PUERTO RICO
Coral Fellow

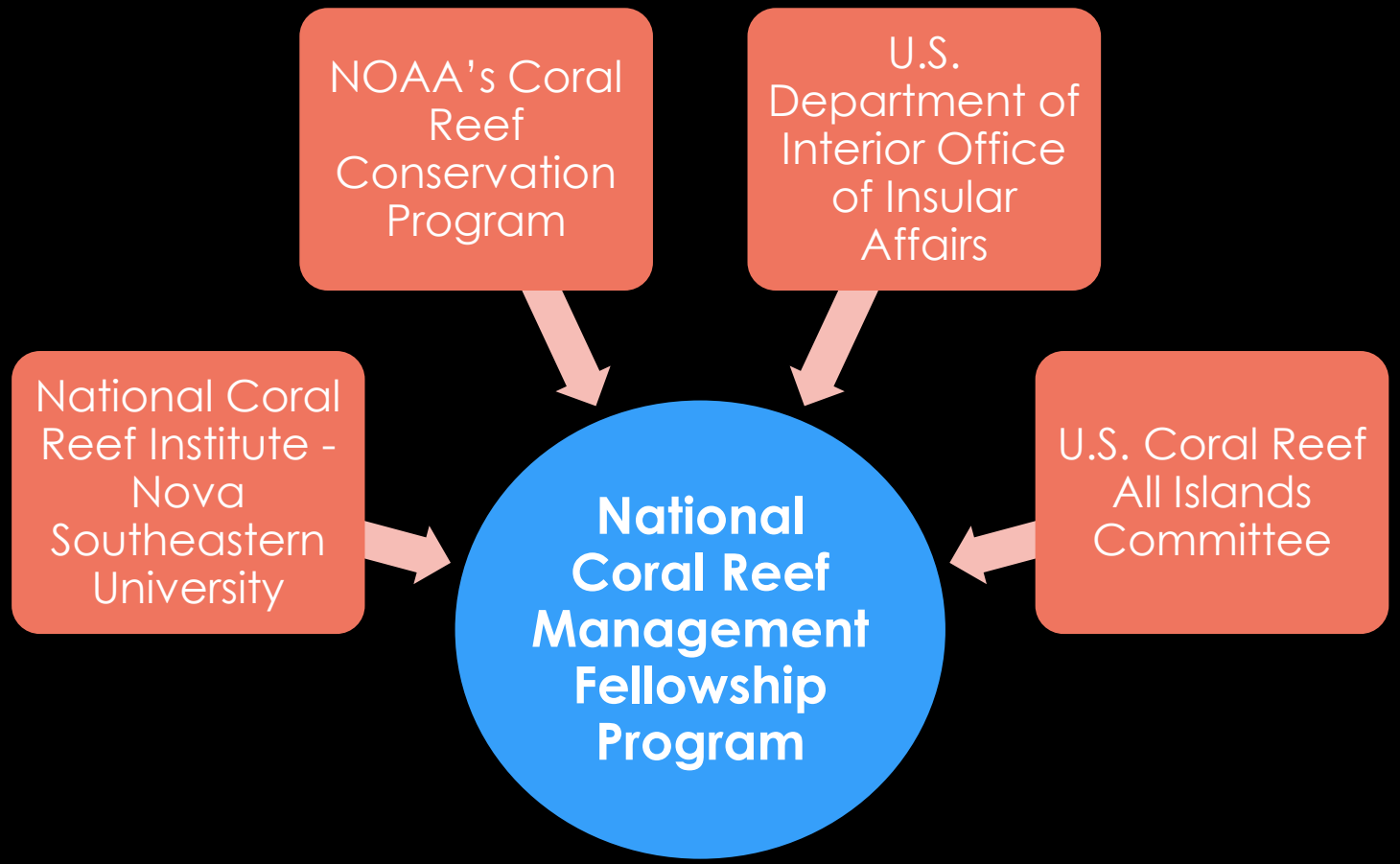
Assessing the Needs of the Puerto Rico Coral Reef Monitoring Program

Mariana C. León Pérez

March 1, 2018

JP Zegarra

National Coral Reef Management Fellowship Program



- American Samoa
- Commonwealth Northern Mariana Islands
- Florida
- Guam
- Hawaii
- **Puerto Rico**
- US Virgin Islands

National Coral Reef Management Fellowship Program

NCRMFP Missions

Provide coral reef management support in each participating jurisdiction by placing highly qualified individuals whose education and work experience meet each location's specific coral reef management's needs

Provide individual fellows with professional opportunities and training in coastal and coral reef resource management

Coral Fellows FY16-17

National Coral Reef Management Fellowship Program – Puerto Rico

Puerto Rico objectives

Assess the Needs of the Puerto Rico Coral Reef Monitoring Program

Improve data accessibility

To identify the conservation and management questions that the Program must tackle and evaluate if any questions are not being address.

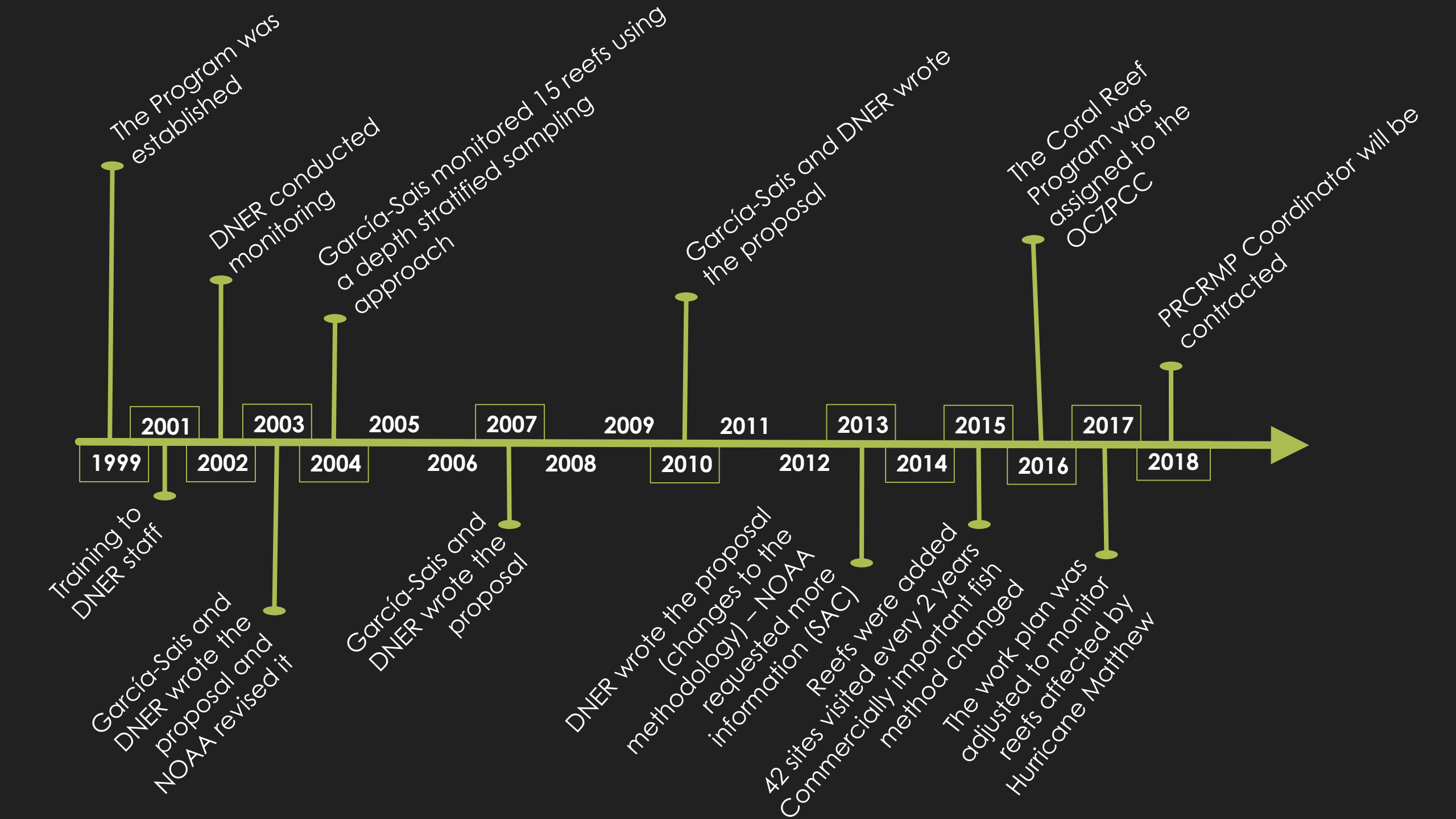
Recommend courses of action to ensure that the Program responds to these management needs.

Puerto Rico Coral Reef Monitoring Program (PRCRMP)

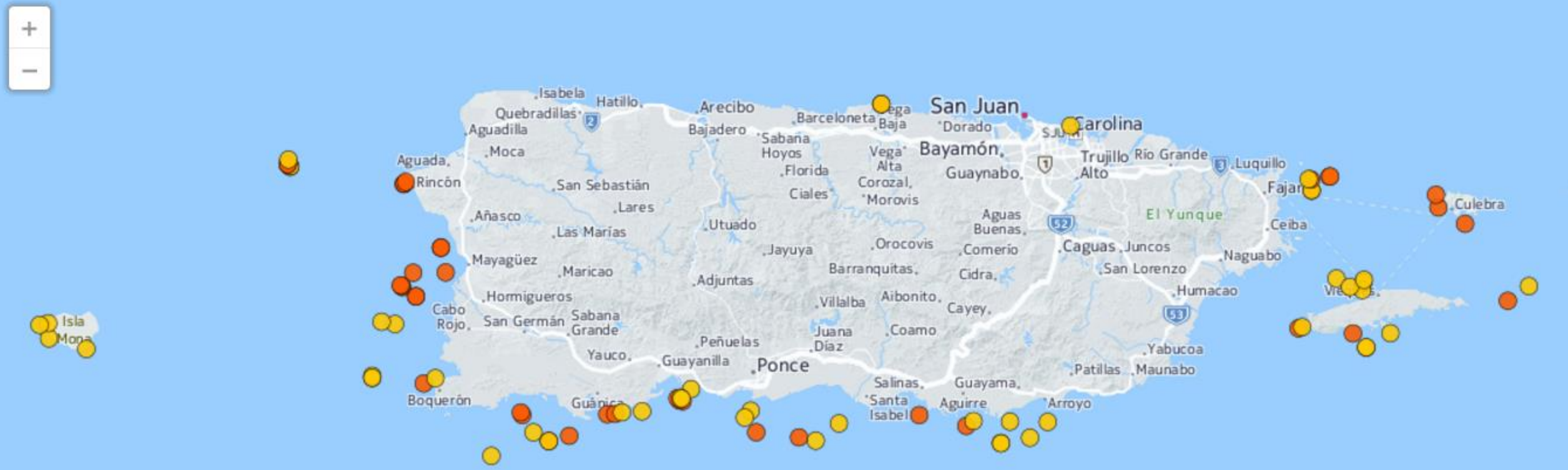
Established in 1999

The Program was composed of the following for components:

- Baseline Characterizations
- Training to DNER staff
- Monitoring
- Education and outreach


