California's Surface Water Ambient Monitoring Program

A New Tool for Water Quality Assessment -Algae as Bioindicators

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California Water Boards

SWAMP Surface Water Ambient Monitoring Program

Outline

1. Introduction (bioassessment, algae, bioindicators, index of biotic integrity, and nutrient numeric endpoints)
2. The Algae Plan
3. Status of the Algae Program in CA

- Current Programs
- Standard Operating Procedures (SOP)
- Laboratory Analysis of Stream Algae
- Taxonomic Group
- Quality Assurance and Quality Control
- SWAMP Database Modules for Algae
- Grants and preliminary data

4. Next Steps

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1. Introduction - Bioassessment

- Biological Assessments ("Bioassessment") are an evaluation of the biological condition of a waterbody using the resident biota in surface waters
- Biological assessments play a key role in California's water quality programs (integrate over times, reflect overall ecological integrity)
- In the past, SWAMP focused the bioassessment studies on benthic macroinvertebrates

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1. Introduction – Algae as Bioindicators

- USEPA recommends using multiple biological communities for bioassessment
- Algae could be used as a 2nd bioindicator, providing multiple lines of evidence
- Of the common bioindicators, algae are most directly responsive to nutrients
- Algae can colonize any stream substratum, thus applicable in diverse range of stream types
- Algae respond rapidly to changes in environment
  - Detect changes on a shorter temporal scale than other bioindicators
  - May be applicable in shorter-lived systems (e.g. ephemeral streams)

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Algae in Southern CA streams

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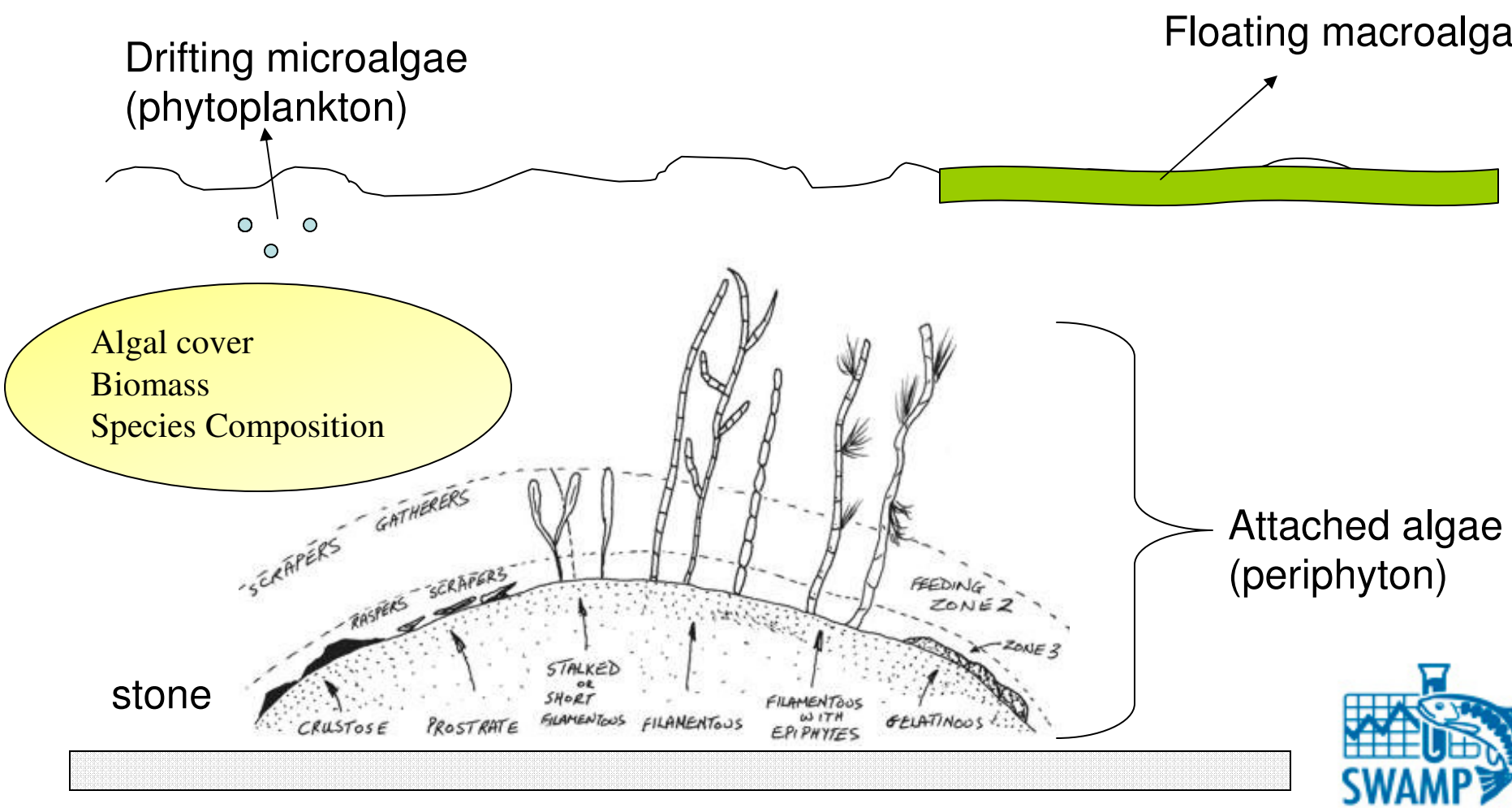
1. Introduction – Algae



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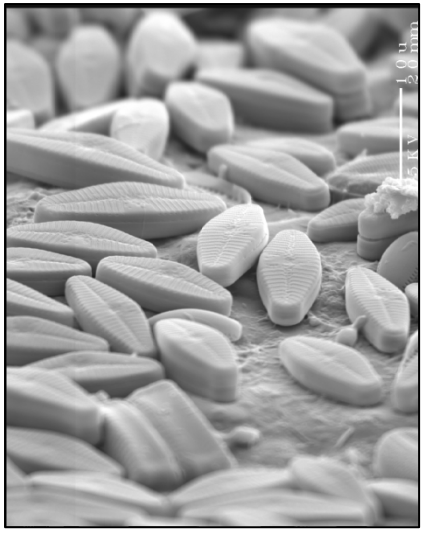
1. Introduction - Diatoms

- Diatoms have a silica cell wall
- Most important group of benthic algae (90%)
- Known to response to environmental conditions like *nutrients, organic pollution, acidification, salinity*
- simple sample method (scraped from substrate)
- Identification to the species level possible in each stage (species identification difficult)



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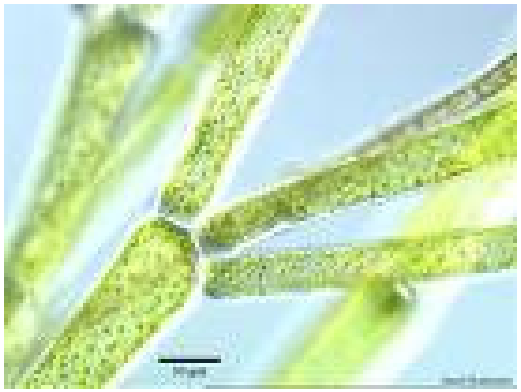
1. Introduction – Soft Algae

- Mostly blue-green algae (cyanobacteria), green algae, and red algae
- Tend to be more patchy than diatoms
- More difficult to sample than diatoms (e.g. Cladophora)
- More difficult to count
- Difficult to identify to species level
- Green algae are the “nuisance algae”
- Blue-green algae can be produce toxins → potential danger



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1. Introduction - Algae Index of Biotic Integrity (IBI) and nutrient numeric endpoints (NNE)

as diagnostic tool
→ algae index of biotic integrity
(key indicator: species)

as secondary indicators
→ for nutrient numeric endpoints
(key indicator: biomass)

Algae Index of Biotic Integrity is based on multiple metrics

↓

Combine in a single score

↓

Score sites based on IBI

(*or index of eutrophication, organic pollution, siltation*)

stressors →biological endpoints →beneficial use impairment

Nutrients → *Algal biomass* → *benthic community*
dissolved oxygen *odor/aesthetics*

