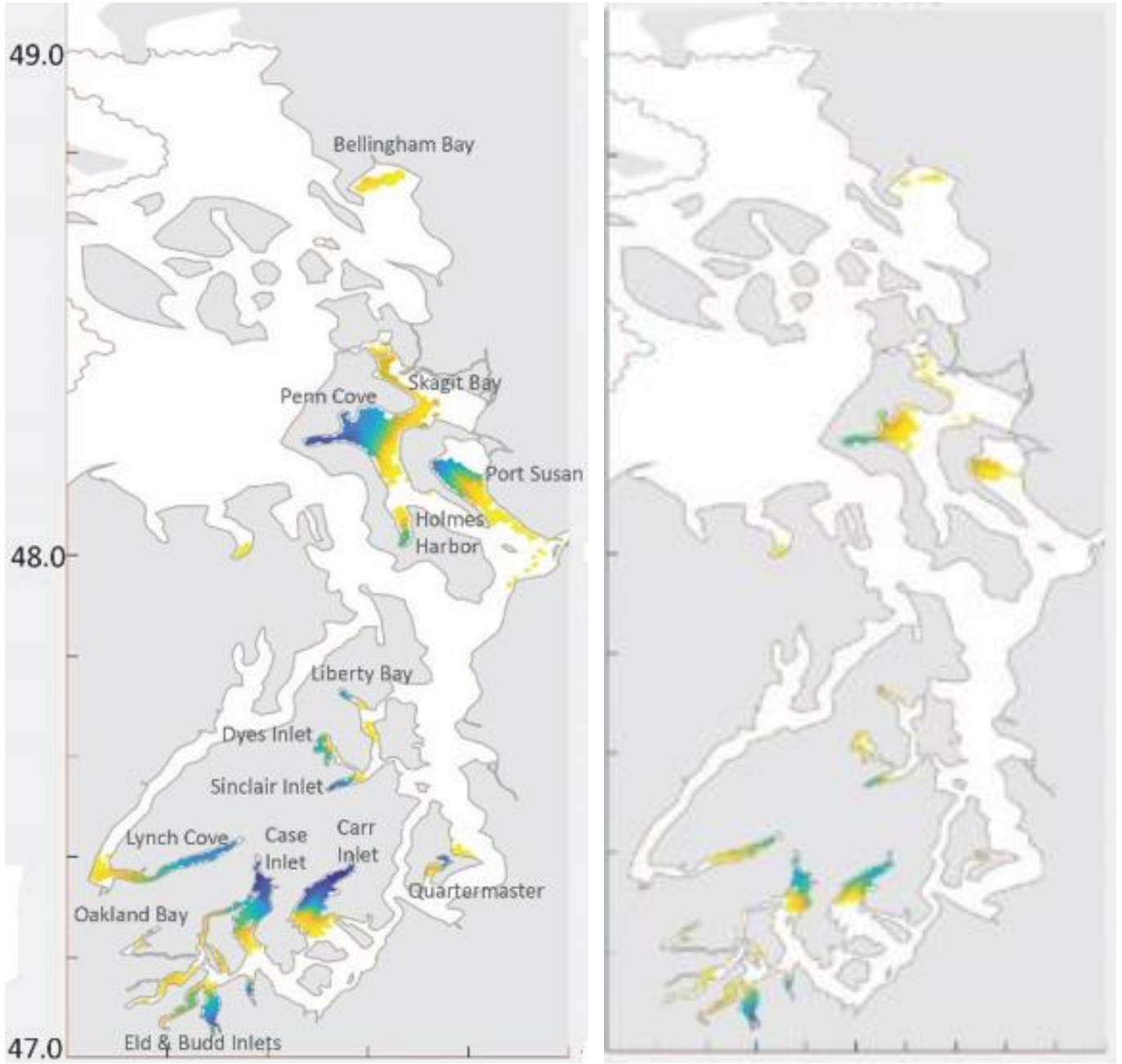
1. Set all WWTP in Washington waters to a BNR8 (DIN and $CBOD_5$ at 8 mg/L) through out the year
2. Compare the annual reductions with Seasonal reductions evaluated in Bounding Scenario Report

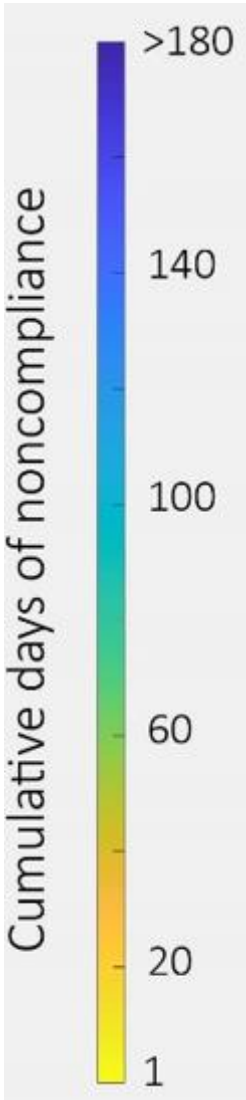
Scenario 3 and Bounding Scenario loads 2006	TN Load (Kg/d)	TN Reduction	TOC Load (Kg/d)	TOC Reduction
Existing	56,323	n/a	198,341	0.0%
Scen3 BNR8-All (annual)	35,137	37.6%	195,066	1.7%
BNR8-All (seasonal)	44,289	21.4%	196,683	0.8%
BNR8-1000 (seasonal)	46,667	17.1%	196,907	0.7%
BNR8-8000 (seasonal)	48,747	13.5%	198,090	0.1%