1999
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
The Program was established
DNER conducted monitoring
García-Sais monitored 15 reefs using a depth stratified sampling approach
García-Sais and DNER wrote the proposal
The Coral Reef Program was assigned to the OCZPCC
PRCRMP Coordinator will be contracted
Training to DNER staff
García-Sais and DNER wrote the proposal and NOAA revised it
García-Sais and DNER wrote the proposal
DNER wrote the proposal (changes to the methodology) – NOAA requested more information (SAC)
Reefs were added
42 sites visited every 2 years
Commercially important fish method changed
The work plan was adjusted to monitor reefs affected by Hurricane Matthew

Coral Reef Sites Visited from 1999 to 2017



(40) ESTACIONES MONITOREADAS ACTUALMENTE

(44) ESTACIONES CARACTERIZADAS Y/O MONITOREADAS EN EL PASADO

http://drna.pr.gov/programas-y-proyectos/coralpr/

Sites currently monitored by the Program

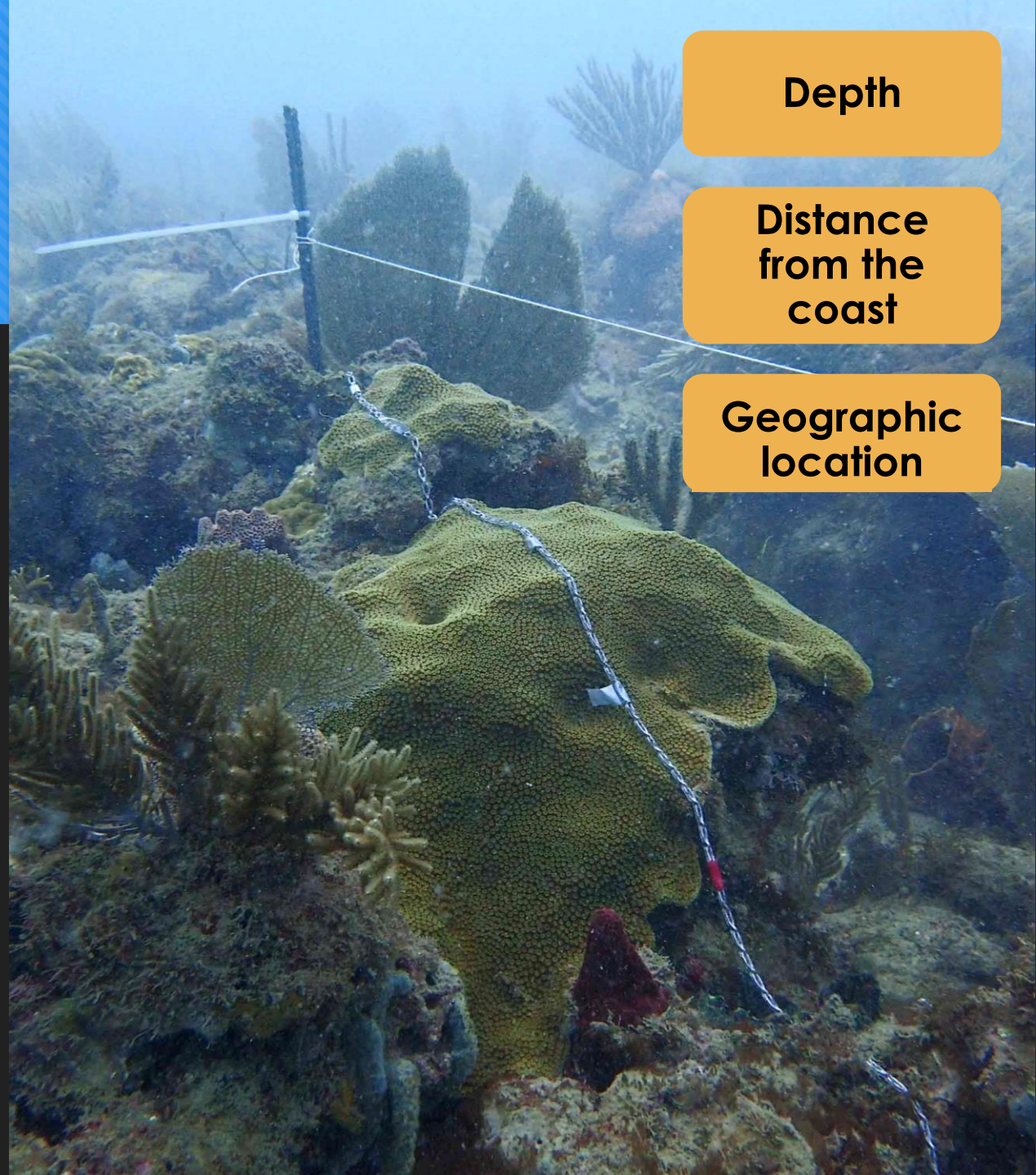
Location	Reef Station	Depth (m)	Latest Monitoring Year
Cabo Rojo	Resuellos Reef	8	2017
	Gallardo Reef	3	2017
	El Negro 10m	7.8	2016
	El Negro 5m	4.6	2016
	Guanajibo 20	18	2016
Culebra	Dakity	20	2016
	Luis Pena	5.4	2016
	Carlos Rosario	10	2016
Desecheo	Puerto Canoas - Shelf-edge	28.5	2015
	Puerto Botes - Mid-shelf	18.5	2015
	Puerto Botes - Inner-shelf	15.5	2015
Fajardo	Cayo Palominito	10	2016
	Cayo Palomino	20	2016
	Cayo Diablo	5.4	2016
Guánica	Cayo Coral	7.6	2017
	Cayo Aurora	3.5	2017
	Guanica Shelf-Edge (Efra's Wall)	19	2017
Guayanilla	Maria Langa 20m	15.8	2017
	Maria Langa 10m	8.9	2017
	Maria Langa 5m	3.1	2017

Location	Reef Station	Depth (m)	Latest Monitoring Year
La Parguera	La Boya Vieja-Shelf-edge Reef	18	2017
	Media Luna Fore-Reef 10m	9	2017
	Media Luna Back-Reef 5m	4	2017
Mayaguez	Tourmaline - Outer-shelf - 10 m	10	2017
	Tourmaline - Outer-shelf - 20 m	19	2017
	Tourmaline - Shelf-edge	28.5	2017
	Rodriguez	3.8	2016
	Manchas Ext 20m	18.5	2016
	Manchas Ext 10m	9.2	2016
Ponce	Caja de Muerto	7.6	2017
	Derrumbadero	16.7	2017
Rincon	Tres Palmas_20m	20	2017
	Tres Palmas_10m	10	2017
	Tres Palmas_5m	4	2017
Salinas	Cayo Caribes	9.1	2017
	Cayo Ratones	4	2017
Vega Baja	Cibuco Reef	10	2016
Vieques	Boya Esperanza	9.1	2016
	Canjilones	15.2	2016
	El Seco	35	2016

Sampling Design and Methods

5 permanent transects (10m)

- Benthic sessile organisms
  - continuous intercept chain-link method
- Motile megabenthic invertebrates
  - Belt transect (10X3m)
- Fish
  - Belt transect (10X3m)
- Fish species of ecological and economical importance
  - Active Search Census (ASEC) - past
  - Belt transect (20X3m) - present



What data is collected?

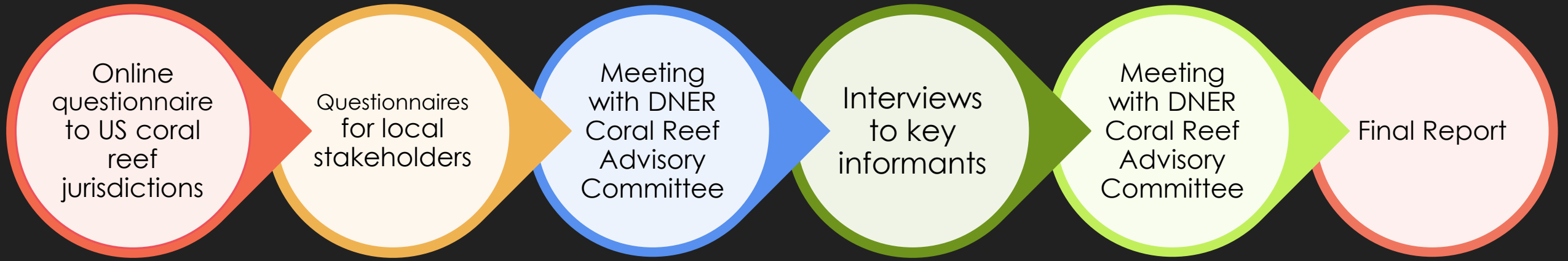
- Rugosity
- Benthic organisms
  - Total percent cover
    - Abiotic (per subcategory)
    - Algae (per sp.)
    - Cyanobacteria
    - Hard corals (per sp.)
    - Soft corals (per sp. and #colonies/transect)
    - Other benthic invertebrates (per sp.)
    - Sponges (per sp.)
  - Motile megabenthic invertebrates (per sp.)
    - Species total (#sp/area)
    - Abundance (t#ind/area)
- Fish (per sp. and size (starting in 2015)
  - Species total (#sp/area)
  - Abundance (t#ind/area)
  - Biodiversity Index (starting in 2017)

Important Findings

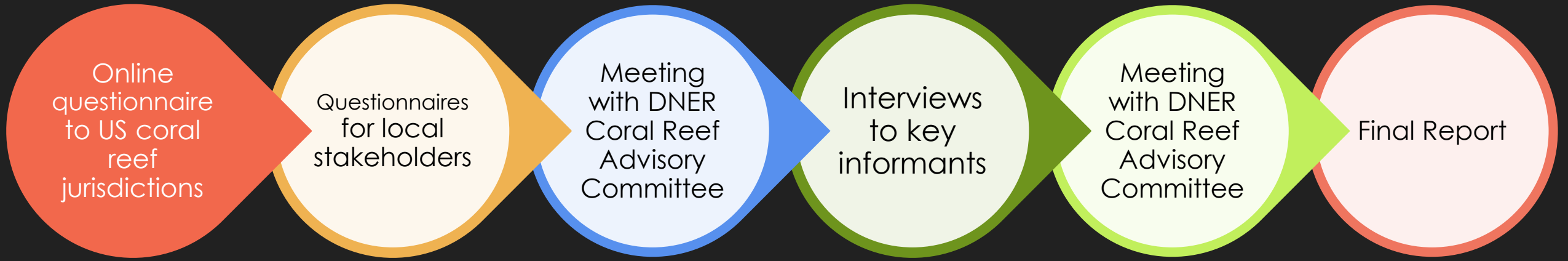
- Impacts and lingering effects of the 2005 regional bleaching event.
  - Mesophotic and coastal reefs were the least affected.
  - Phase shifts were documented in the benthic community structure.
  - In some reefs a moderate but consistent recovery has been documented in the percent of live coral.
- The status of large and commercially important fish remains precarious (problem - ecological integrity).
- Presence and prevalence of disease (Tres Palmas reef), severe mechanical damage and predatory pressure by corallivorous gastropods (Gallardo Reef) in *A. palmata*.
- Alarming high percent cover of the encrusting algae *Ramicrusta textilis* in some reefs.
- The mesophotic fish community at El Seco in Vieques, can be regarded as highly biodiverse, well balanced in terms of its trophic components and an important reservoir of commercially exploited coral reef fishes.