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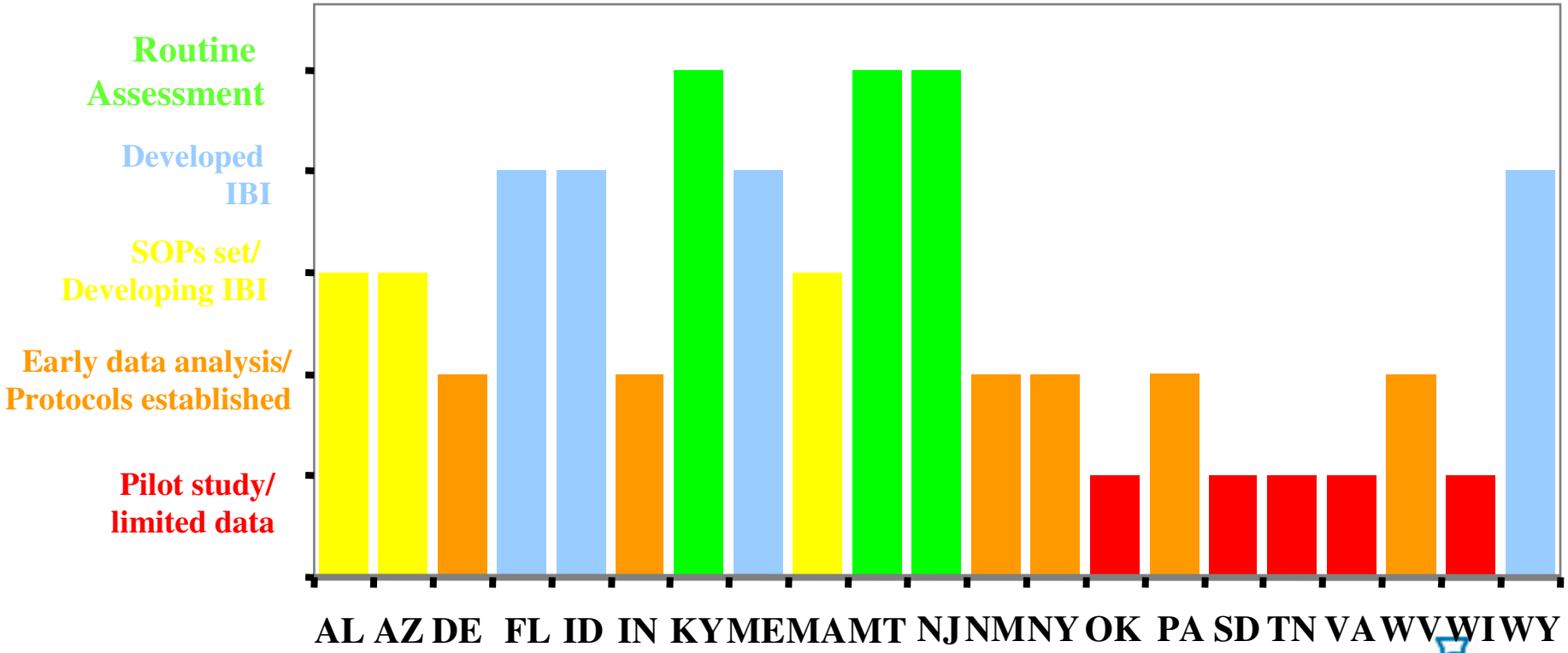
1. Introduction – algae bioassessment in other states



(McLaughlin & Fetscher, 2008)

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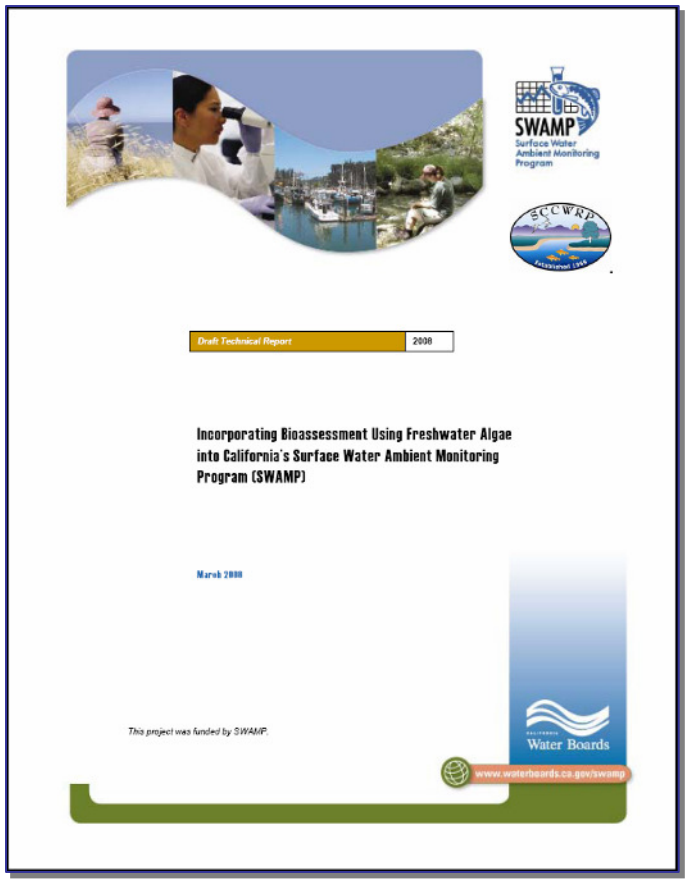
2. The Algae Plan



Incorporating Bioassessment Using Freshwater Algae into California's Surface Water Ambient Monitoring Program (SWAMP)

May 2008

Available at the SWAMP website
Reports/Statewide/Bioassessment

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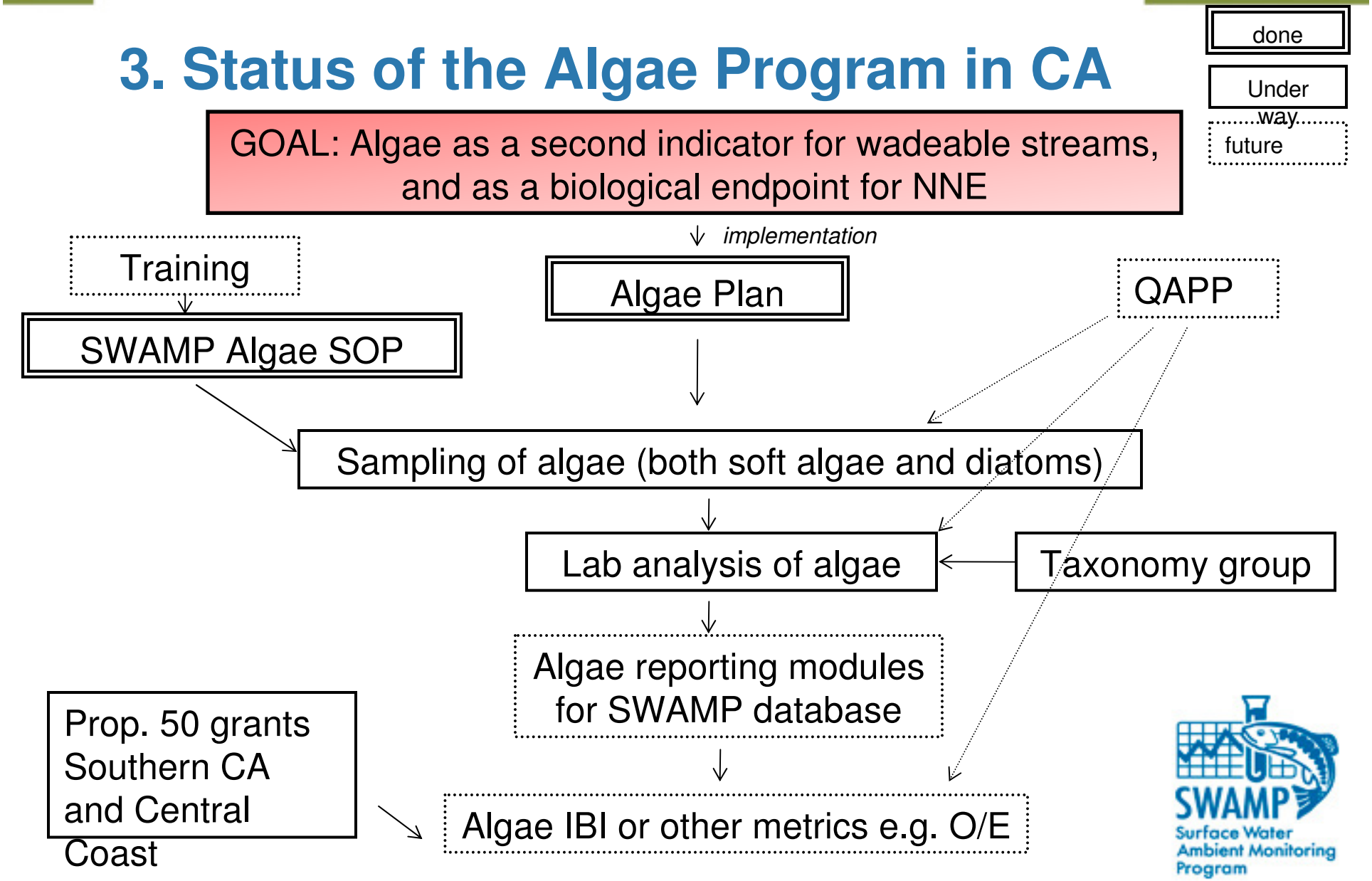