Scenario 3

2006 Existing

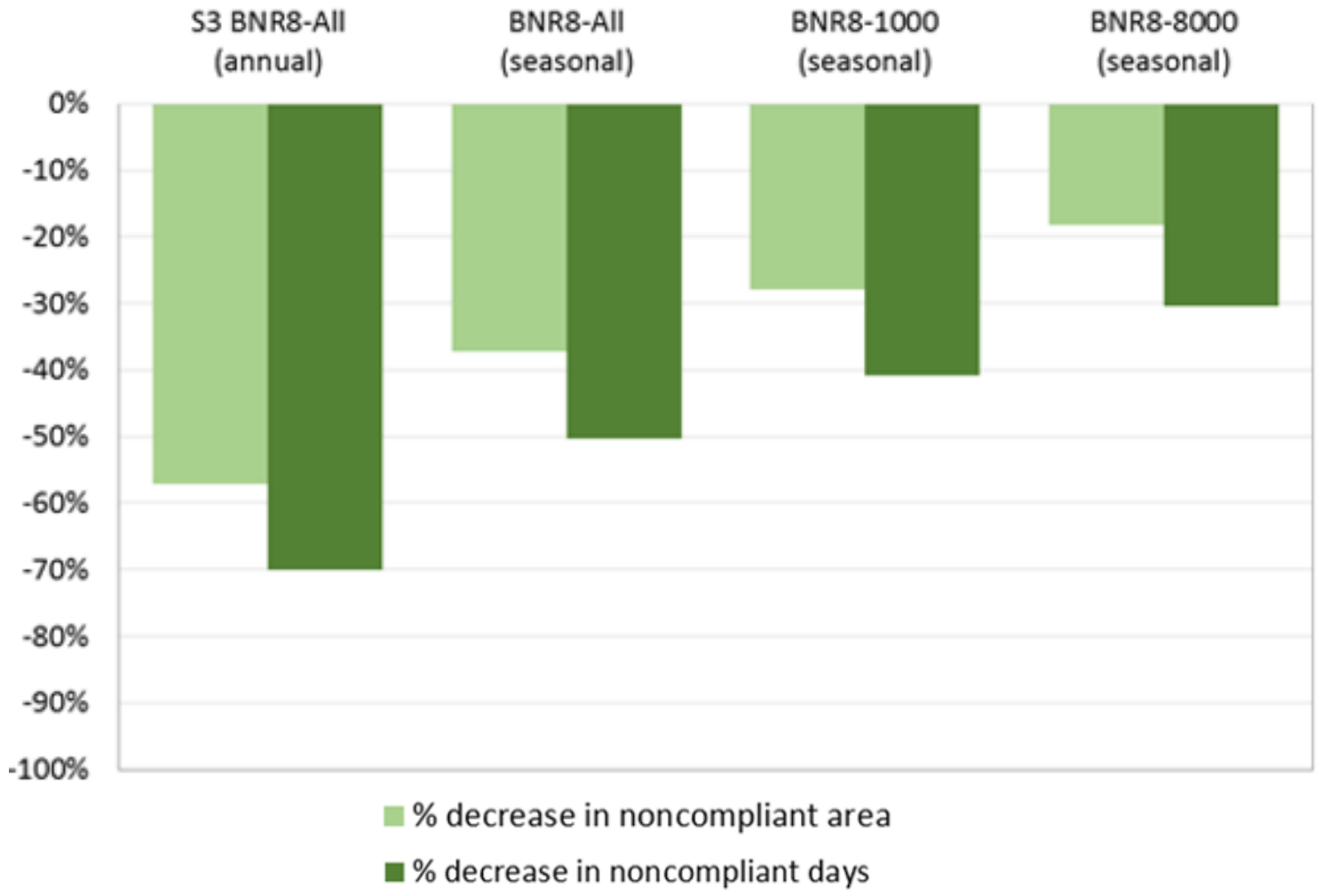
BNR8 applied annually to all WWTPs





Scenario 3 compared to Bounding Scenarios: Percent reduction in domain noncompliance (2006)

Domain = Washington waters



Scenario 5: What combination of watershed and marine point source nutrient load reductions are needed to meet DO standards in Puget Sound?

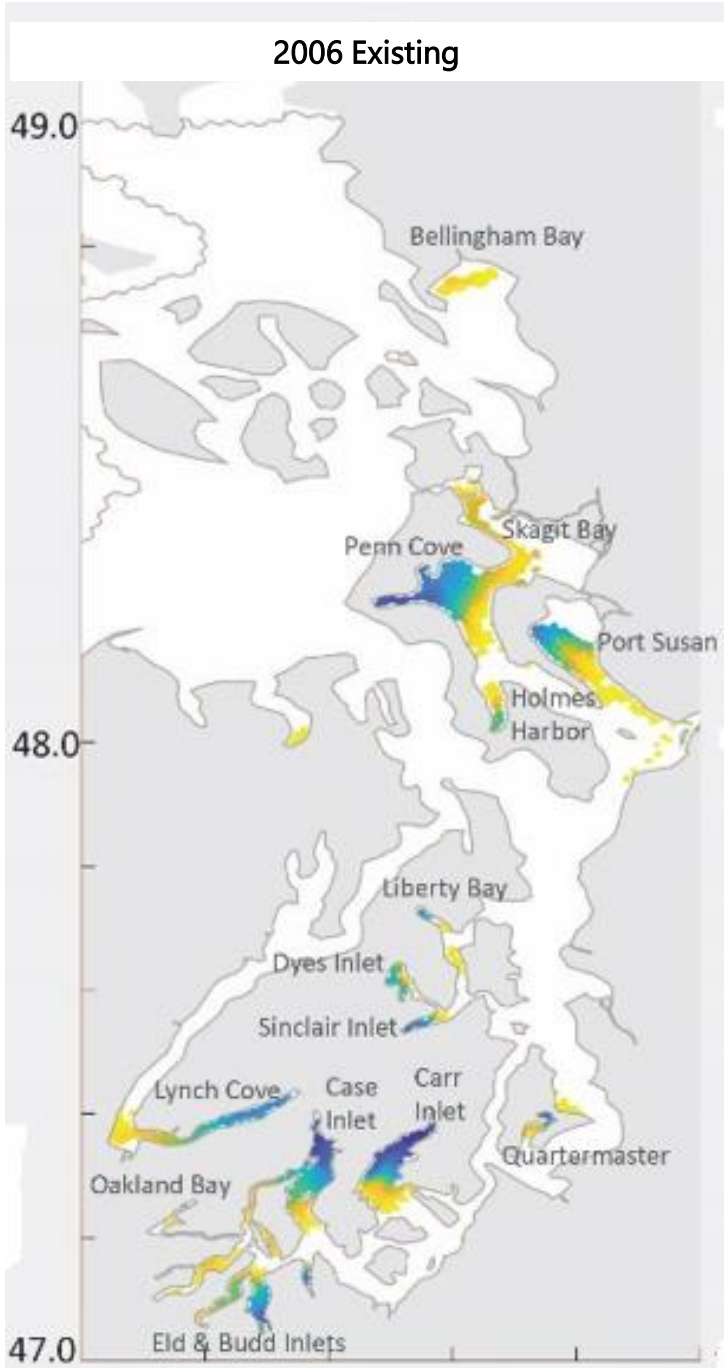
Approach:

1. Scen5a: 15% all watersheds BNR8 annual all WWTP
2. Scen5b: 40% all watersheds BNR8 annual all WWTP
3. Scen5c: 40% all watersheds with balanced BNR all WWTP
4. Scen5d: 40% all watersheds BNR3 annual all WWTP
5. Scen5e: 65% all watersheds BNR3 annual all WWTP

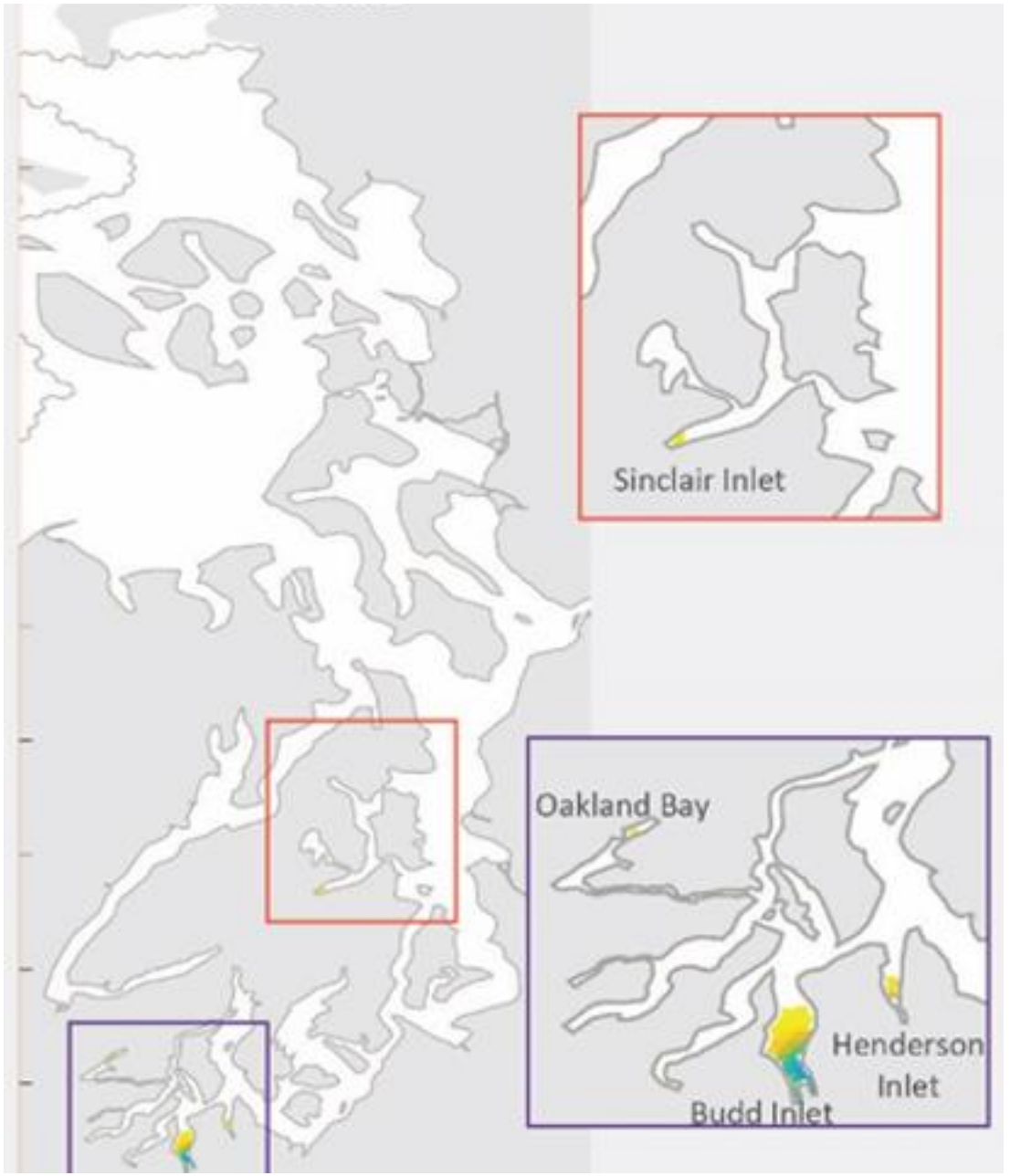
Scenario 5 loads 2006	TN Load (Kg/d)	TN Reduction	TOC Load (Kg/d)	TOC Reduction
Existing	56,323	n/a	198,341	0.0%
Scen5a 15% watersheds, BNR8	32,654	42.0%	167,378	15.6%
Scen5b 40% watersheds, BNR8	27,893	50.5%	122,299	38.3%
Scen5c 40% watersheds, BNR balanced	24,845	55.9%	122,299	38.3%
Scen5d 40% watersheds, BNR3	20,846	63.0%	122,299	38.3%
Scen5e 65% watersheds, BNR3	16,085	71.4%	77,220	61.1%