Assessment of the PRCRMP Needs

Assessment Overview



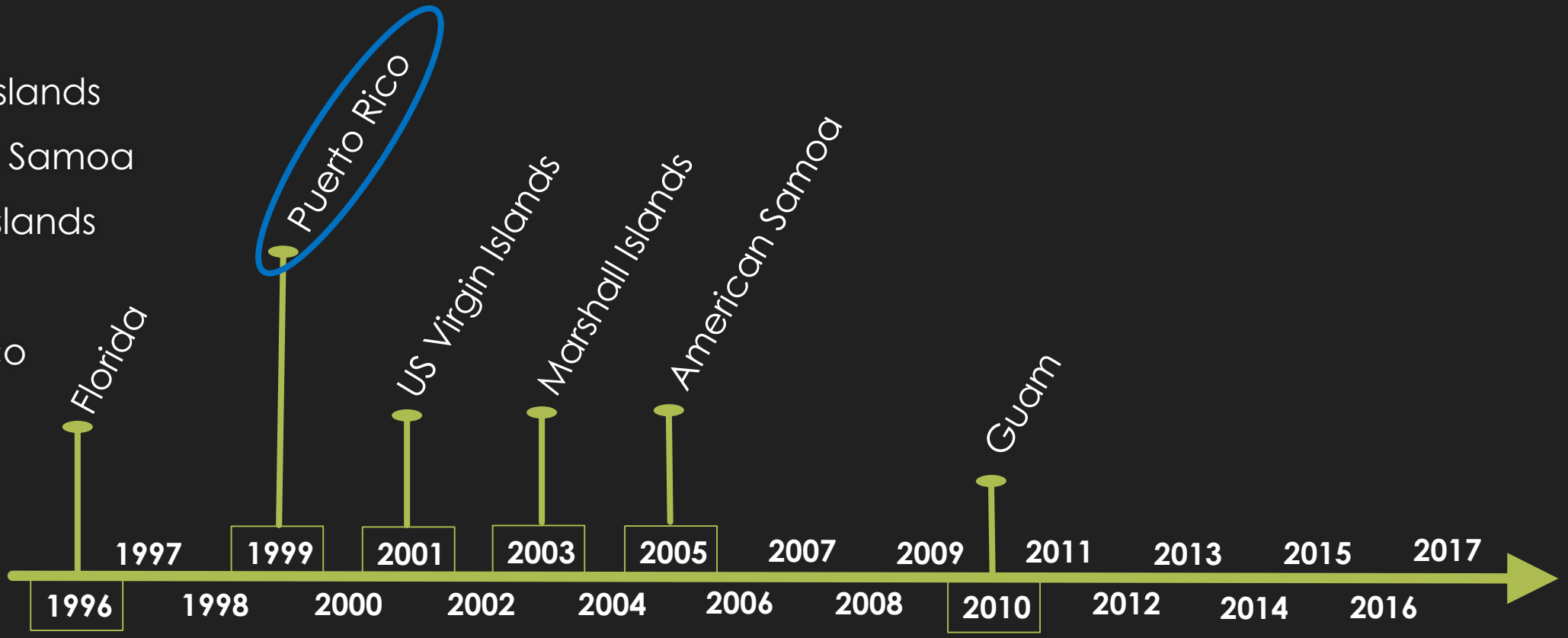
Assessment Overview



Questionnaire to US Coral Reef Jurisdictions

US jurisdictions that completed the questionnaire:

- Guam
- US Virgin Islands
- American Samoa
- Marshall Islands
- Florida
- Puerto Rico



Strengths

American Samoa

- Document changes at a specific site

Florida

- Permanent transects - can determine changes in coral cover or abundace with greater precision

Guam

- High density sampling within relative large reef areas

Marshall Islands

- Standarization of methodology so that we can train surveyors to use it

Puerto Rico

- Stratified sampling approach
- High precision and robust
- The relationship between benthic complexity and reef fishes can be analyzed
- The consistency of survey personnel reduces sampling errors
- Cost-effective
- 17 years of consistent monitoring data

US Virgin Islands

- Permanent transects
- Benthic videos, as can be revised anytime

Weaknesses

American Samoa

- Not enough sites to infer changes at an island level
- Boat availability

Florida

- Spatially limited because it employs fixed sites and repeated measures

Guam

- Bureucratic and political issues
- Dependent on the weather condition

Marshall Islands

- Number and capacity of surveyors

Puerto Rico

- Site specific: Does not provide an assessment of the real live coral cover for the jurisdiction
- Smaller geographical coverage

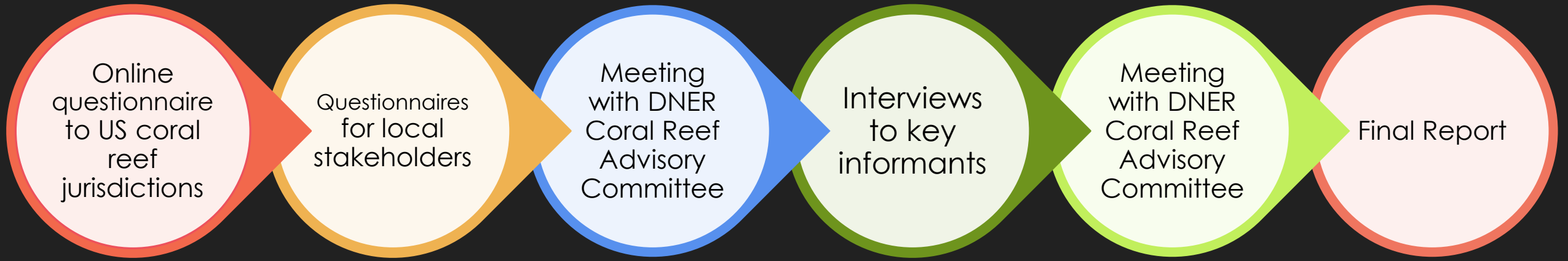
US Virgin Islands

- Only 33 sites
- One timepoint for fish surveys each year

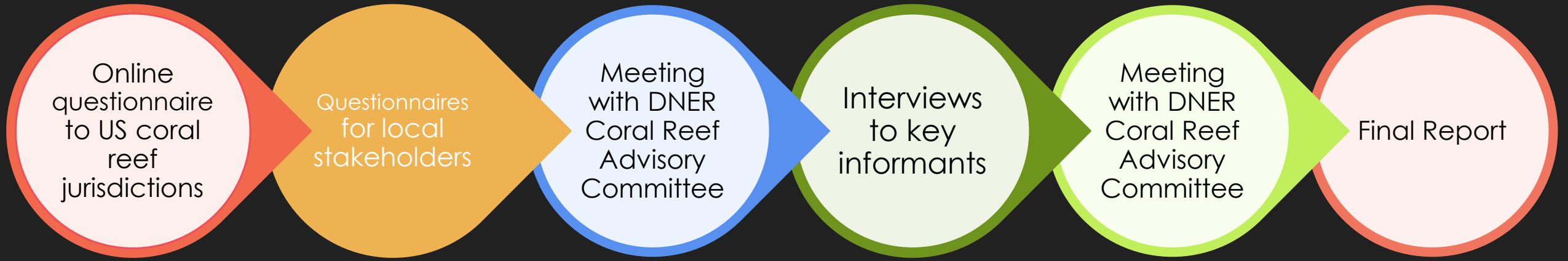
Administrative questions…

	American Samoa	Florida	Guam	Marshall Islands	Puerto Rico	US Virgin Islands
Does your Program have been revised?	Yes	Yes	No	Yes	Yes	No
Does your Program have received additional funds apart from NOAA CRCP?	No	Yes • EPA and NPS	No	Yes • DOI and World Bank	No	Yes • DOI and University