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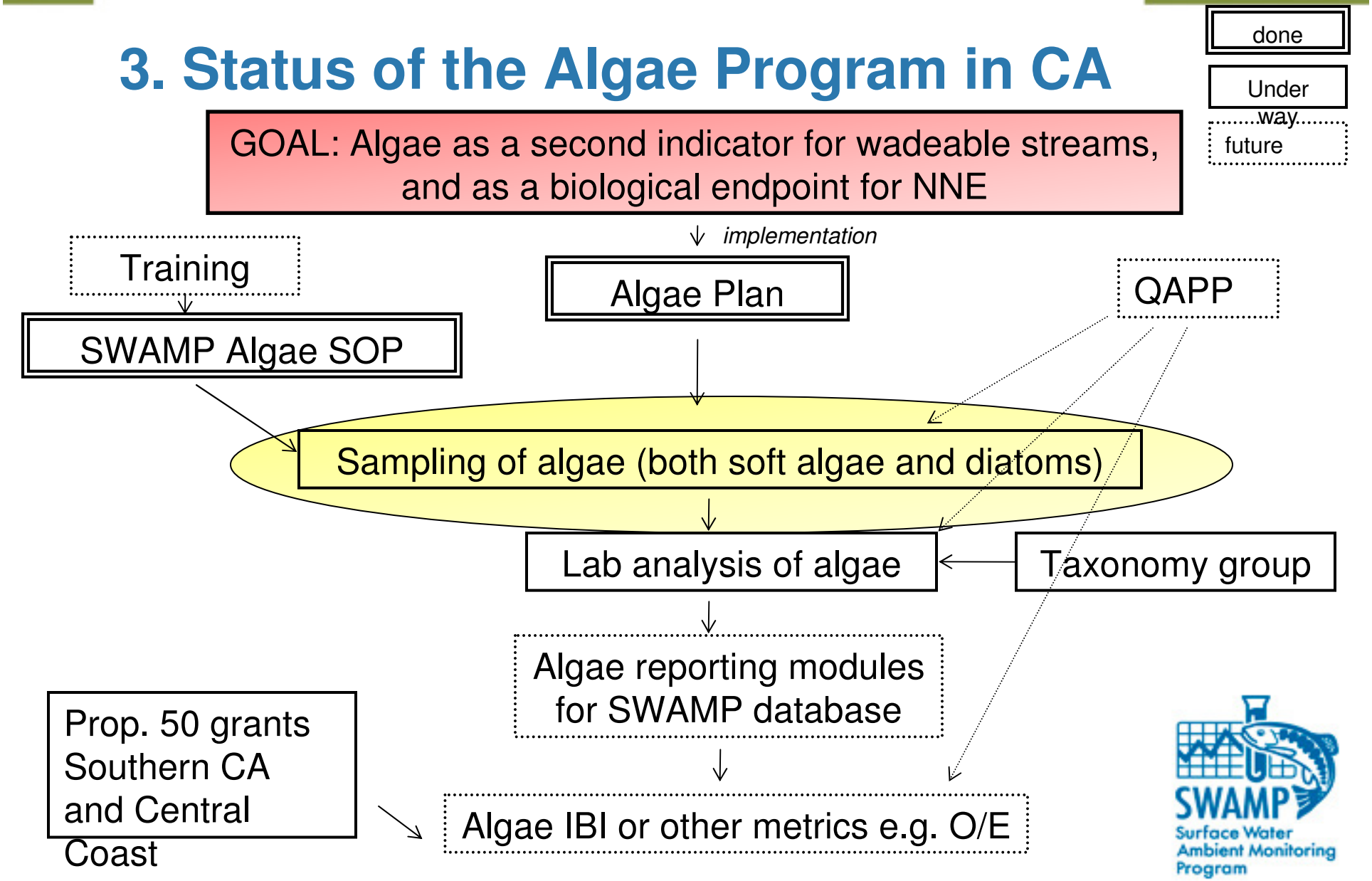

History of algae sampling in CA

- National programs:
  USEPA Environmental Monitoring and Assessment Program (EMAP)
  USGS National Water Quality Assessment Program (NAWQA)
  (9 years of diatoms/soft algae sampling)
- Included in special studies, e.g. TMDL studies (biomass), San Gabriel Watershed and Big Bear studies (community composition)
- Dave Herbst, Sierra Nevada Aquatic Research Lab (SNARL)
  Sampling since 1999, total of 300 algae samples
  Preliminary IBI draft report, Aug. 2008

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Current Programs – Sampling Programs

SWAMP sampling programs include algae since 2008

- 2008 sampling efforts:
  - 96 statewide samples (Perennial Stream Assessment and Reference Site Study)
  - 83 regional samples (R2, R4, R9)
- 2009 sampling
  - 294 statewide samples (Perennial Stream Assessment, Reference Site Study, and the Storm Water Monitoring Coalition in Southern CA)
  - 140 regional samples (R1, R2, R4, R8, R9)
- Some Stormwater Permits require algae sampling
- Prop. 50 grants algae sampling

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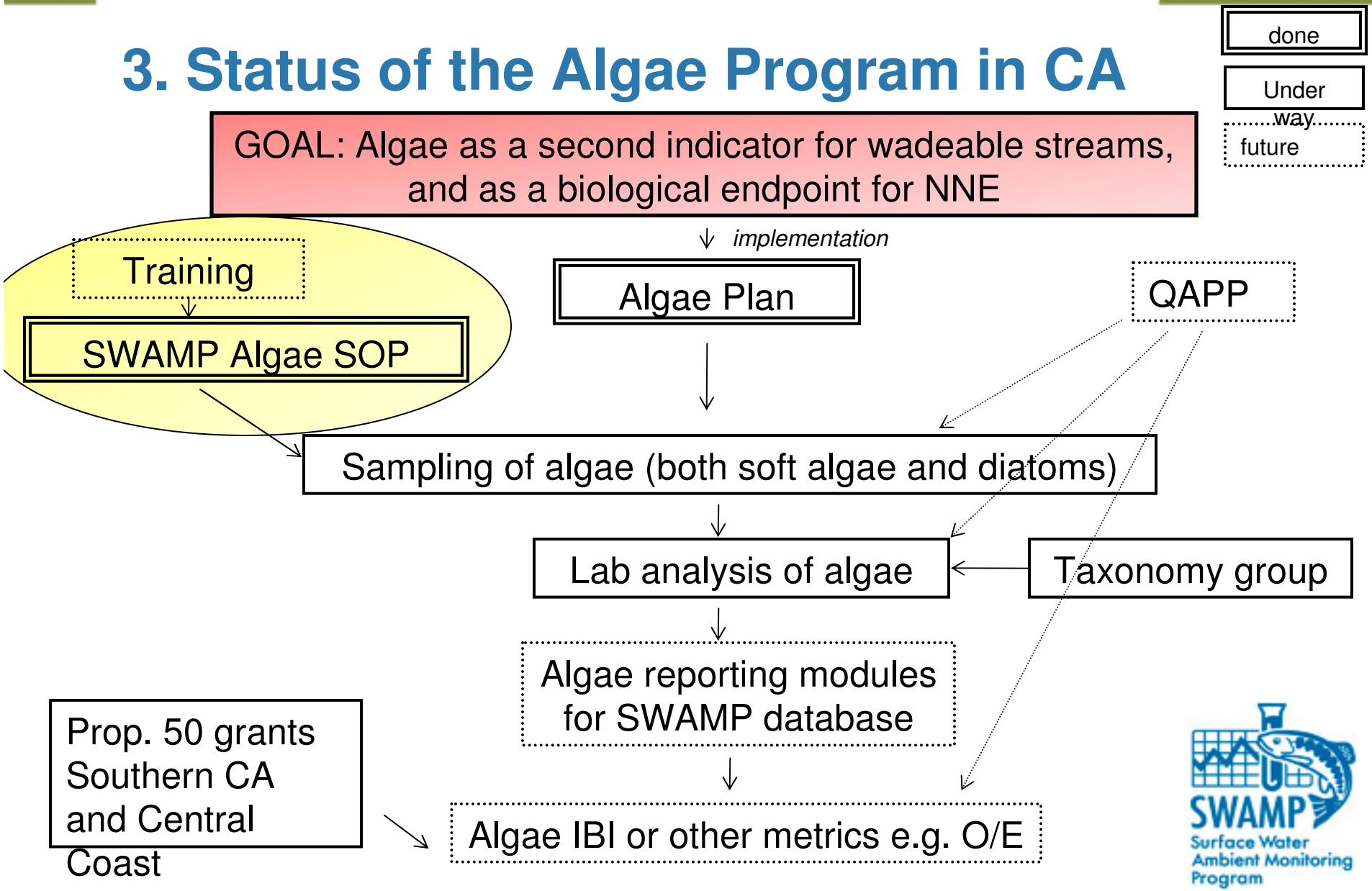
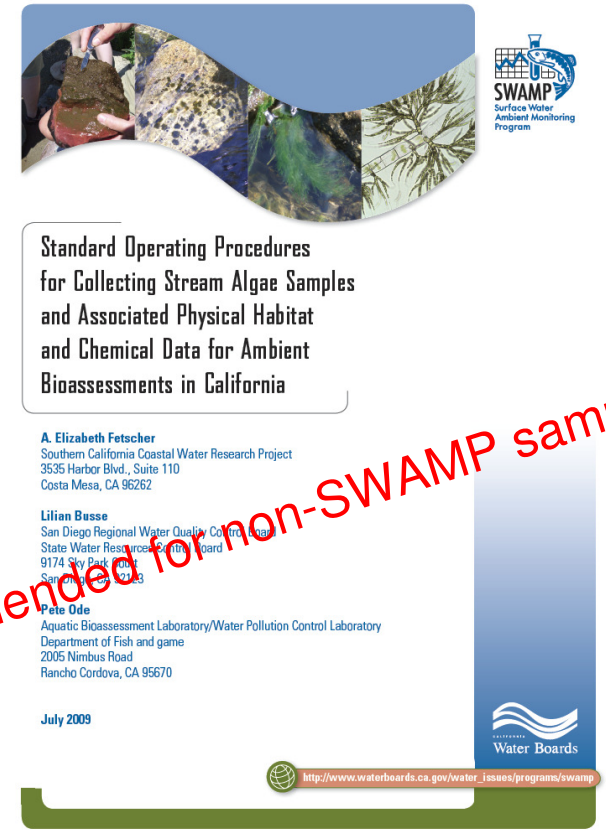
3. Status of the Algae Program in CA