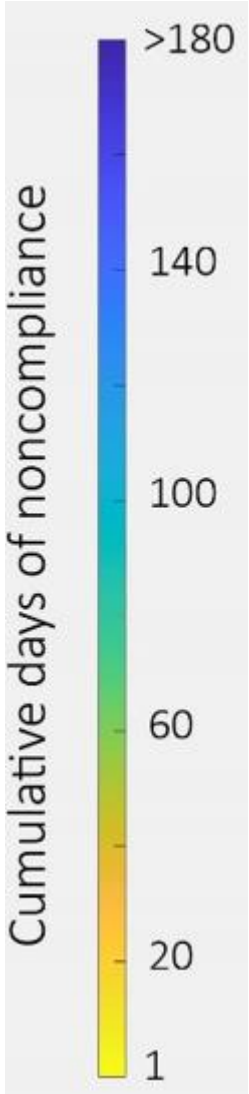
Scenario 5e

2006 Existing



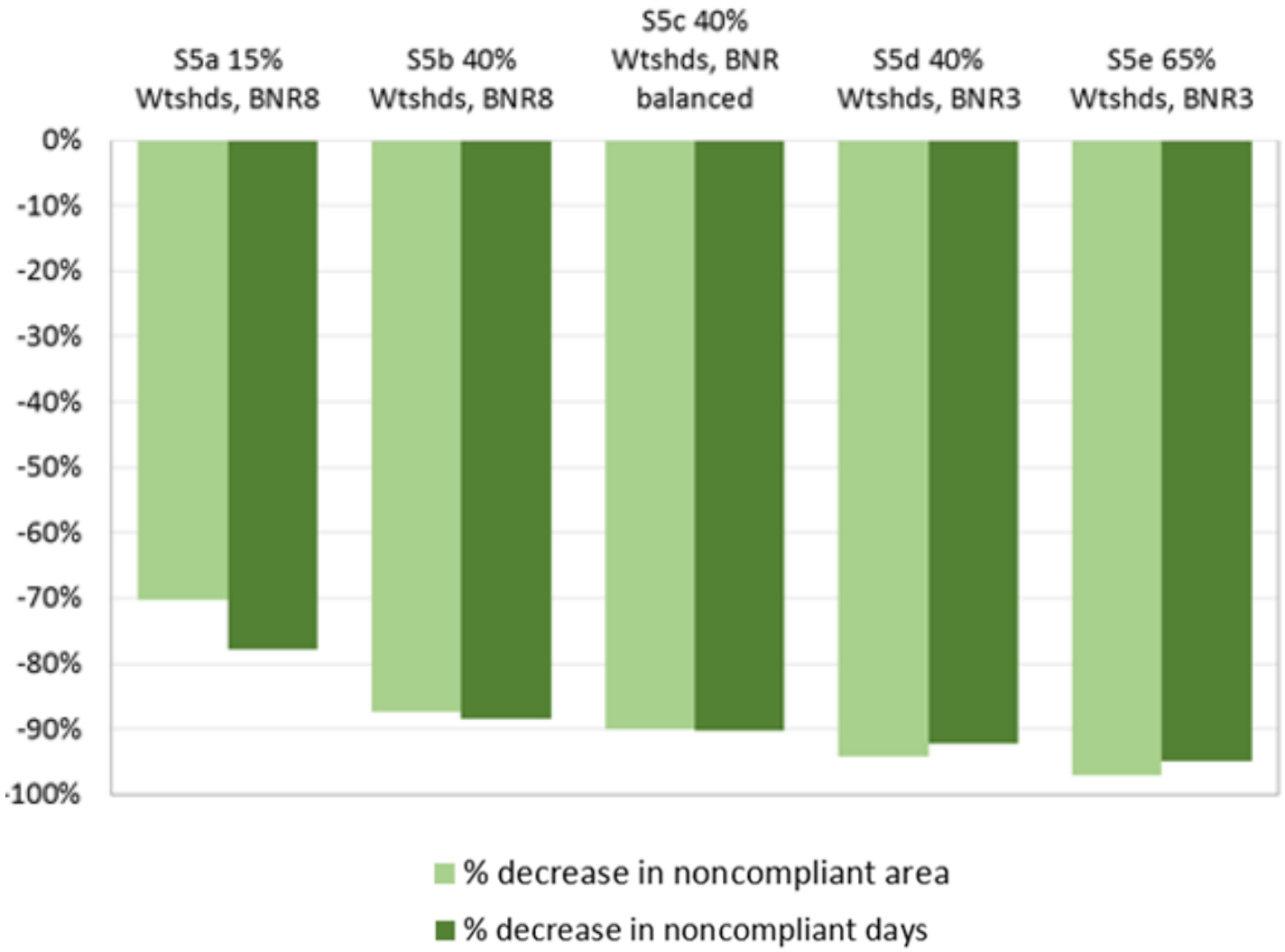
Scn5e: Watersheds at 65% reductions,
WWTPs at BNR3