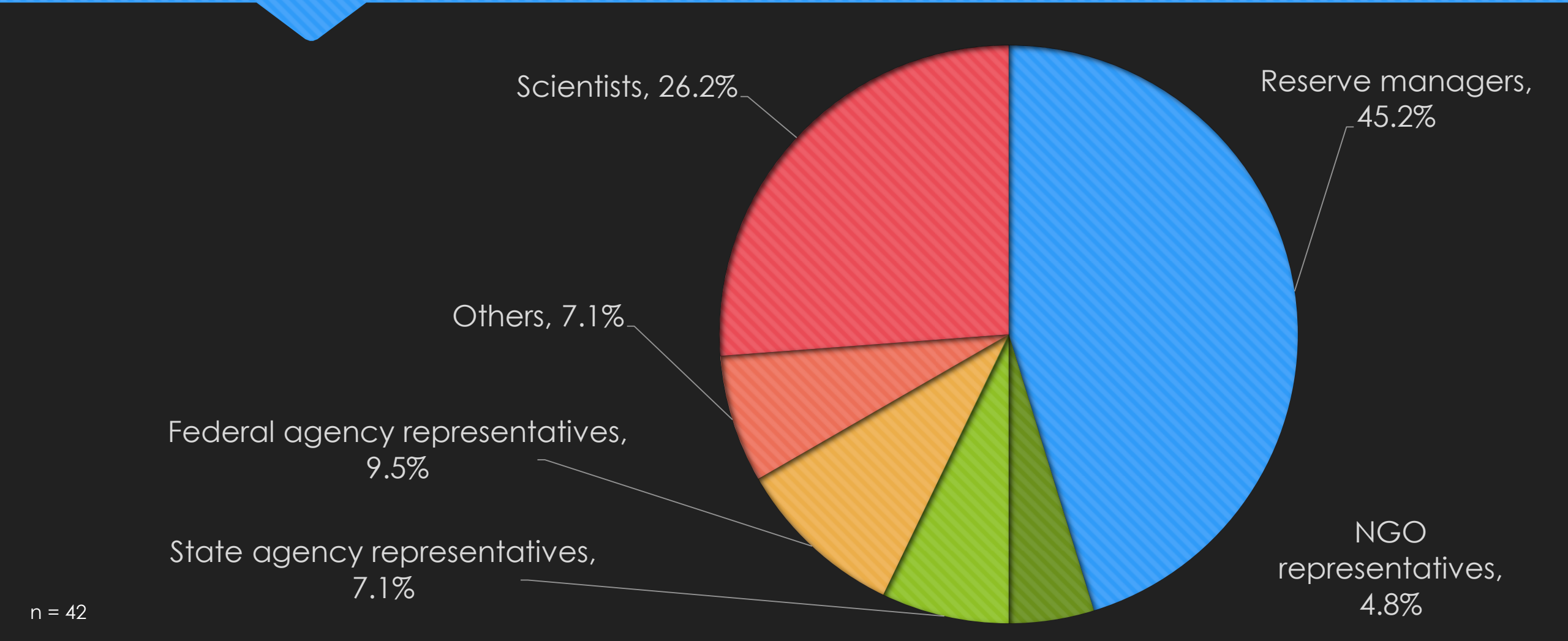
Assessment Overview



Assessment Overview

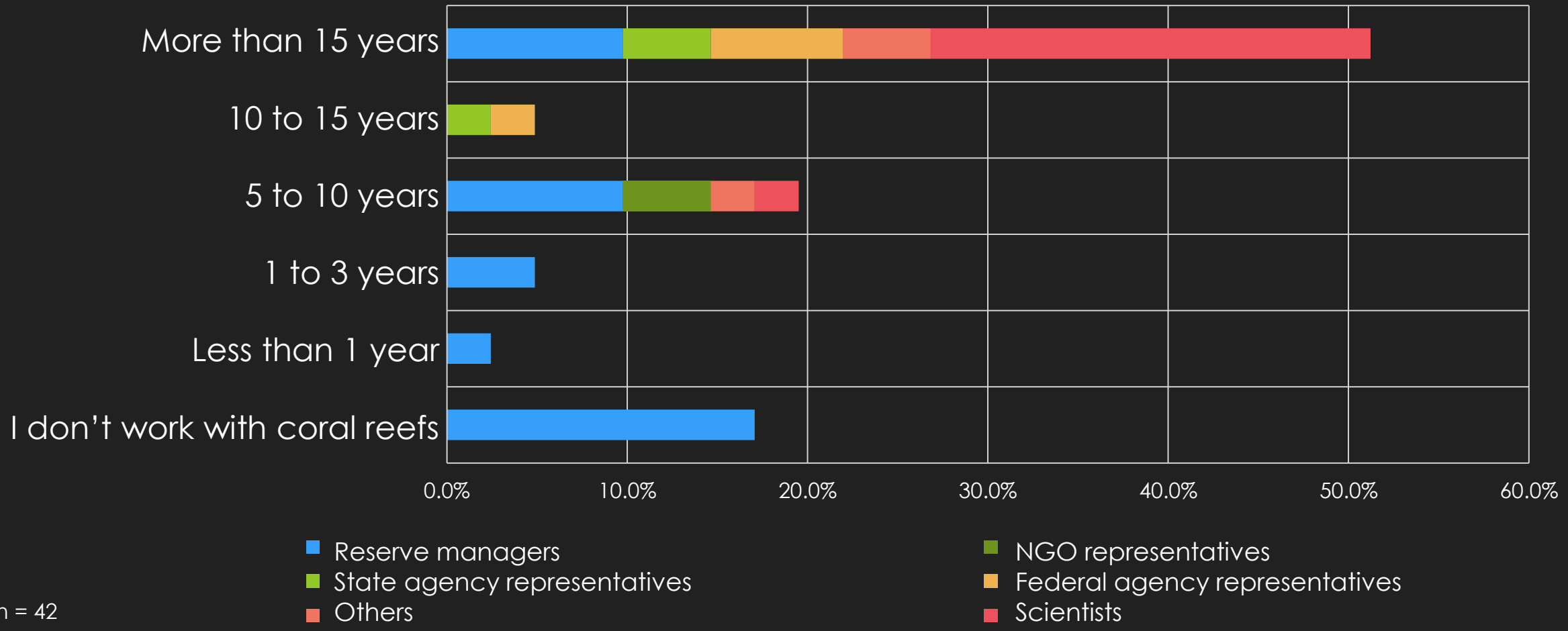


Composition of Participants



n = 42

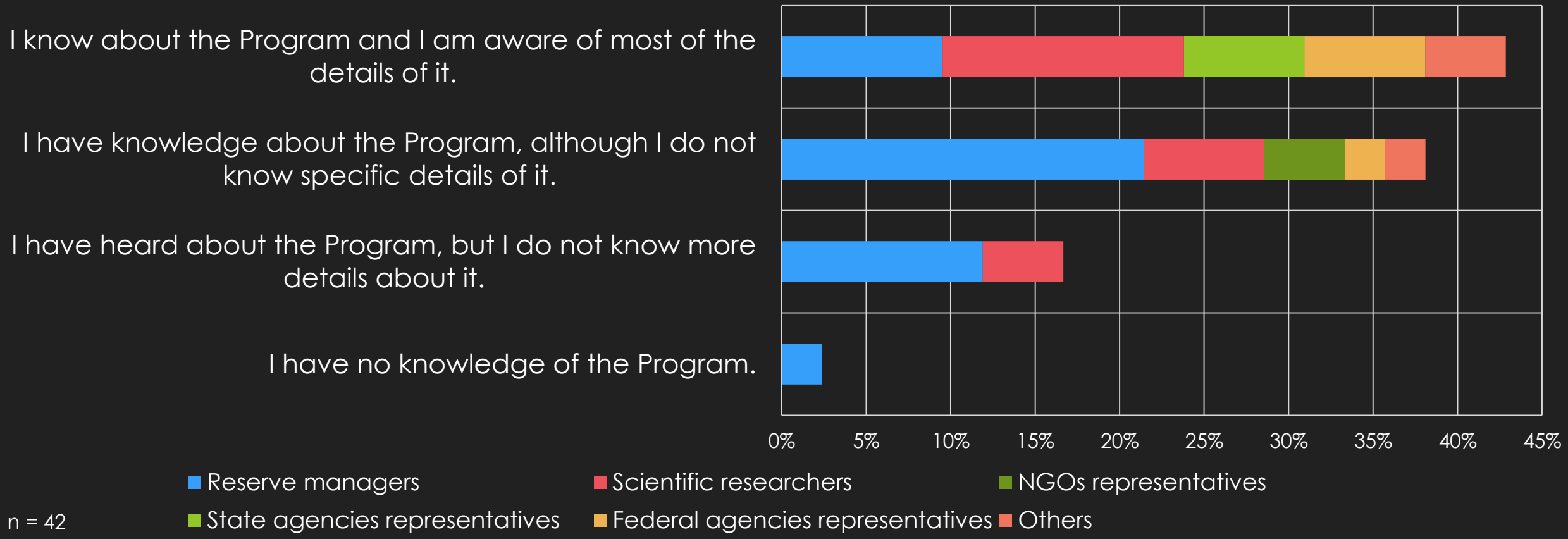
Participants' Years of Experience with Coral Reefs



n = 42

Familiarity of participants with the PRCRMP

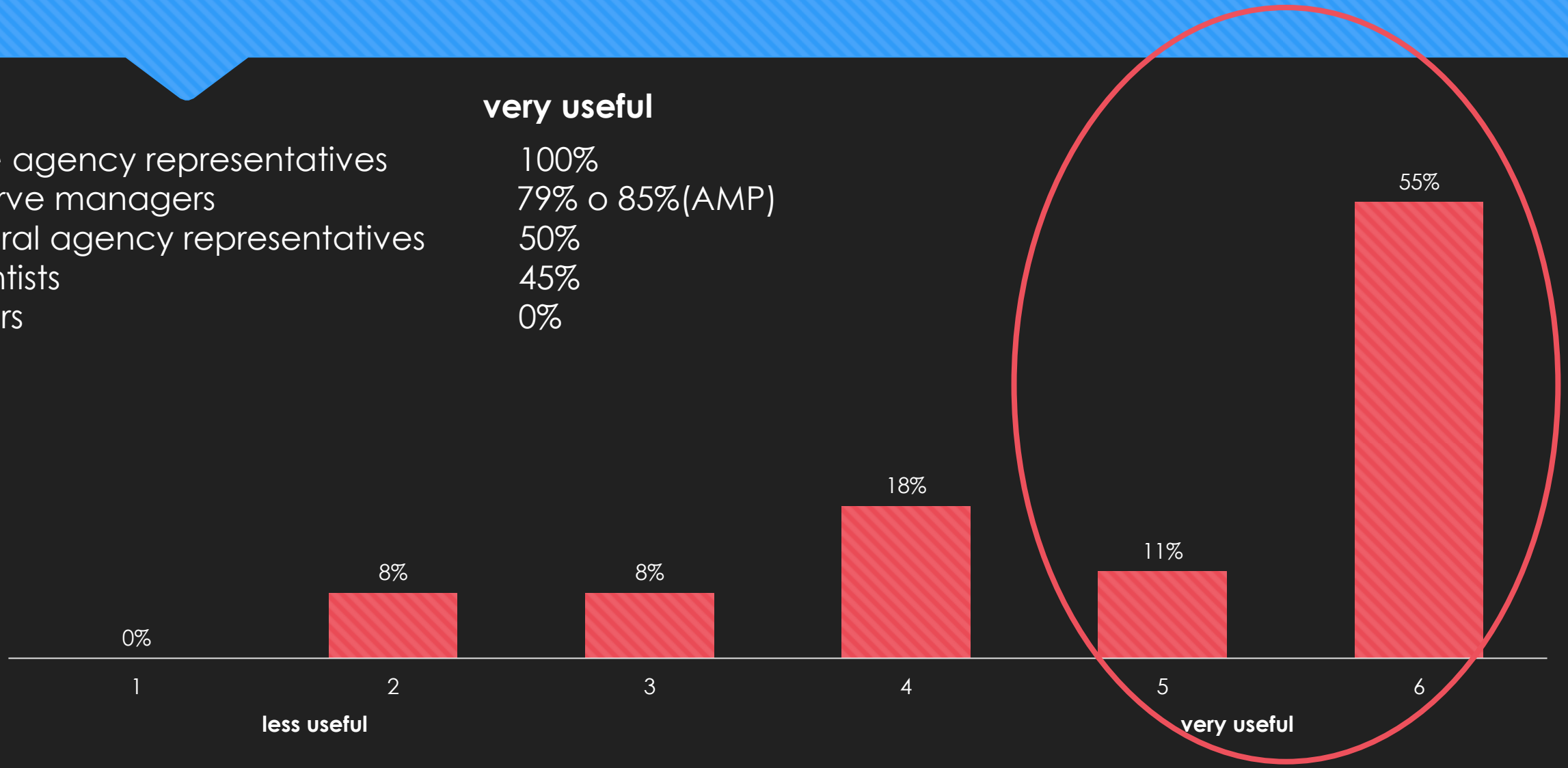
How much you know about the PRCRMP?



n = 42

How useful is the PRCRMP data for your work?

	very useful
State agency representatives	100%
Reserve managers	79% o 85%(AMP)
Federal agency representatives	50%
Scientists	45%
Others	0%



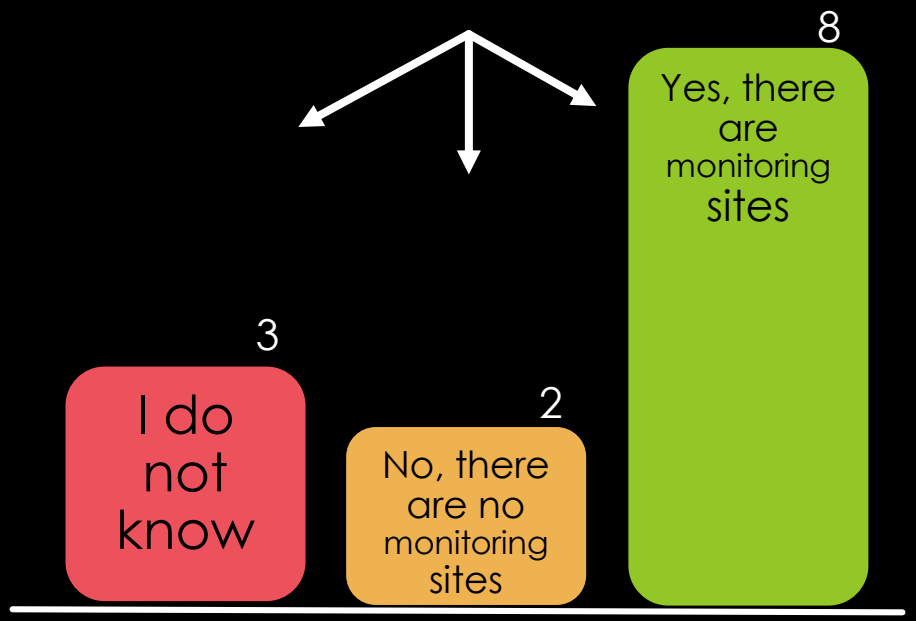
n = 38

Do you manage a reserve with a marine component?