Standard Operating Procedures (SOP)

SOP Benthic Macroinvertebrates

SOP Stream Algae



required for SWAMP sampling, recommended for non-SWAMP sampling

Coming soon!

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Standard Operating Procedures

- Final version will be available soon! Check SWAMP website
- Training will be offered (through the Water Board's Training Academy) in the following regions:
  R2/R3 training
  R5/R6/R7 training
  central training in Sacramento
- Since spring of 2009, sampling was conducted with the new SOP

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Standard Operating Procedures

- Draft SOP for 2008 sampling was based on the established EMAP method with some additions from SCCWRP
- additions to EMAP:
  qual. sampling for soft algae
  percent algal cover
  recording of sampling device and substrate
- ***Reachwide Benthos Sampling Method (Multihabitat): 11 transects in a stream reach, will collect samples in multiple habitats, ONE ALGAE SAMPLE***

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Standard Operating Procedures

- 1. Introduction
- 2. Getting started
- 3. Reach delineation and water chemistry sampling
- 4. Reachwide Benthos Sampling of Algae
- 5. Algal Sample Processing
- 6. Physical Habitat Transect-Based Measurements to Accompany Algal Bioassessment
- 7. Physical Habitat Inter-Transect-Based Measurements
- 8. Reachwide Measurements
- 9. References
- 10. Glossary

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Standard Operating Procedures

- 4. Reachwide Benthos Sampling of Algae

1. Percent Algal Cover (Floating Algae and Attached Algae)
2. Biomass (Chlorophyll and Ash Free Dry Mass)
3. Species Composition (Diatoms and/or Soft Algae)

appropriate indicators depend on the program's goals

- percent algal cover is a quick indicator for algal biomass
- chlorophyll and AFDM are indicators of algal biomass, key indicator for NNE
- species composition information needed for IBI, indicative of factors such as trophic status

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Standard Operating Procedures

5. Algal Sample Processing

Table 1a
Sample and data collection elements included in algal and BMI bioassessment (Ode 2007; Table 1).
X indicates elements included in algal bioassessment. F indicates elements that are part of the "Full" protocol for conducting BMI bioassessment, B corresponds to elements of the "Basic" BMI protocol, and O indicates elements that are "Optional".

	Algal indicator for	Collection method	Collection vessel	Preservation/fixation method/holding times	Qualitative live sample required?
Percent Algal Cover	Stream productivity measured as algal abundance	Point-intercept add-on to the PHab pebble count	N/A	N/A	N/A
Chlorophyll a[6]	Stream productivity measured as algal biomass; key indicator for the Nutrient Numeric Endpoints (NNE) framework	RWB sample collection	Glass-fiber filter	Wet ice, dark (foil-wrapped); Freezing within 4h, and filter analysis within 28d	N/A
AFDM	Stream productivity measured as biomass of organic matter (including algae); indicator for the NNE framework	RWB sample collection	Glass-fiber filter (pre-combusted[7])	Wet ice, dark (foil-wrapped); Freezing within 4h, and filter analysis within 28d	N/A
Diatoms	Used in IBIs. Indicative of factors such as trophic status; organic enrichment; low DO; siltation; pH; metals	RWB sample collection	50 mL centrifuge tube	Add 10% buffered formalin for a 2% final concentration immediately after collection; keep dark and away from heat	Optional
Soft-bodied algae[8]	Used in IBIs. Indicative of factors such as nitrogen limitation/ trophic status; siltation; pH; temperature, light availability, nuisance/ toxic algal blooms	RWB sample collection	50 mL centrifuge tube	Keep unfixed samples in dark on wet (NOT DRY) ice; add glutaraldehyde (to a 2.5% final concentration) as soon as possible, but no later than 4 days after sampling; after fixing, keep dark and away from heat	Required

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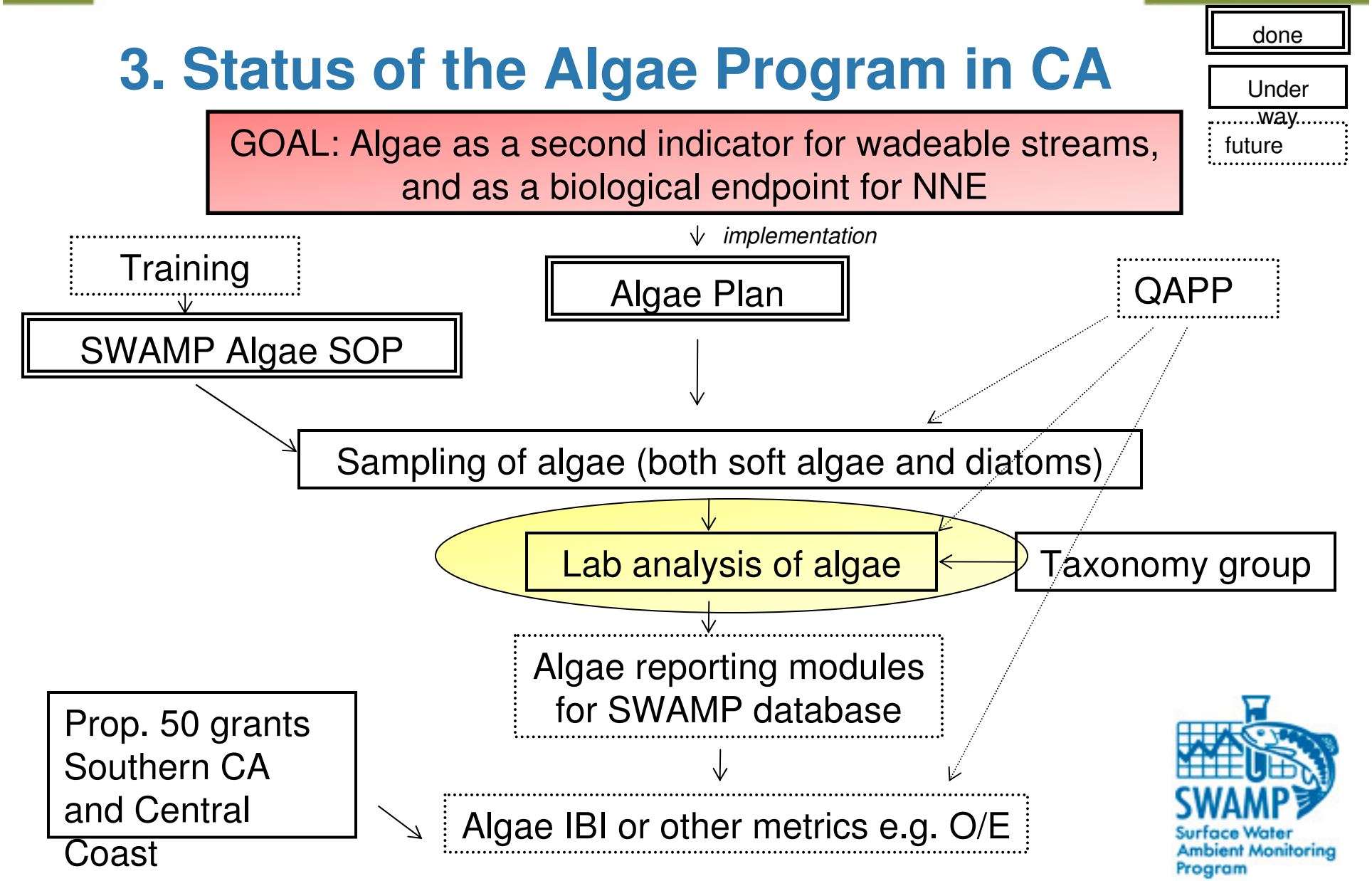
3. Status of the Algae Program in CA