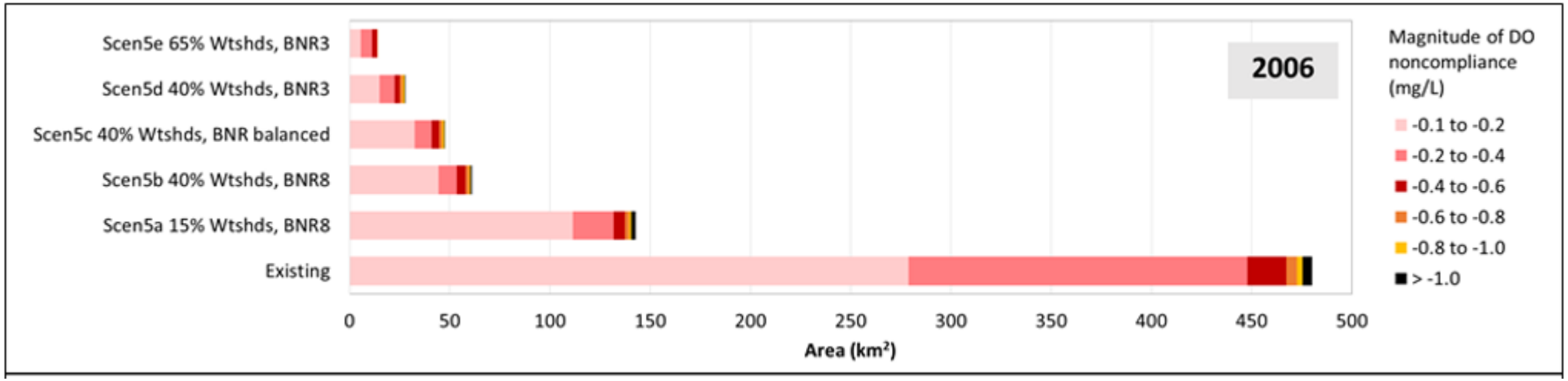


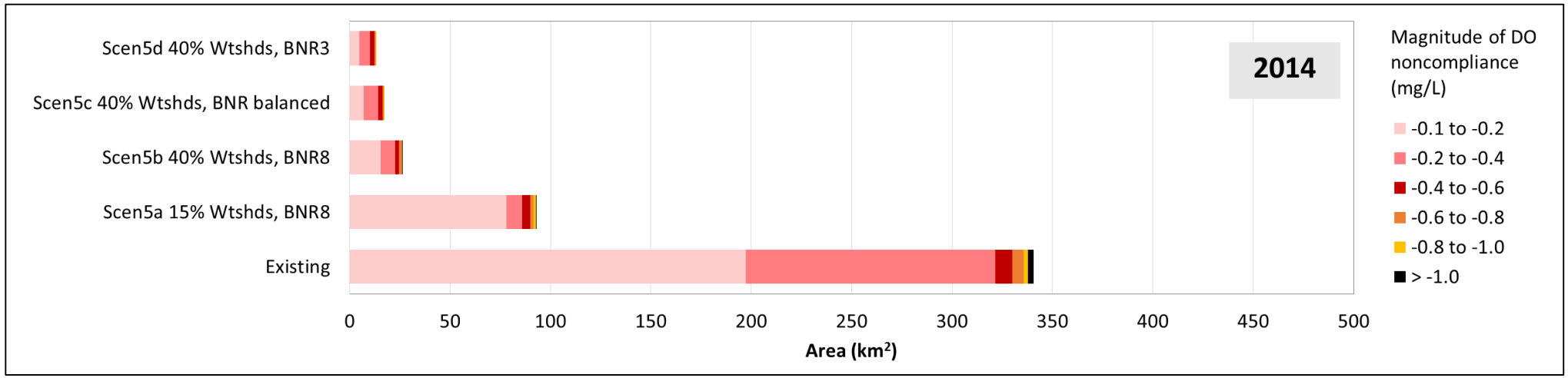
Scenario 5 model runs (cond.): Percent reduction in domain noncompliance (2006)

Domain = Washington waters



Area of predicted DO noncompliance in different noncompliance magnitude ranges in WA waters of the Salish Sea under existing and Scenario 5 alternatives in 2006 and 2014