n = 19

Yes (63%)

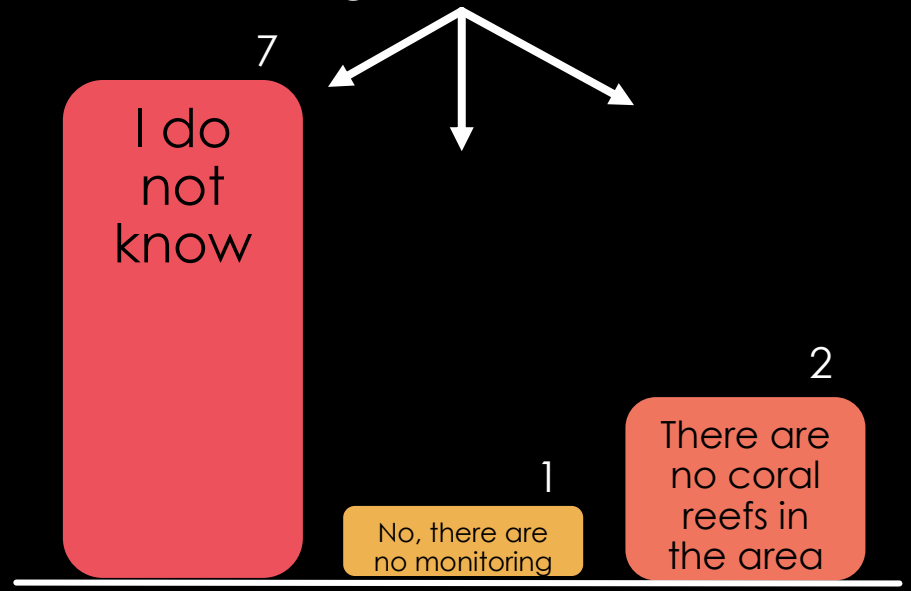
Do you know if the PRCRMP have monitored coral reefs in your management area?



n = 23

NO (37%)

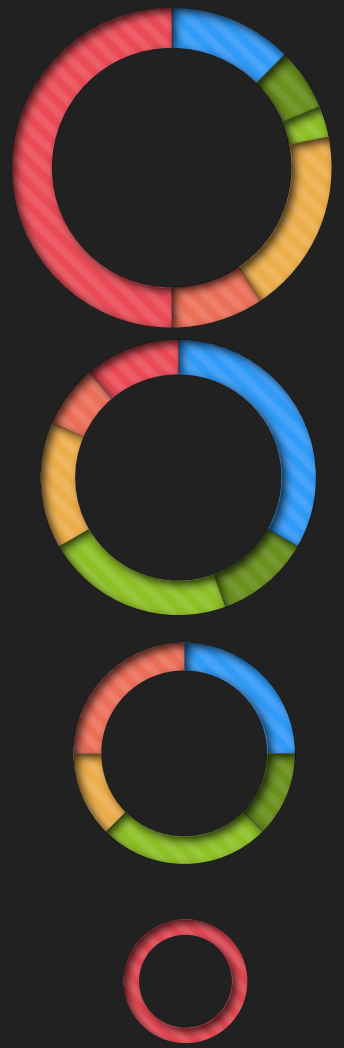
Do you know if the PRCRMP have monitored coral reefs near the watershed delta were your management area is?



The majority (**83%**) indicated that is **very important** for the management of their reserves to know the status and trends of coral reefs

n = 22

How participants use (or would use) the PRCRMP data in their work…



46% Reference

- for writing proposals, conducting research, comparing with other data and for requesting funds

39% Management

- for evaluating management actions, establishing coral farms or restoration areas, establishing management priorities and for zonification

11% Education

- for promoting conservation and restauration and for users education

4% Does not use the data

- because of issues with sampling design and data accessibility

- Reserve managers
- State agency representatives
- Others
- NGO representatives
- Federal agency representatives
- Scientists

n = 70 of 39 participants

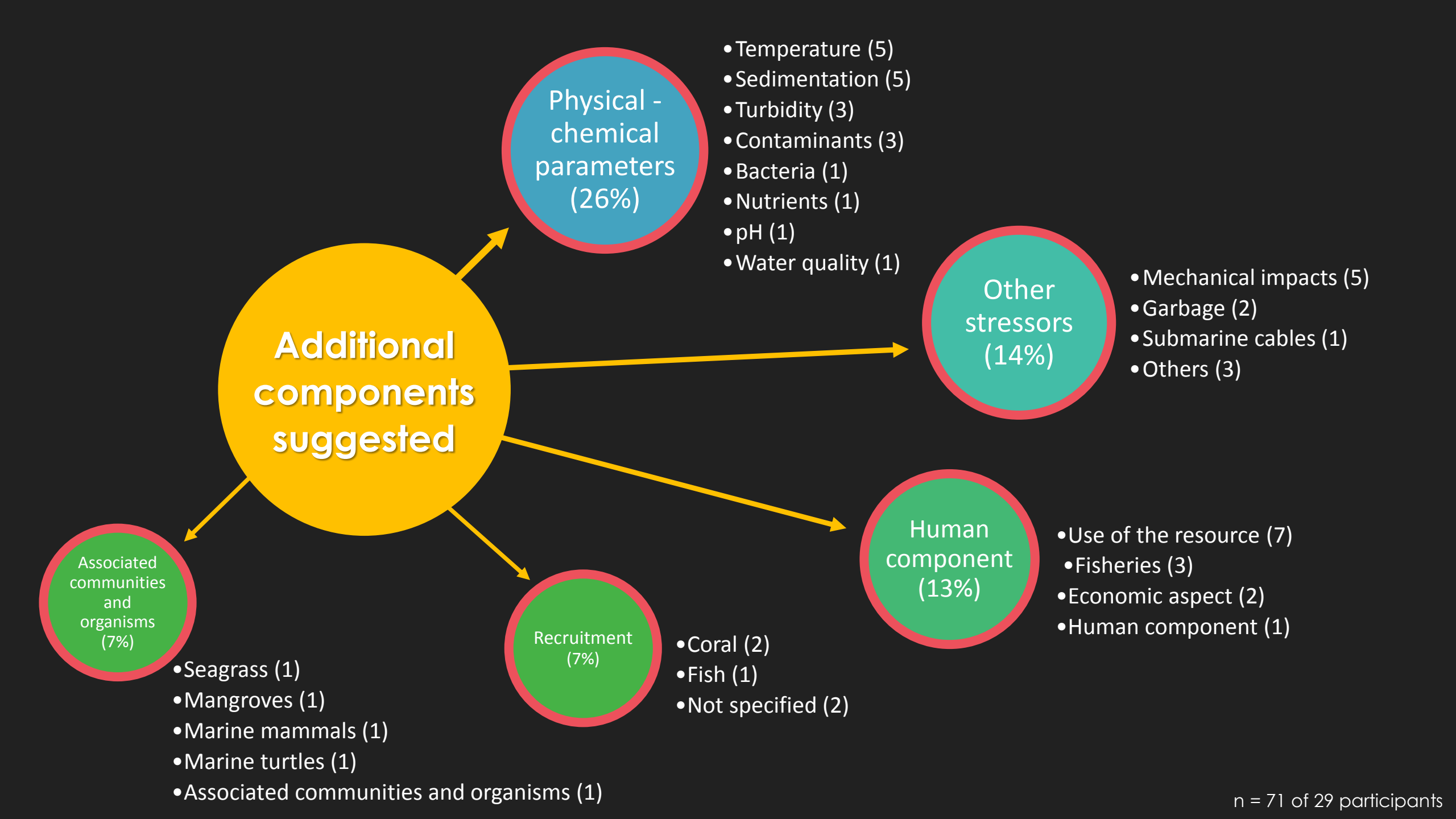
What data is collected?

- Rugosity
- Benthic organisms
  - Total percent cover
    - Abiotic (per subcategory)
    - Algae (per sp.)
    - Cyanobacteria
    - Hard corals (per sp.)
    - Soft corals (per sp. and #colonies/transect)
    - Other benthic invertebrates (per sp.)
    - Sponges (per sp.)
  - Motile megabenthic invertebrates (per sp.)
    - Species total (#sp/area)
    - Abundance (t#ind/area)
- Fish (per sp. and size (starting in 2015)
  - Species total (#sp/area)
  - Abundance (t#ind/area)
  - Biodiversity Index (starting in 2017)

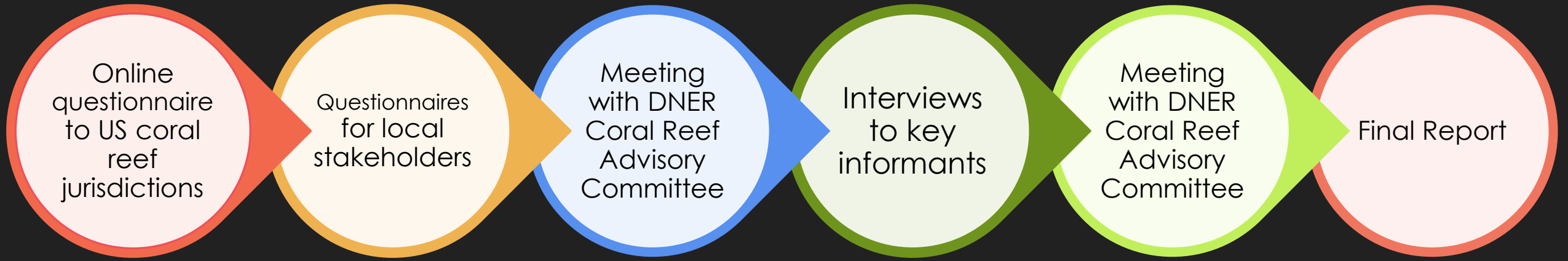
PRCRMP data analysis that scientists consider very important for the conservation and management of this resource

- 100% Changes and trends in the benthic community structure through the years
- 91% Changes and trends in the fish community structure through the years
- 91% Presence and abundance of motile macroinvertebrates as *Diadema antillarum, Panulirus argus, Coralliophila caribaea*, among others
- 82% Trends in the benthic community structure through a turbidity gradient
- 82% Presence and impacts of coral bleaching event
- 82% Size frequency of ecologically and commercially important fish species
- 73% Trends in the benthic community structure through a depth gradient
- 73% Presence and prevalence of coral diseases
- 64% Trends in the fish community structure through a depth gradient
- 64% Relationships between benthic characteristics and fish community composition
- 64% Relationships between rugosity, live coral cover, and fish abundance and diversity