Laboratory Analysis of Stream Algae

1. Percent Algal Cover: analysis in the field, no lab analysis necessary
2. Biomass (Chlorophyll/Ash Free Dry Mass): chemical analysis in the lab necessary
3. Species Composition: algae species identification to lowest taxonomic level; currently there are two laboratories that are used for algae identification for statewide and regional programs:
   - soft algae: Bob Sheath, CSU San Marcos
   - diatoms: Patrick Kociolek, University of Colorado
   (It is the recommendation that at this point the same two labs should be used until the taxonomy is resolved)

- Costs:
  Percent Algal Cover: included in field sampling
  Chlorophyll/Ash Free Dry Mass: Chlorophyll: $71, AFDM: $43
  Species Identification: Diatoms: $315, Soft Algae: $315

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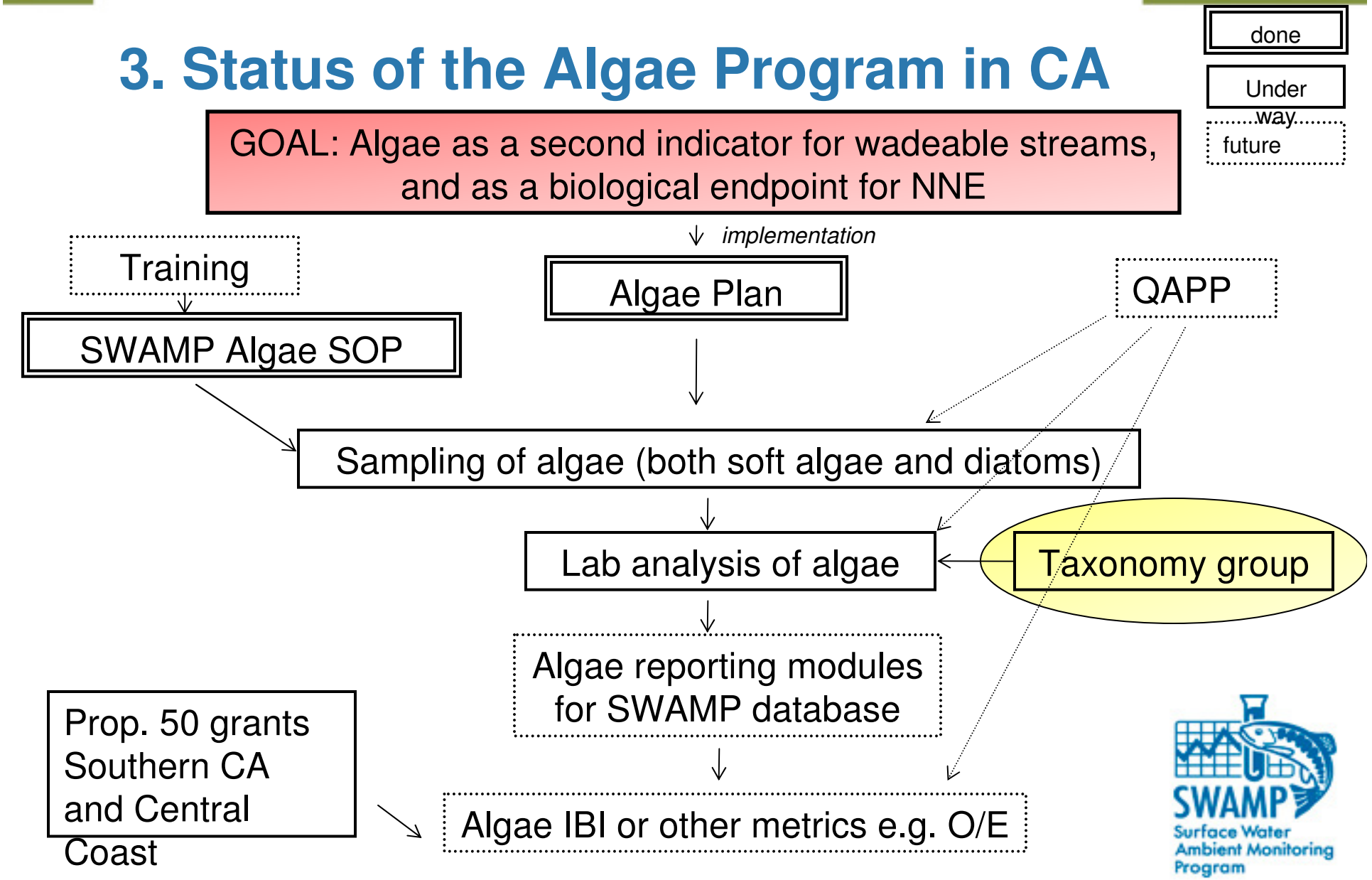

Taxonomic Group

- Taxonomy of freshwater algae in California is not fully resolved
- For algae identification and comparison of datasets taxonomic standards must be developed
- SWAMP funds the development of an Algae Taxonomic Group. The goals are:
  1. Setting up a non-profit group
  2. Development of taxonomic standards
  (3. Development of online-tools for identification)

  Program director: Marc Los Huertos, CSU Monterey Bay
  First Meeting: October 23, 2009

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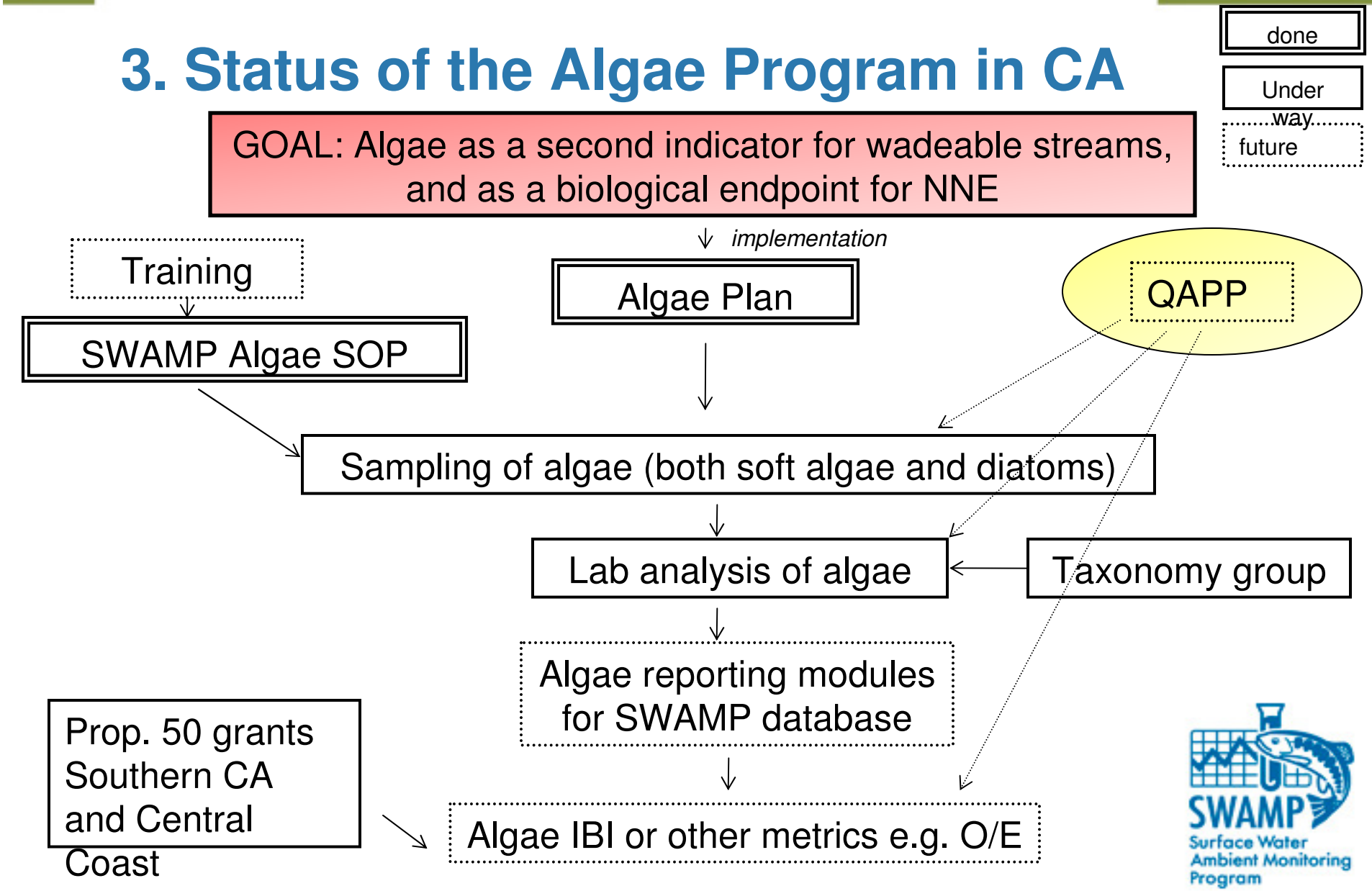