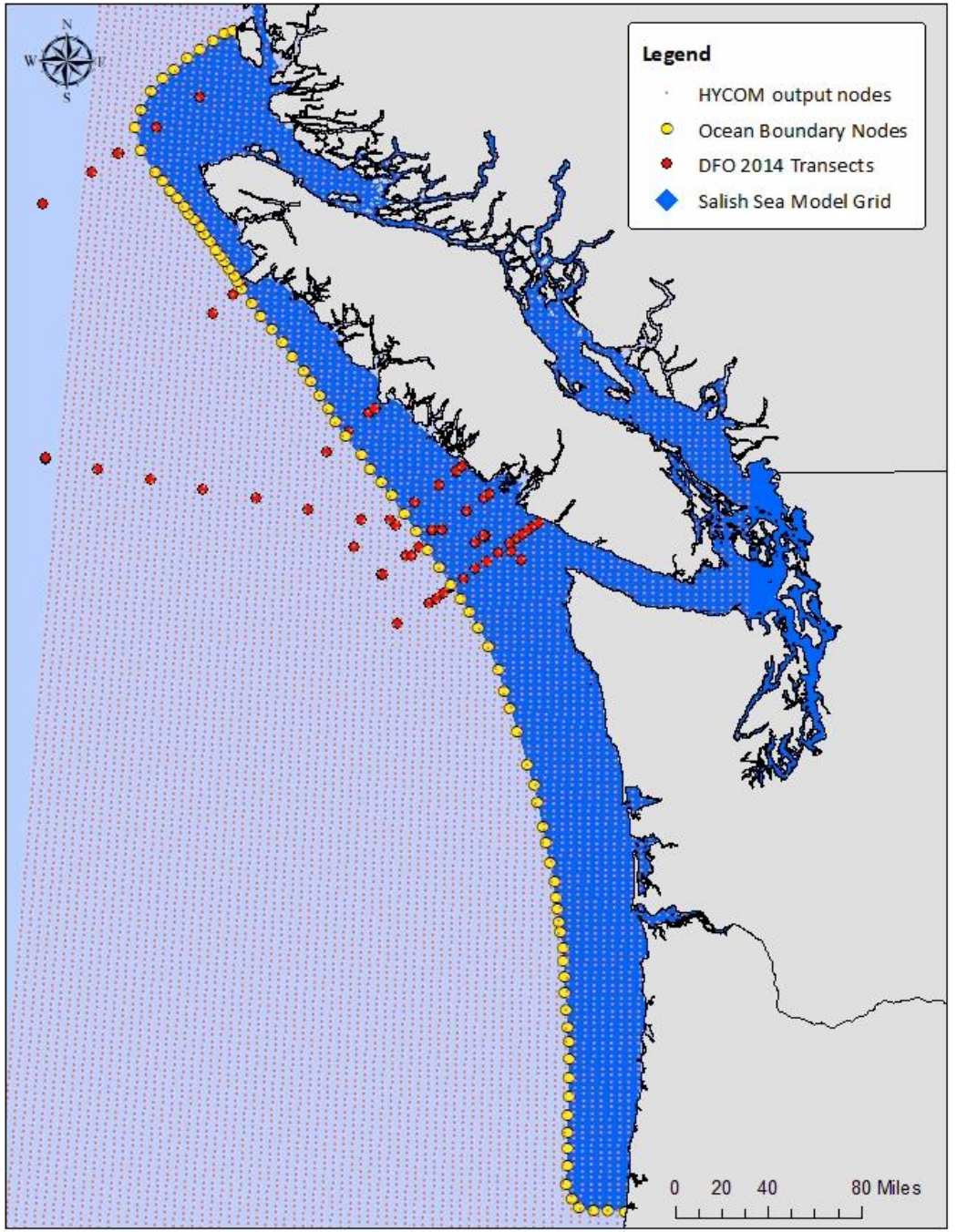
Highlights of SSM Application Updates

John Gala

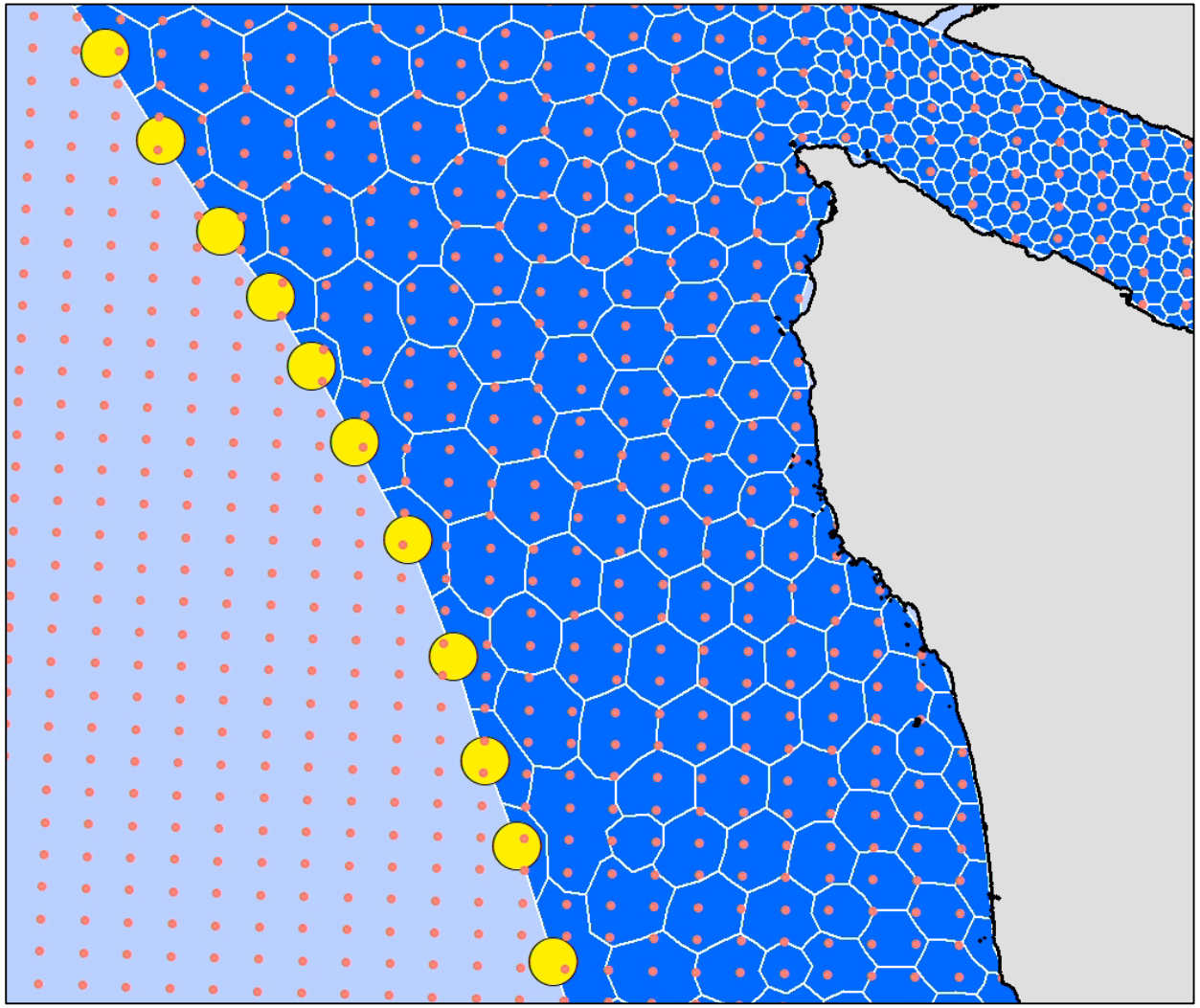
DEPARTMENT OF ECOLOGY
State of Washington