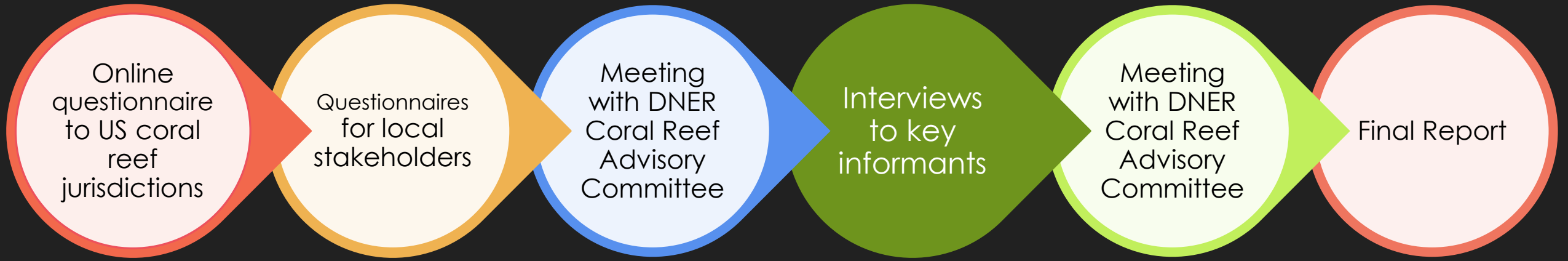
n = 11


Additional components suggested
Physical - chemical parameters (26%)
•Temperature (5)
•Sedimentation (5)
•Turbidity (3)
•Contaminants (3)
•Bacteria (1)
•Nutrients (1)
•pH (1)
•Water quality (1)
Other stressors (14%)
•Mechanical impacts (5)
•Garbage (2)
•Submarine cables (1)
•Others (3)
Human component (13%)
•Use of the resource (7)
•Fisheries (3)
•Economic aspect (2)
•Human component (1)
Recruitment (7%)
•Coral (2)
•Fish (1)
•Not specified (2)
Associated communities and organisms (7%)
•Seagrass (1)
•Mangroves (1)
•Marine mammals (1)
•Marine turtles (1)
•Associated communities and organisms (1)
n = 71 of 29 participants

Assessment Overview



Assessment Overview



Interviews to key informants to validate findings and develop recommendations

- Dates: May through June 2017
- Number of questions: 31 (the majority open questions)
- Length of interview: 45 minutes to 2 hours
- Number of interviewees: 13

RESEARCHERS

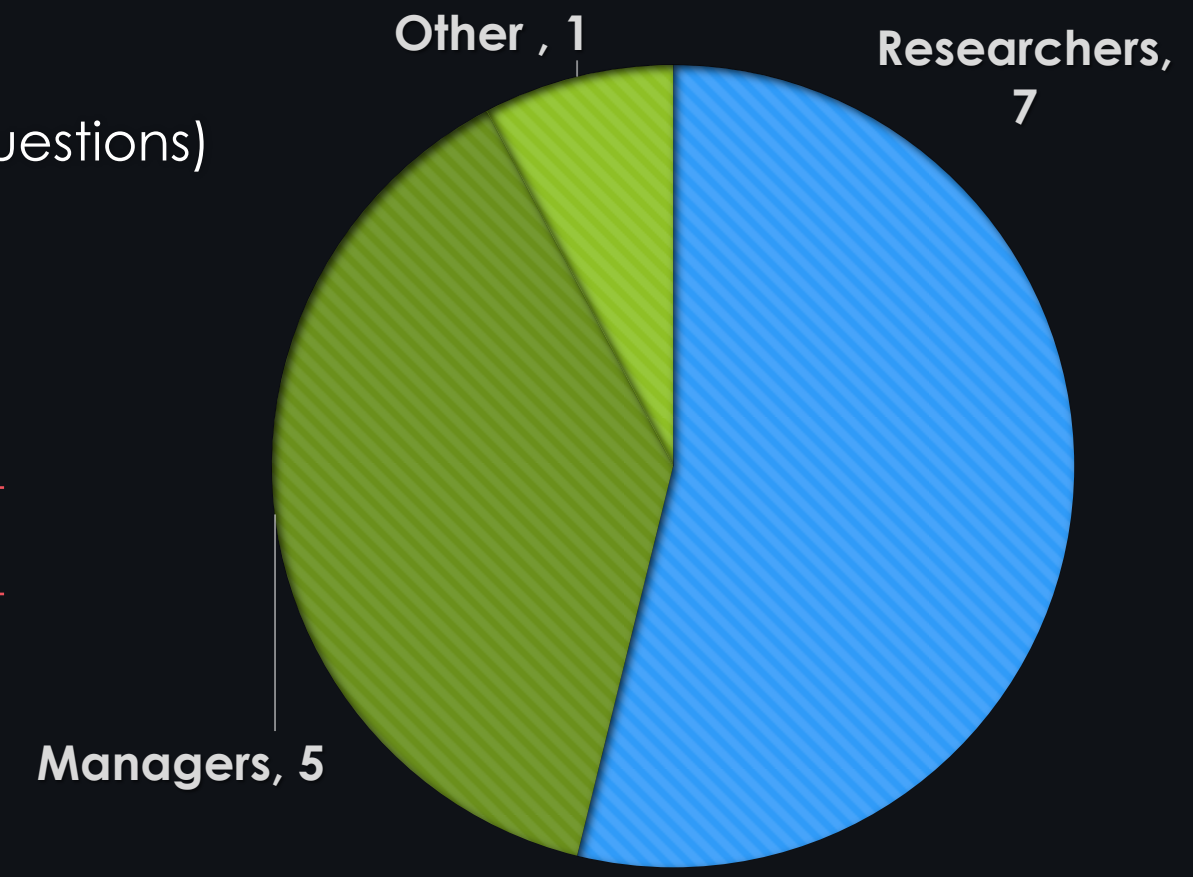
Ernesto Weil
JJ Cruz Motta
Jorge García Sais
Michelle Scharer
Richard Appeldoorn
Roy Armstrong
Stacey Williams

MANAGERS

Antares Ramos
Ernesto Díaz
Graciela García
Nilda Jimenez
Ricardo López

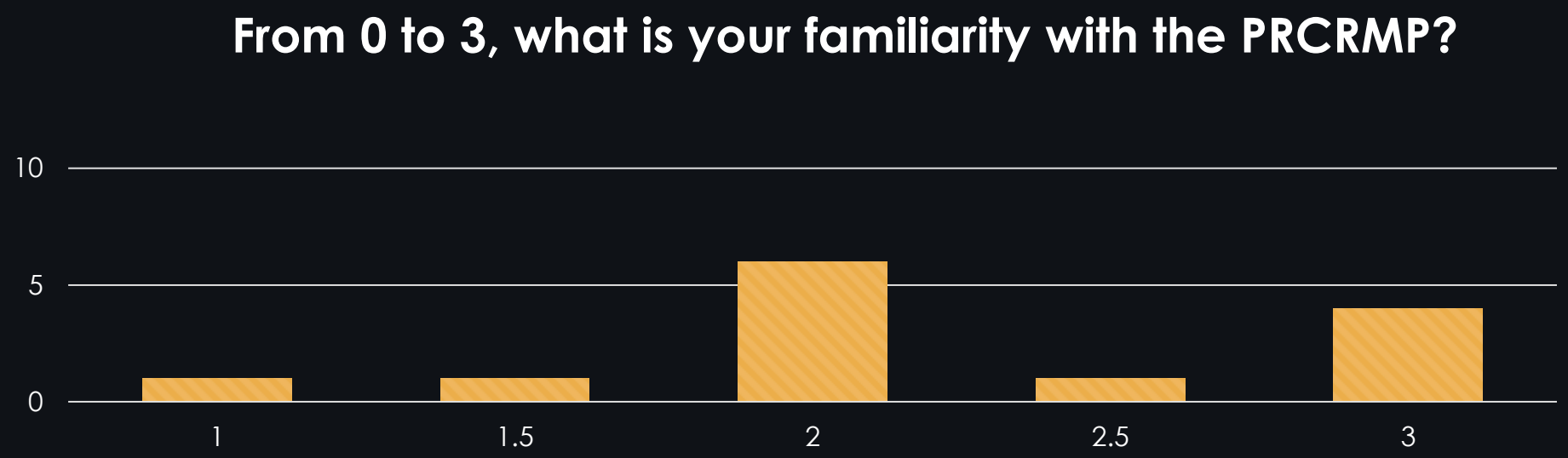
OTHER

Joel Meléndez



Before getting to the results of the interviews, consider these…

- Participants had different levels of familiarity with the Program



- Statistics place an important role in the analysis and implementation of the program. However, not all interviewees had a strong background in statistics.

Results

Advantages and Disadvantages of the Methods used by the PRCRMP and NCRMP

Most Important Data and Analysis conducted by the PRCRMP and Additional Analysis Recommended

Additional Components Suggested

Advantages and disadvantages identified by interviewees

CONTINUOUS INTERCEPT CHAIN-LINK METHOD

12/13 have worked or know about this method

- 7 Detailed and reliable to measure changes through time
- 2 Cost-effective
- 1 Simple
- 1 Variability is reduced
- 1 Quick

- Time and/or labor intensive 6
- Transect don't represent the reef community 2
- Chain may be harmful to the corals 2

Advantages and disadvantages identified by interviewees

BELT TRANSECT (FISH AND MOTILE MEGA BENTHIC INVERTEBRATES)

It is an appropriate method	5
Works in reefs with low visibility and/or high rugosity	2
You can compare with benthos and rugosity of the same transect	2
Variability is reduced	1

Transect size is not ideal for all species	2
Divers disperse fish outside of the transect	2
Size of invertebrates is not measured	1
"Cleaning stations" are not considered	1
It does not take into account the hour of the day for fish census	1

Advantages and disadvantages of NCRMP methods

Five (5) participants knew about NCRMP and four (4) only knew a litter bit

Spatial strength	5
Quick	3
Important information for DNER	2
Others	7

It can't detect changes through time, since it is random	8
To much internal variability	3
Low cost-effectivity	2
The change of the fish method (cylinder) was not validated	2
Since it is not completely random, it do not provide the real percent coral cover	2
Coral demography is conducted randomly not permanently in the same colonies	2
Others	7

NCRMP and PRCRMP

- All participants agreed that there are opportunities for collaboration
  - many specified that it is necessary to further analyze for what purposes and how the data of each monitoring program will be used
    - many were unsure on specifically how the data could be combined
  - databases of both monitoring programs are needed in order to analyze and compare the data
- A person with strong statistical knowledge most be consulted in this process

Can you identify 3 to 5 data or analysis, currently conducted by the PRCRMP, that are most important for the management of coral reefs in PR?