Quality Assurance and Quality Control

- A Quality Assurance Project Plan (QAPP) for algae needs to be prepared for Quality Assurance (QA) and Quality Control (QC)
- A QAPP for bioassessment using benthic macroinvertebrates was recently developed (see SWAMP website)
- The QAPP will cover field sampling, laboratory analysis, and data analysis
- Some new parts need to be developed for the QAPP for algae
- QAPP for algae will start with funding from SWAMP this year

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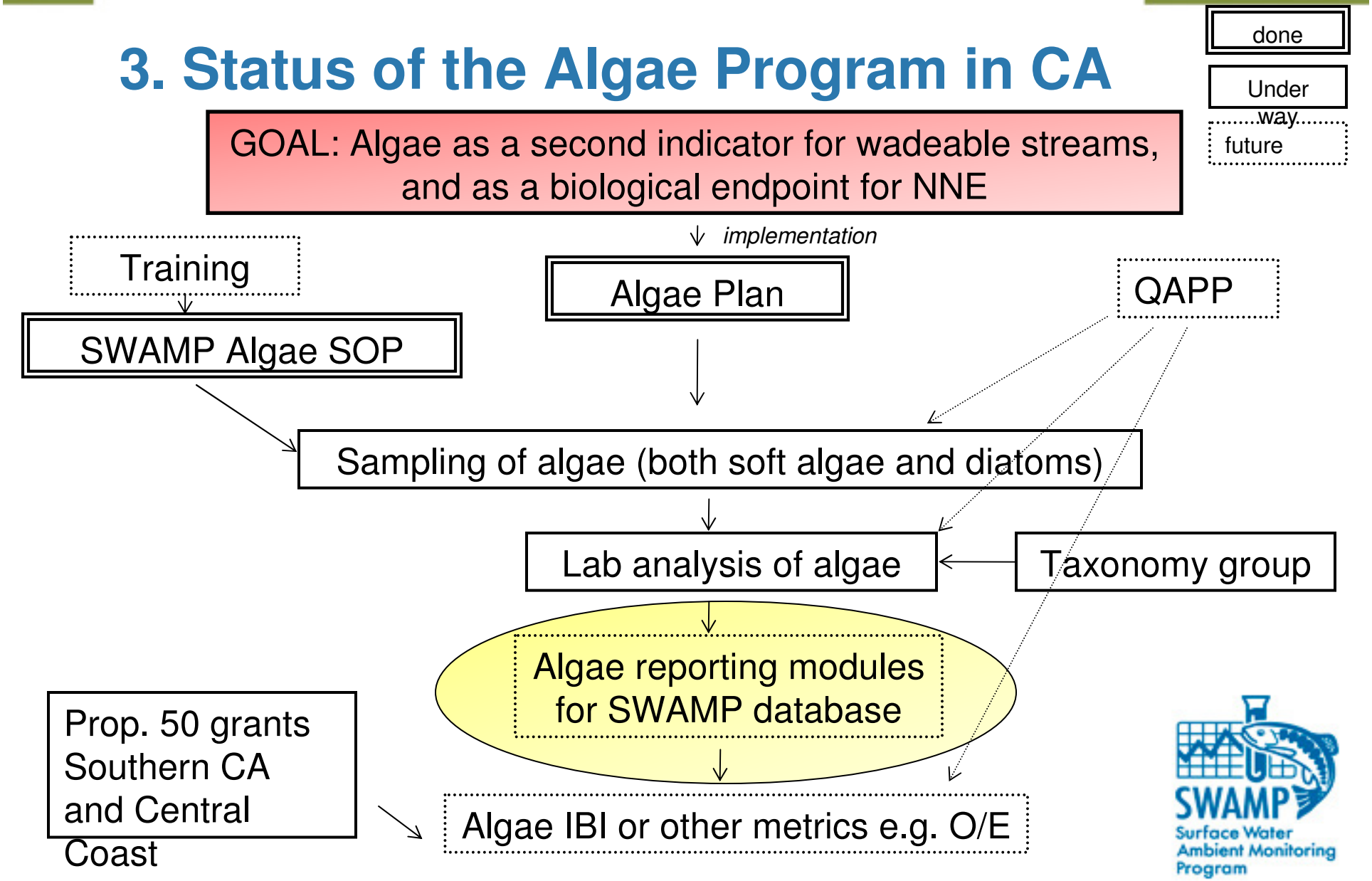
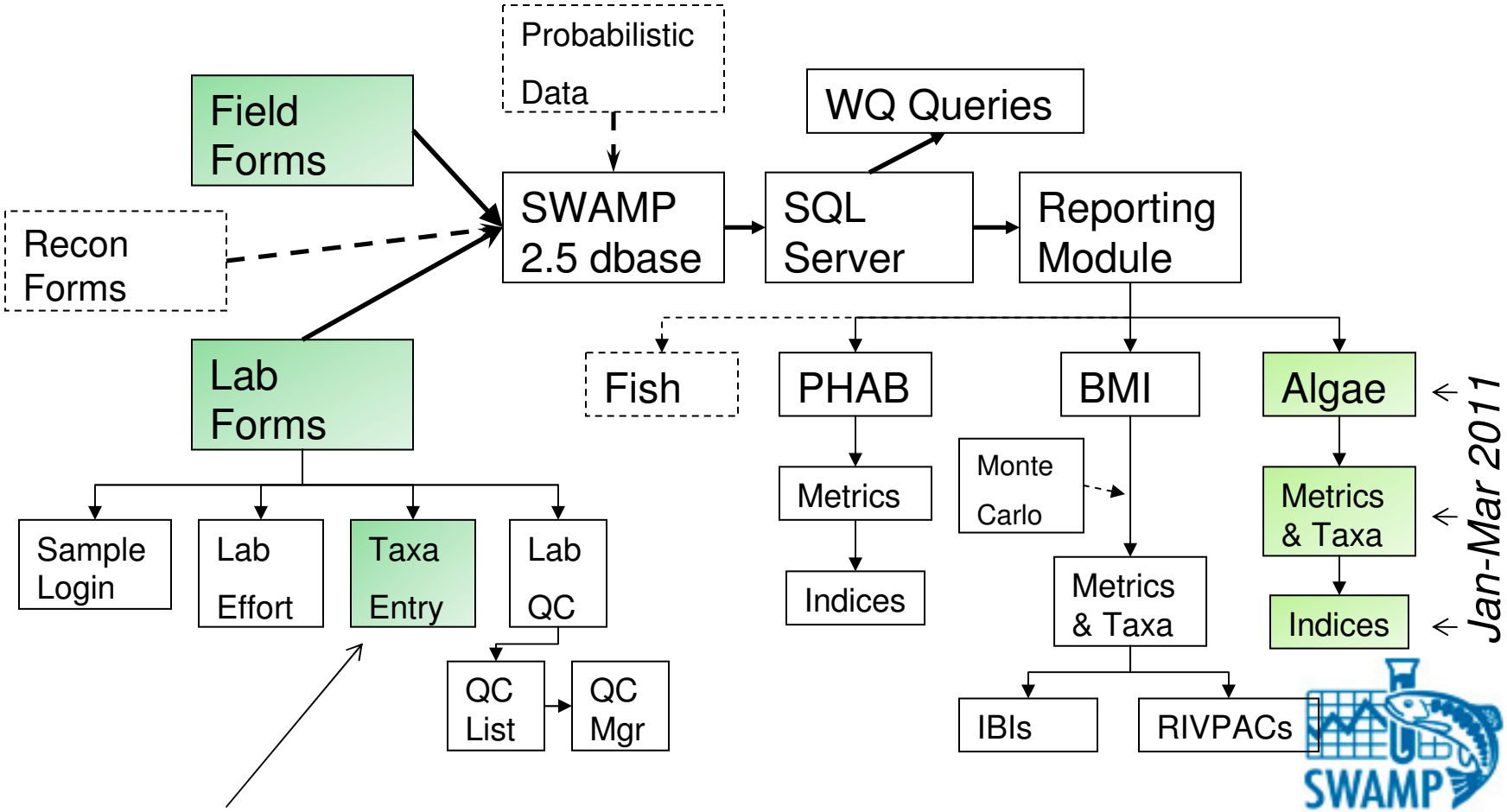
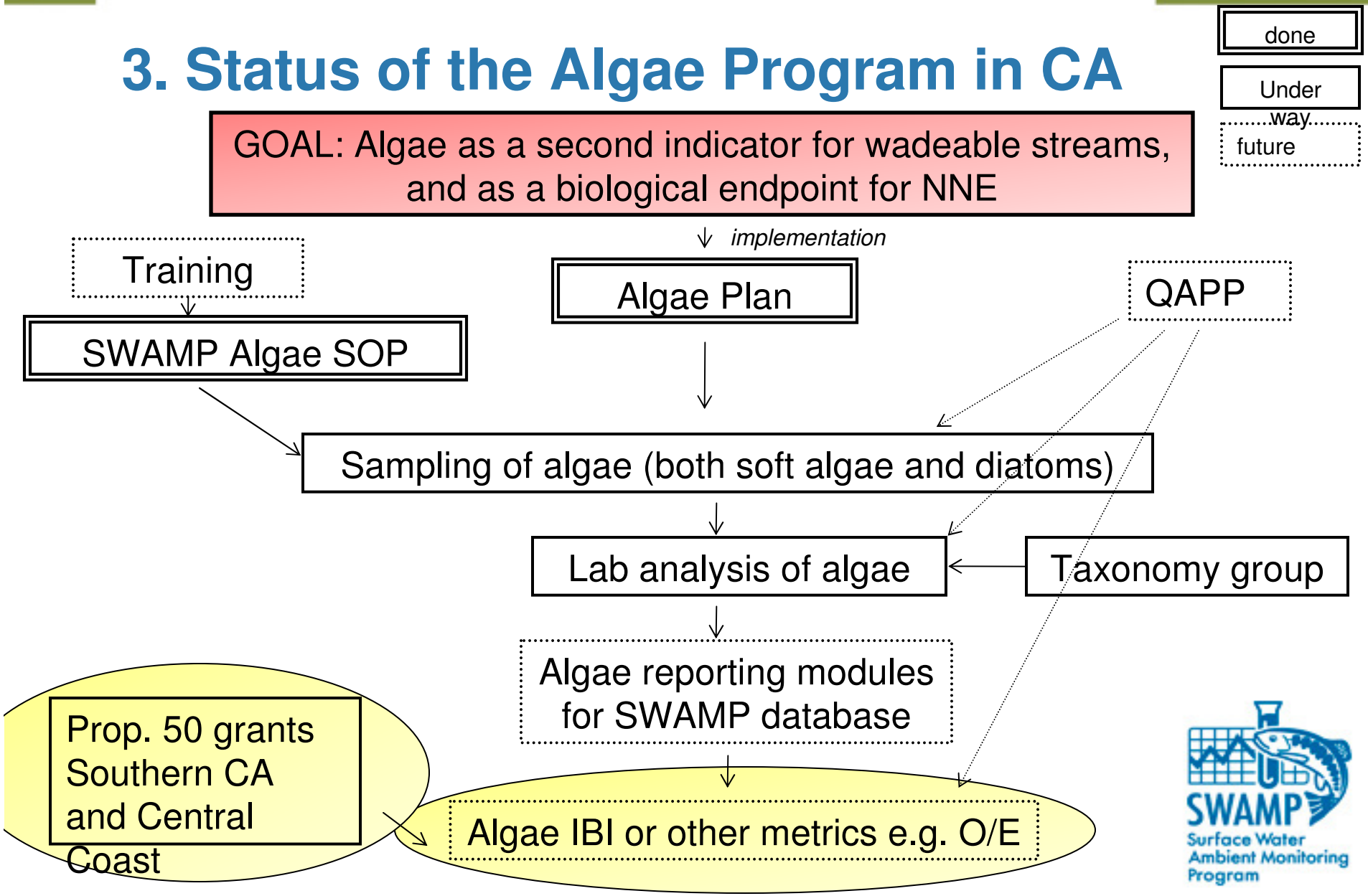