2014 Ocean Boundary Conditions

- Open Boundary Condition (OBC)
  - SSM has 87 OBC nodes.
- Hybrid Coordinate Ocean Model (HYCOM)
  - Better spatial and temporal resolution than Canada's Department of Fisheries and Oceans (DFO) data.
  - Native model variables include temperature and salinity, u and v velocity etc.
- Use of Observational Data
  - DFO data still used for other variables.



2014 Ocean Boundary Conditions

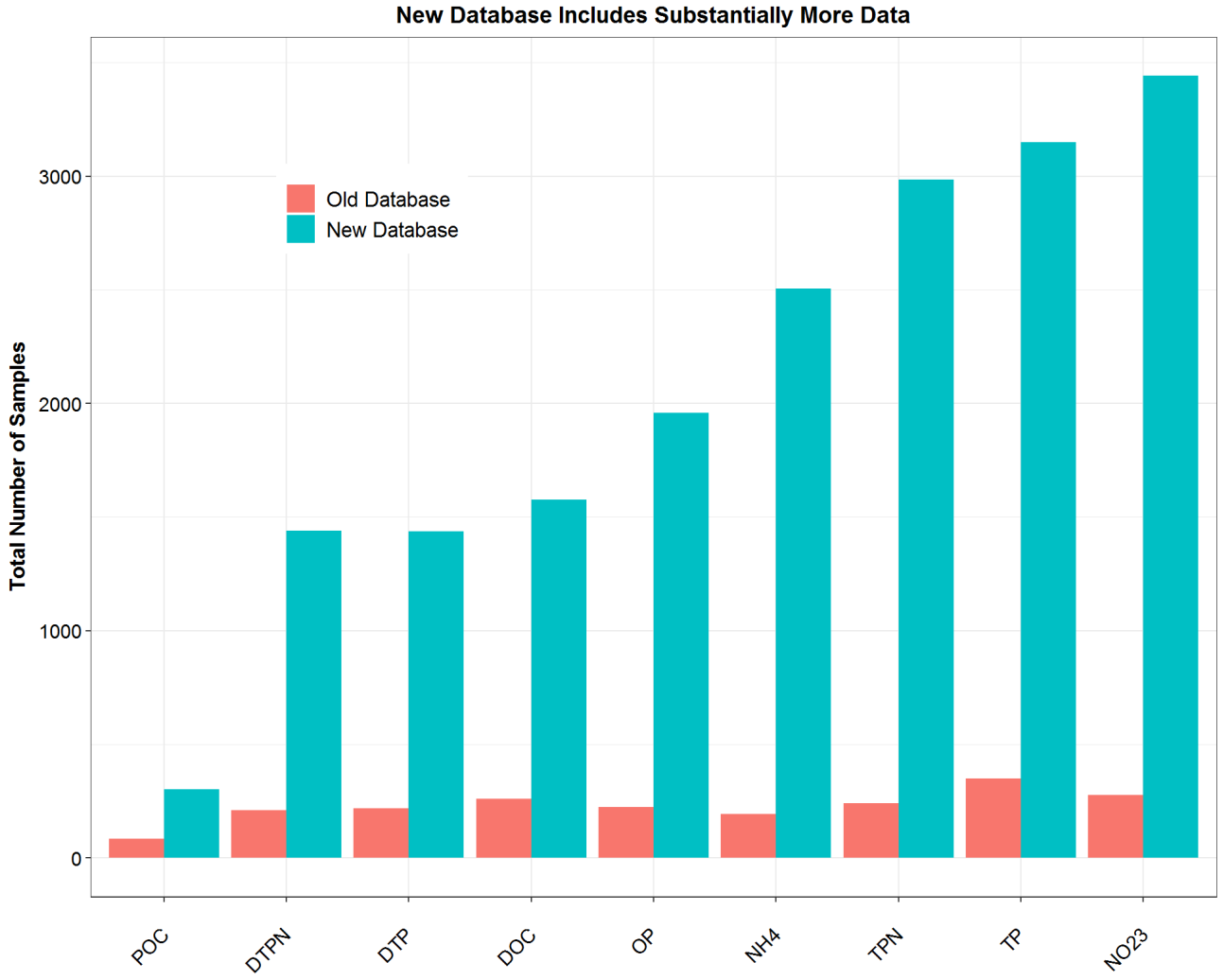


Legend

- HYCOM output nodes
- Ocean Boundary Nodes
- Salish Sea Model Grid

- For more detail see (Ahmed et al. 2021 Appendix D)