Six (6) of the participants said they have seen the data before and five (5) partially

In general, interviewees had difficulties answering this question

8/13 (62%) verbalized that all data and analysis are important and/or than none should be removed

4 (1 statistic, 2 researchers and 1 manager) said that a statistic analysis is required before considering removing, modifying or adding data or analysis to the program

Analysis of the PRCRMP data

Additional analysis recommended for the Program's data

- First a data base is required
- Benthic categories through time
- Analysis at diferent spatial levels
- Fish biomass
- Population analysis of motile invertebrates (flamingo, lobster, etc.)
- Diadema antillarum
- Stock assessment (fisheries biology models)
- Tendency of herbivores fish populations
- Ornamental fish
- No more information can be obtained
- Exotic species

Analysis already conducted but mentioned by the participants:

- Disease prevalence
- Encrusting coralline algae
- Coral bleaching impacts

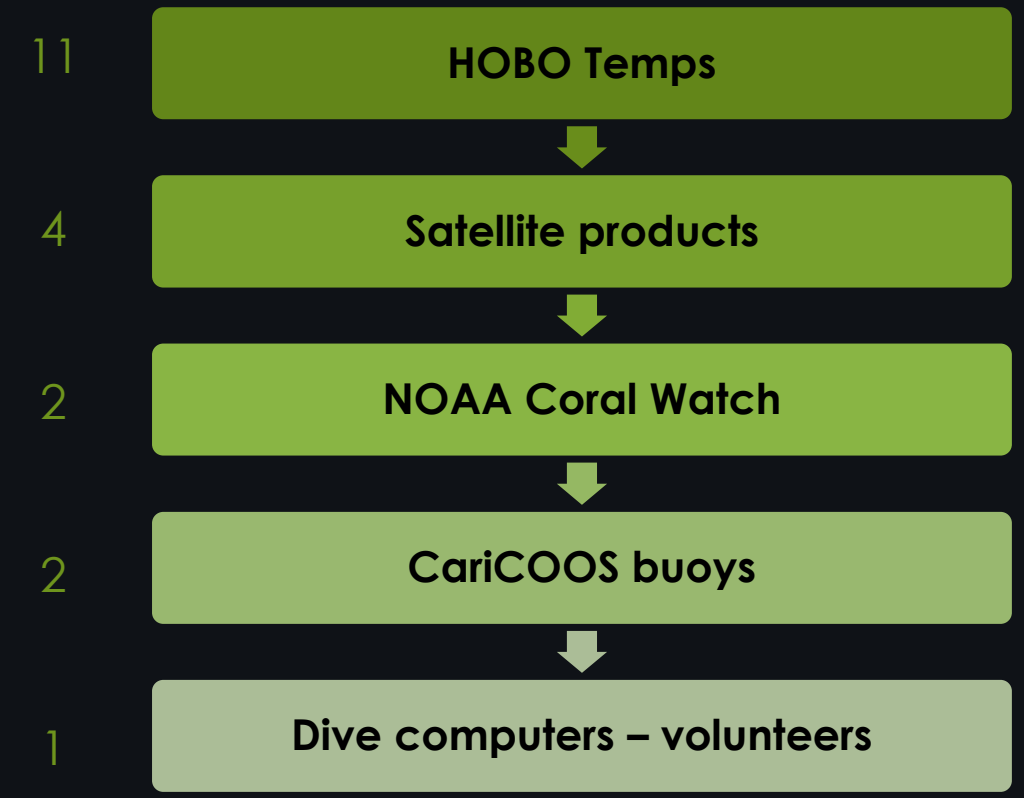
1

Temperature

Importance

- **All** interviewees coincide that temperature is important for the PRCRMP in order to:
  - assess the impacts of climate change,
  - relate the observed changes in the reef with changes in temperature,
  - assess the impacts of water discharges and acute disturbances

Methods



Coral Recruitment

Importance

- **All** interviewees coincide that coral recruitment is important for the PRCRMP in order to:
  - know the potential for recuperation after a hurricane
  - identify areas with macroalgae problems
  - know if the populations are being maintained and to restore if necessary
  - Find-out if coral species resilient to climate change are the ones recruiting

Methods

It is necessary to consider that coral recruitment is patchy, both temporally and spatially

- Some methods suggested:
  - Quadrats (25X25cm) along a transect
  - ARMS Video or photo transect
    - Florescence (>1mm)

Sedimentation

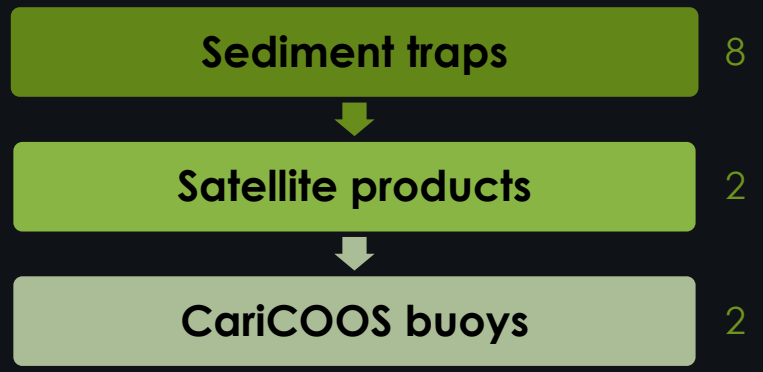
Importance

- The **majority** (69%) of interviewees consider that sedimentation is important for the PRCRMP:
  - to relate with observed changes in the reefs
  - to know the impacts of runoff
  - to know the effectiveness of sediment control strategies
  - to associate the absence of certain species with sedimentation rates
  - to determine the deposition rate and sediments source

Issues presented by 4 scientists and managers:

- "There are many doubts about the impacts of sediments in Puerto Rican coral reefs"
- "95% of the turbidity in PR is cause by chlorophyll concentrations not inorganic sedimentation"
- "Not necessarily there is a direct relationship between the BMP's implemented and the sediments measured at the nearby reefs"

Methods



Turbidity

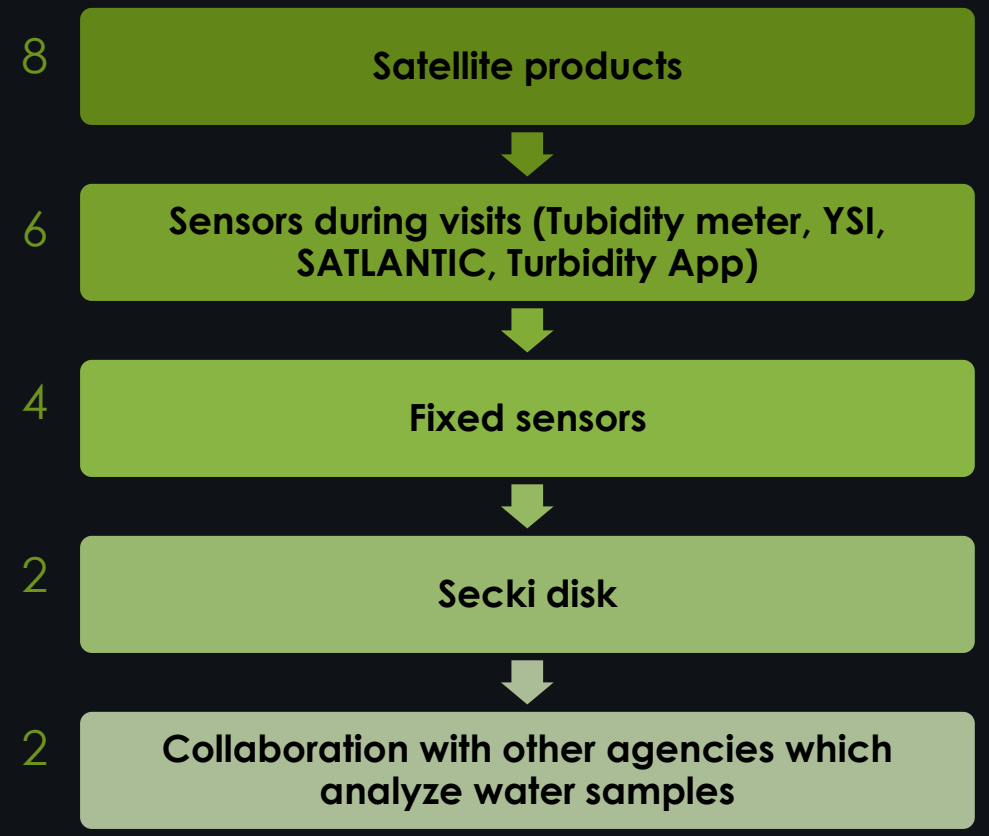
Importance

- The **majority** (69%) of interviewees consider that turbidity is important for the PRCRMP:
  - to relate with observed changes in the reefs
  - to know availability of light for corals

Issues presented by 2 managers:

- "Does not give as much information as sedimentation measurements and is more complex to measure"
- "I do not know how much information it can give about LBSP"

Methods

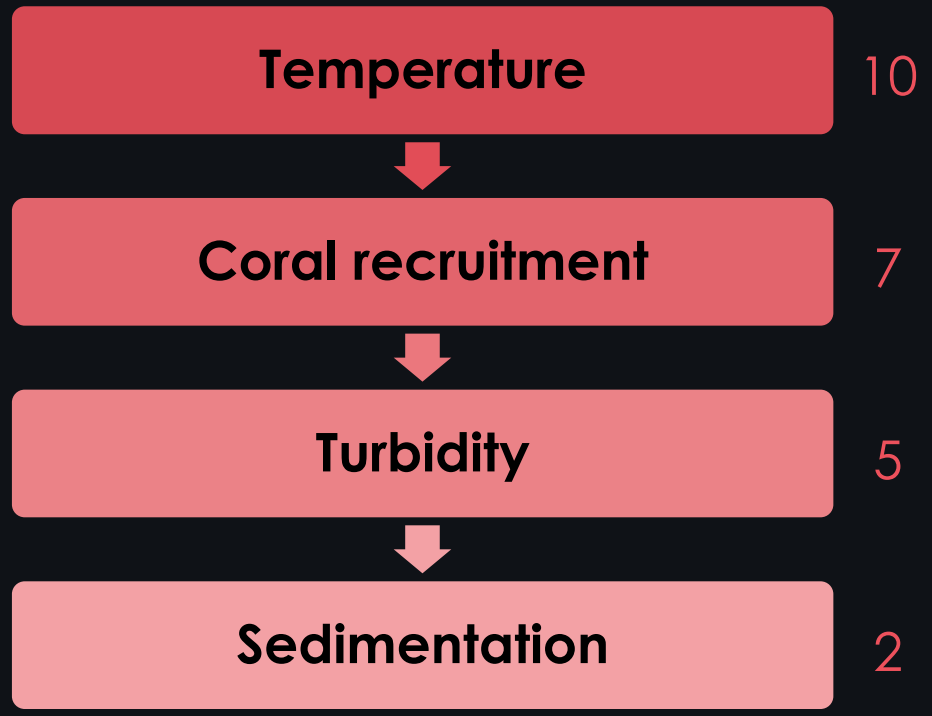


Summary about new parameters…

- Temperature was the most important parameter for the participants. They also expressed that is easy and not expensive to implement.
- Coral recruitment is very important for participants, but the specific questions and areas of interest are yet to be defined.
- Fish recruitment is already included in a certain way by measuring the length of the commercially and/or ecologically important species.

Outliers: One participant suggested that instead of adding turbidity and/or sedimentation, to add a WATER QUALITY unit. Others suggested the use of external collaborations for this matter.

If due to budget limitations we have to choose one or two monitoring parameters, which ones you think are more important?