SWAMP database: algae modules



Taxa list will be finalized with taxonomy group

3. Status of the Algae Program in CA



Grants

- Prop 50 grant Southern CA: *IBI development for Southern CA (diatoms and soft algae), pilot studies incl. methods comparison, index period, and ephemeral streams, outreach component for algal harmonization*
  - All samples are taken and analyzed, some data analysis, currently suspended

- Prop 50 grant Central Coast: *IBI and O/E development for Central Coast (diatoms only), large spatial coverage*
  - All samples taken and analyzed, some data analysis, currently suspended

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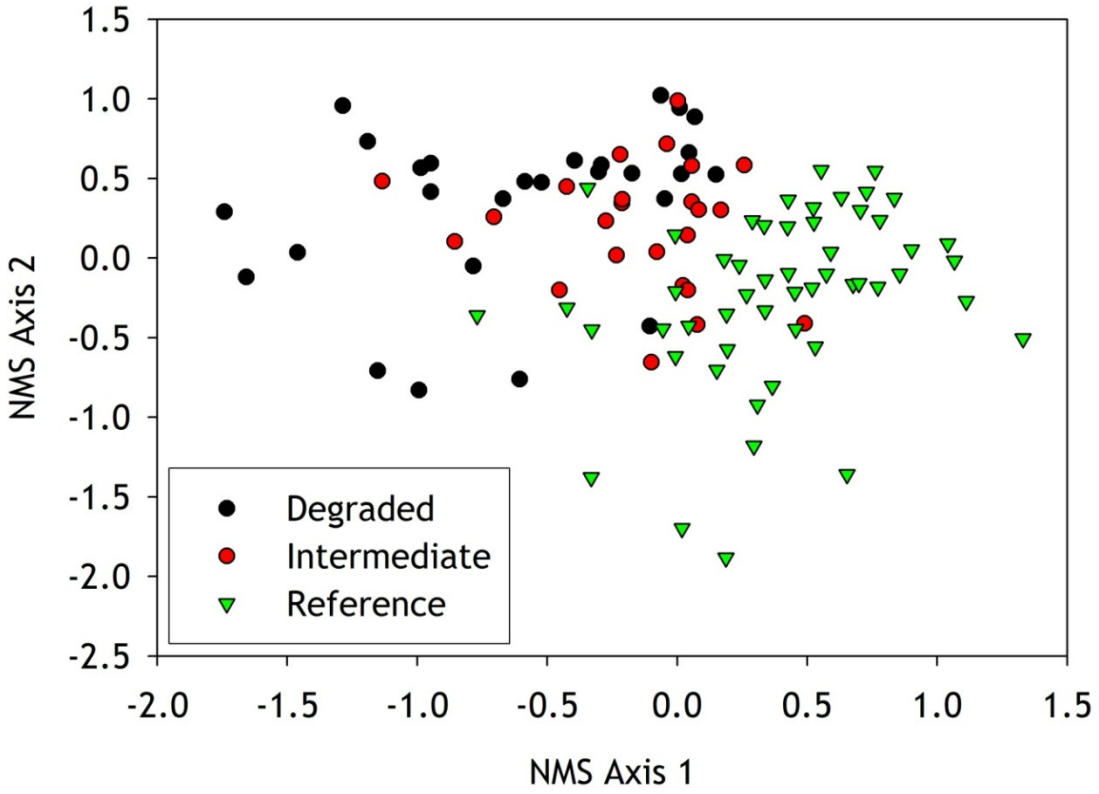
Preliminary Data from Southern CA Grant



2007 + 2008 data: diatoms

(unpublished data, Fetscher et al.)