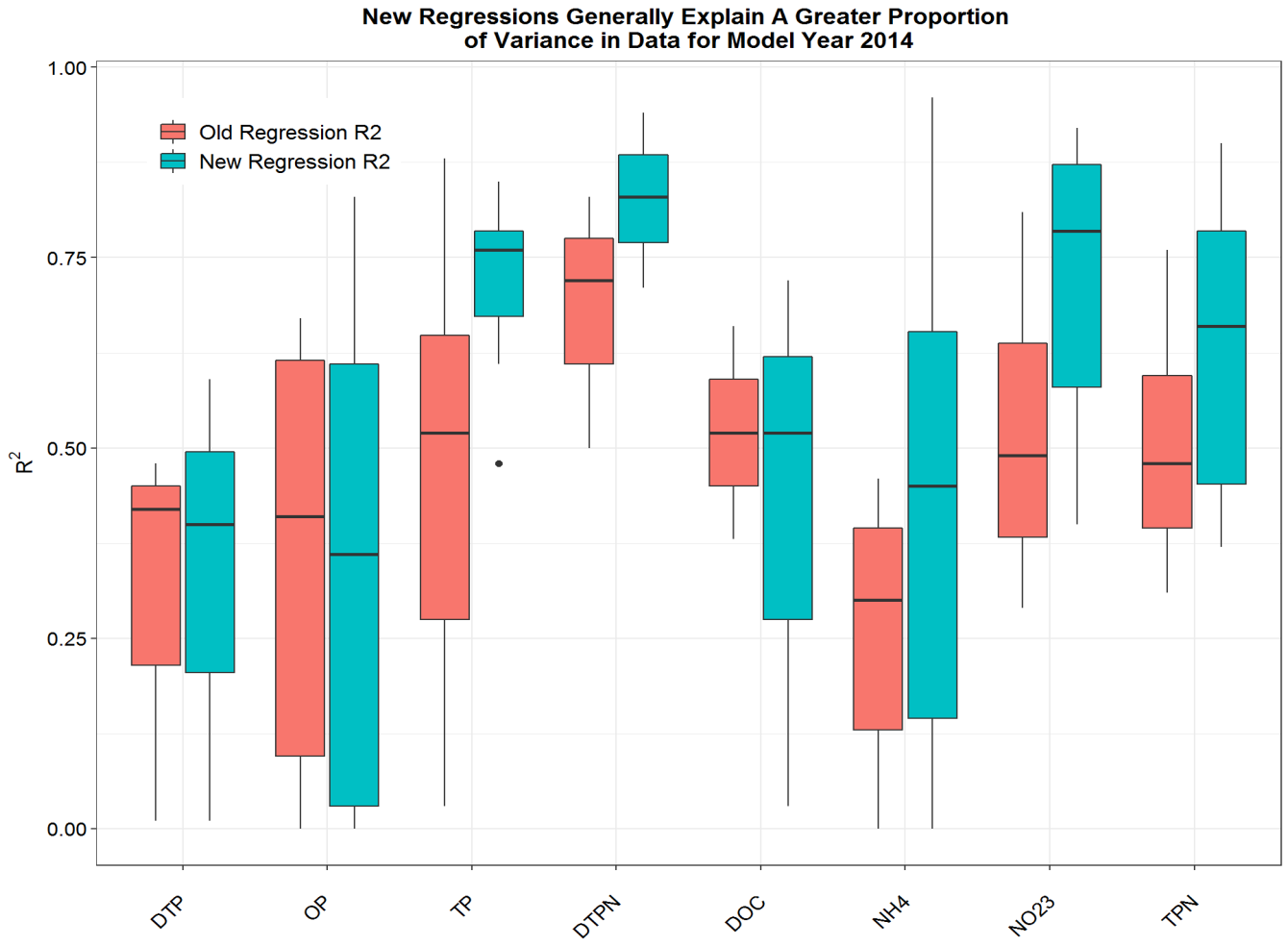
Updated Data Used in Watershed Regressions



- Previous freshwater database primarily utilized 2006/2007 data listed in (Mohamedali et al. 2011).
- New database includes data from Ecology's Environmental Information Management database and Environment Canada freshwater data from 2006-2018.

Updated Watershed Regressions

- Model Year 2014
  - Regressions fit with 2006-2018 dataset using methods described in (Mohamedali et al. 2011 and Ahmed et al. 2021 Appendix A).
- Model Year 2006
  - Updated POC/DOC Regressions used for:
    - Duckabush
    - Nooksack
    - Samish
    - Snohomish
    - Stillaguamish



Potential Further Work

- Continue to explore ways to improve ocean boundary conditions.
- Continue to acquire freshwater observations to estimate watershed inputs.
- Continue to consider available watershed model data that can be used to estimate watershed inputs.

Questions?

Links:

- Optimization Scenarios (Year 1) Technical Memo
- YouTube video of SSM Optimization Scenarios Web Map
- SSM Optimization Scenarios Web Map
- SSM model downloadable files

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Year 1 Take Home Findings

Both WWTP and watershed nitrogen reductions are needed to improve DO in Puget Sound and its resiliency to stress from ocean and climate drivers.

- The effect of watershed nutrient reductions varies depending on the regions they discharge to
- WWTPs nitrogen load reductions can do the most to improve marine DO

As our region's population grows, the noncompliant area is projected to grow larger and total noncompliant days would increase if we continue do nothing.

Optimization Year 2: source combo scenarios

Objectives:

- Identify the range of total load reductions for each basin that meet marine DO standards
- Test improvements by emphasizing load reductions in regions and source categories with the greatest impact
- Better understand flexibility (or not) for alternative spatial and temporal distributions of nitrogen loads while still attaining standards

Model Information Available Online

- www.ecology.wa.gov/SalishSeaModel
- Webmap Tools
  - Bounding Scenarios https://waecy.maps.arcgis.com/apps/webappviewer/index.html?id=2a5d5e519a9d40df8a88f6910786c51f
  - Year 1 Optimization Scenarios https://waecy.maps.arcgis.com/apps/webappviewer/index.html?id=c7318e19bf3141aca62e980a7e5b53f2
- Model Input Files
  - Bounding Scenarios &Year 1 Optimization Scenarios
  - https://fortress.wa.gov/ecy/ezshare/EAP/SalishSea/SalishSeaModelBoundingScenarios.html

Nutrient Reduction Grant Update

Jeff Nejedly

Questions?

Please type your question in the chat box to “all panelists.”

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Thank You!