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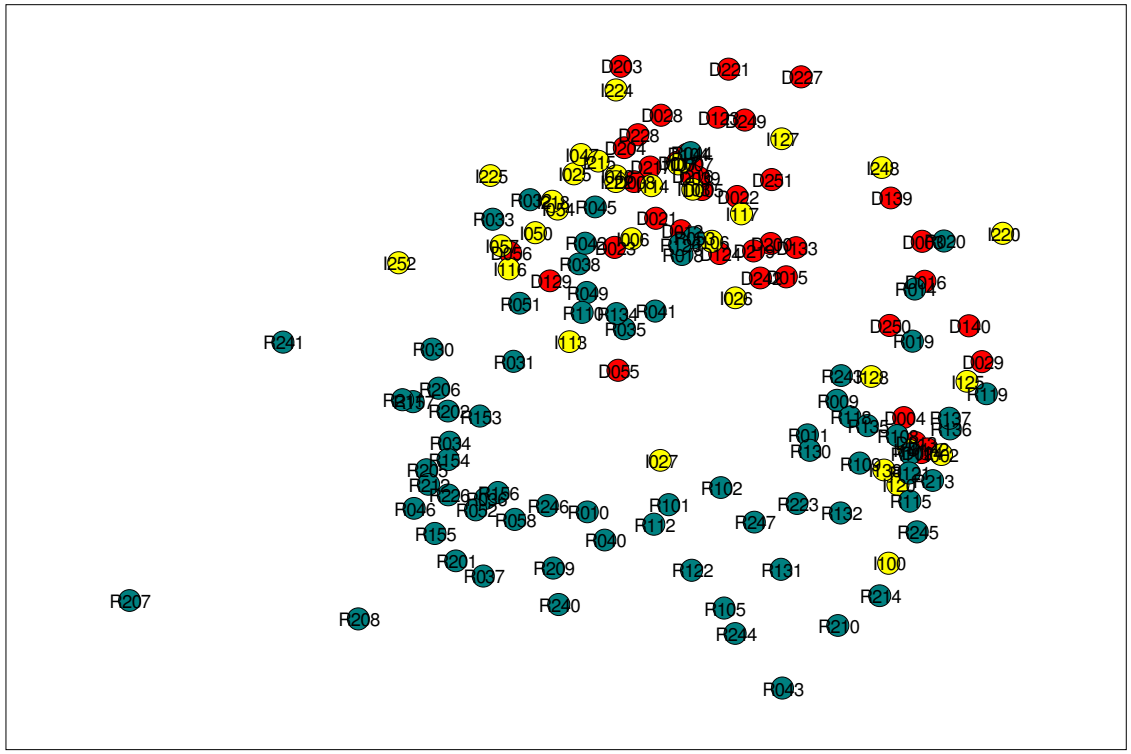
Preliminary Data from Southern CA Grant

NMS Ordination Soft-bodied Algae Summer-Fall 2007/2008



Degraded sites

Intermediate sites

Reference sites

Stress: 0.25

Fourth root data transformation

147 samples

289 species and varieties

(unpublished data, Fetscher et al.)

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4. Next Steps

- Work on taxonomic standardization
- Training for SOP
- Work on QAPP
- Finish the database module
- Development of Algae IBI

USE algae as a second indicator:

- in NPDES permits
- in TMDLs
- in 401 water quality certifications
- to assess the health of the streams
- in 303d listings

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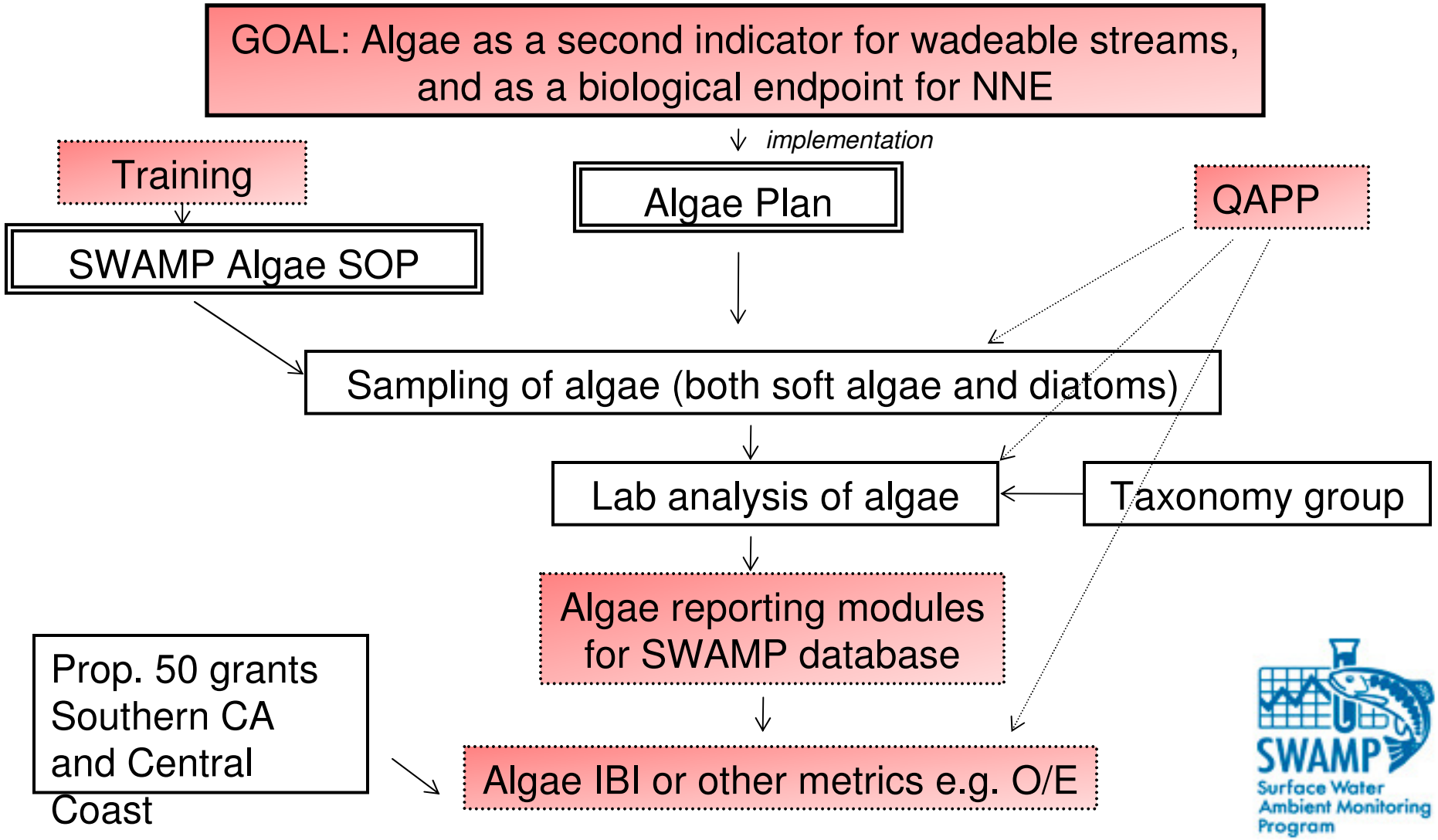
GOAL: Algae as a second indicator for wadeable streams, and as a biological endpoint for NNE
implementation
Training
SWAMP Algae SOP
Algae Plan
QAPP
Sampling of algae (both soft algae and diatoms)
Lab analysis of algae
Taxonomy group
Algae reporting modules for SWAMP database
Prop. 50 grants Southern CA and Central Coast
Algae IBI or other metrics e.g. O/E
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Questions?

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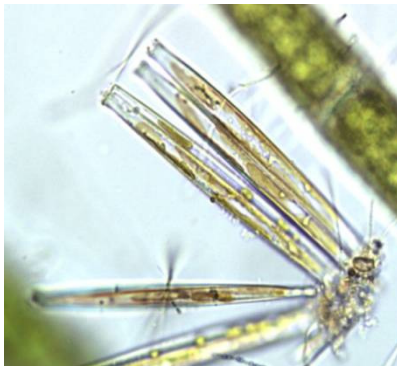
- lbusse@waterboards.ca.gov
- Phone: 858-467-2971



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