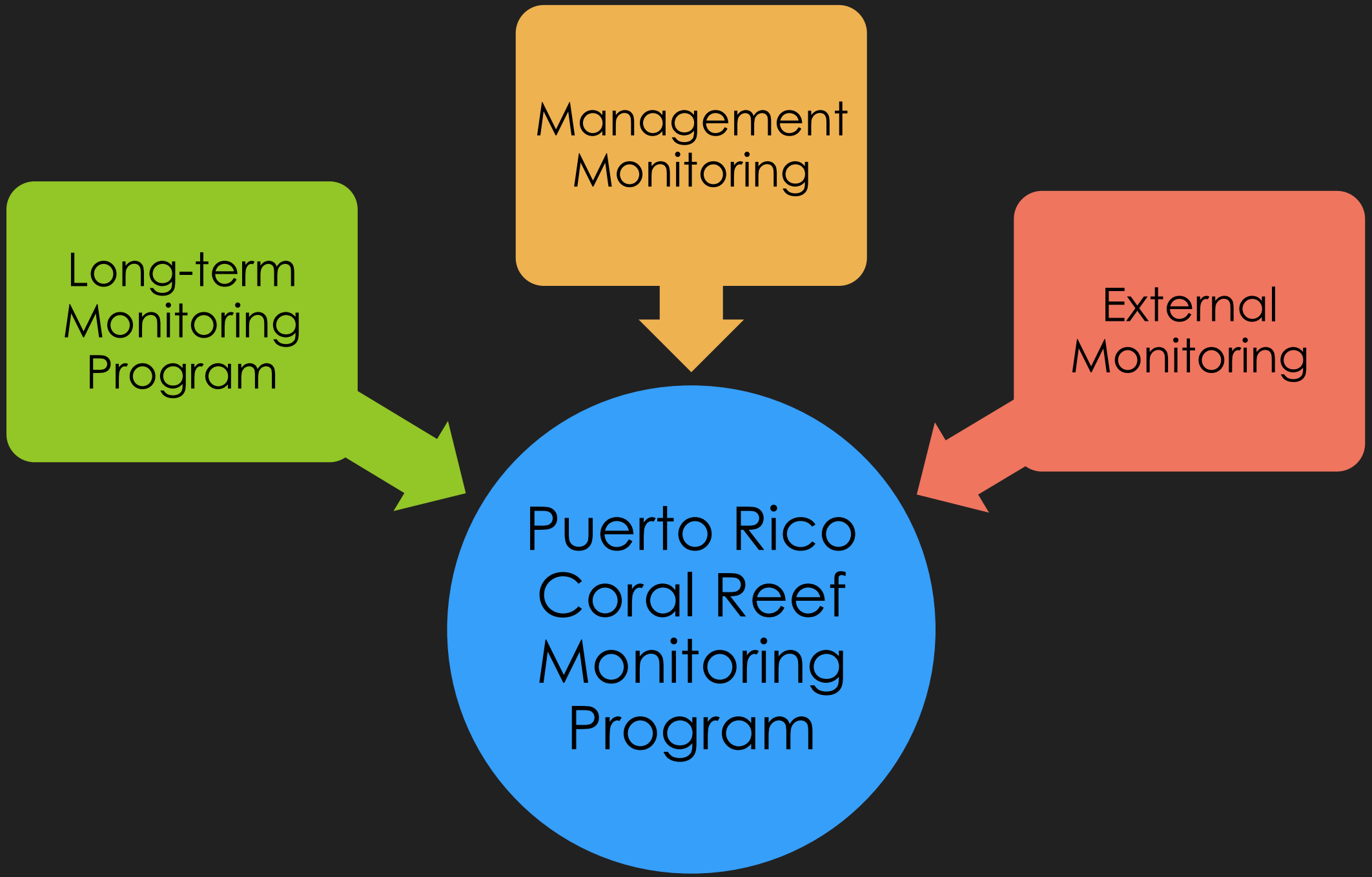
Important data compilation and analysis by the PRCRMP

Existing

- Changes and trends in the benthic and fish community structure through the years
- Presence and abundance of motile megabenthic invertebrates
- Trends in the benthic community structure through a turbidity, depth and coastal-oceanic gradient
- Presence and impacts of coral bleaching events
- Size frequency of ecologically and commercially important fish species
- Presence and prevalence of coral diseases
- Trends in the fish community structure through a depth gradient
- Relationships between benthic characteristic and fish community composition
- Relationships between rugosity, live coral cover, and fish abundance and diversity
- Changes and trends in the *Orbicella annularis* complex
- Percent cover of ESA species

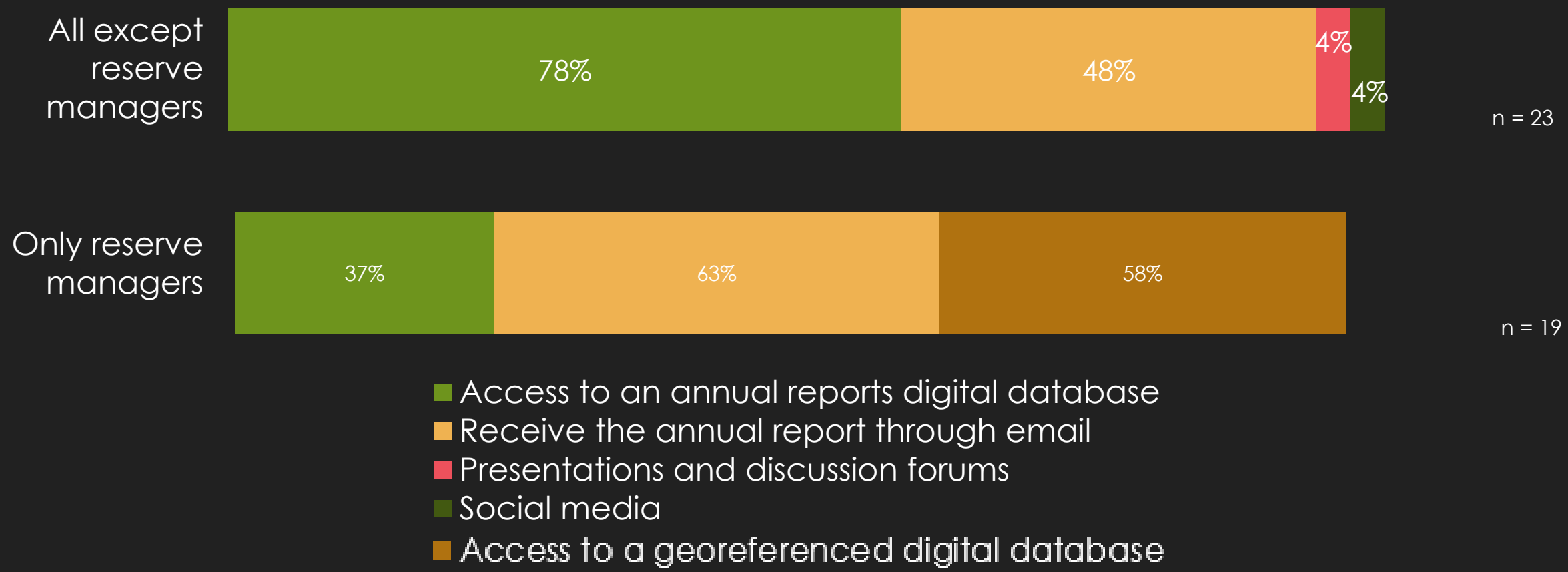
Needed

- Relationship between water temperature changes and changes in the coral reef community structure
- Coral recruitment in monitored sites and other areas of interest
- Relationship between turbidity dynamics and changes in coral reef communities
- Relationship between sediment dynamics and changes in coral reef community structure
- Effectiveness of some management strategies implemented
- Other benthic categories through time
- Changes and trends in coral reef community structure at different spatial levels
- Fish biomass
- Population analysis of motile megabenthic invertebrates
- Stock assessment (fisheries biology models)
- Status and trends of herbivore fish populations
- Exotic species


Management Monitoring
Long-term Monitoring Program
External Monitoring
Puerto Rico Coral Reef Monitoring Program

Improving data accessibility

How participants prefer to have access to the PRCRMP data?



Improving data accessibility

Compilation of all PRCRMP annual reports (1999-2017)

General information about all sites visited by the PRCRMP (1999-2017)

Compilation of PRCRMP data from 1999 to 2015

Classifications of PRCRMP current monitored sites. Not completed.

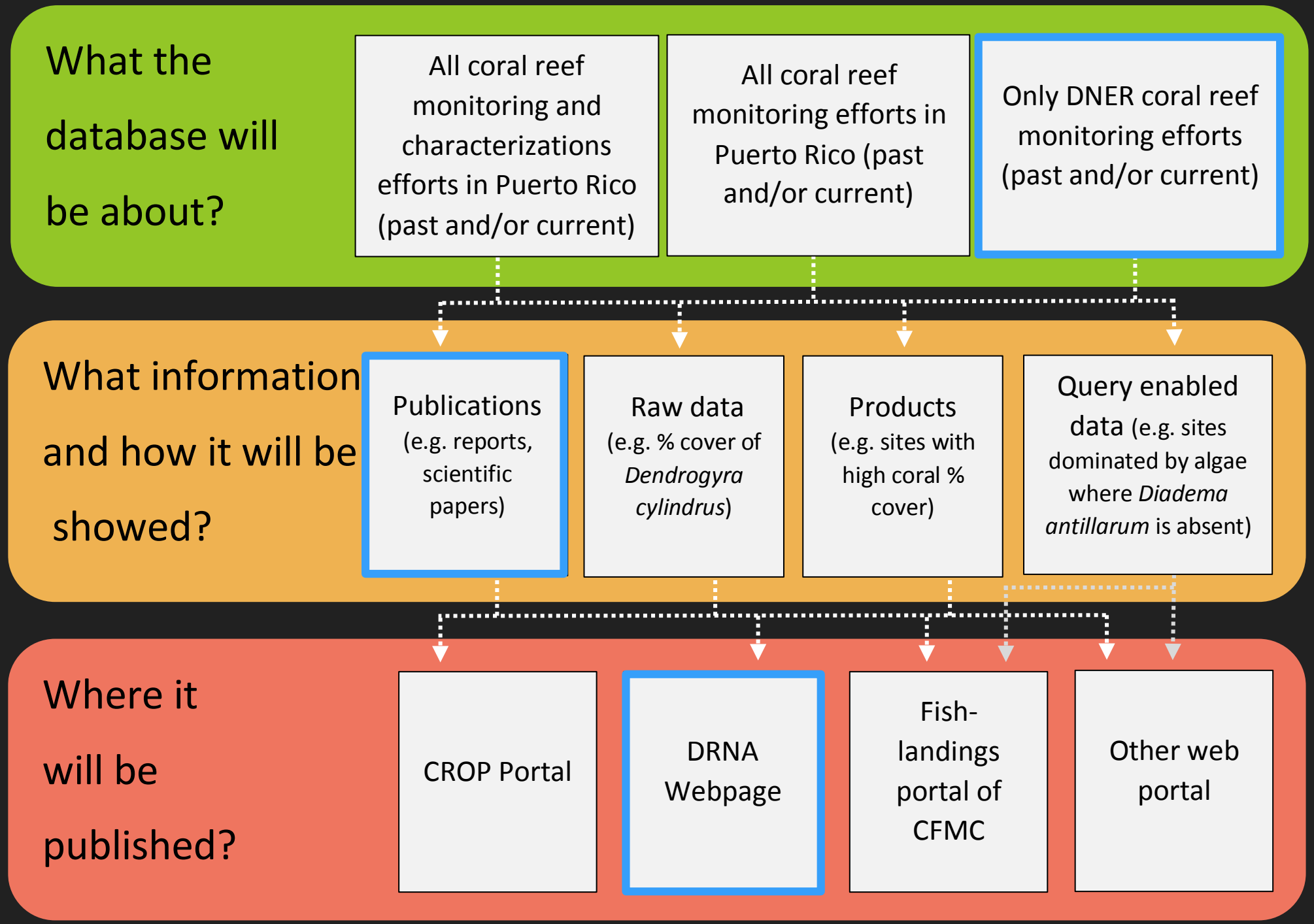
One-pager about the main findings of the PRCRMP

State of 22 Coral Reefs Monitored in Puerto Rico – State of the Coast of Puerto Rico report

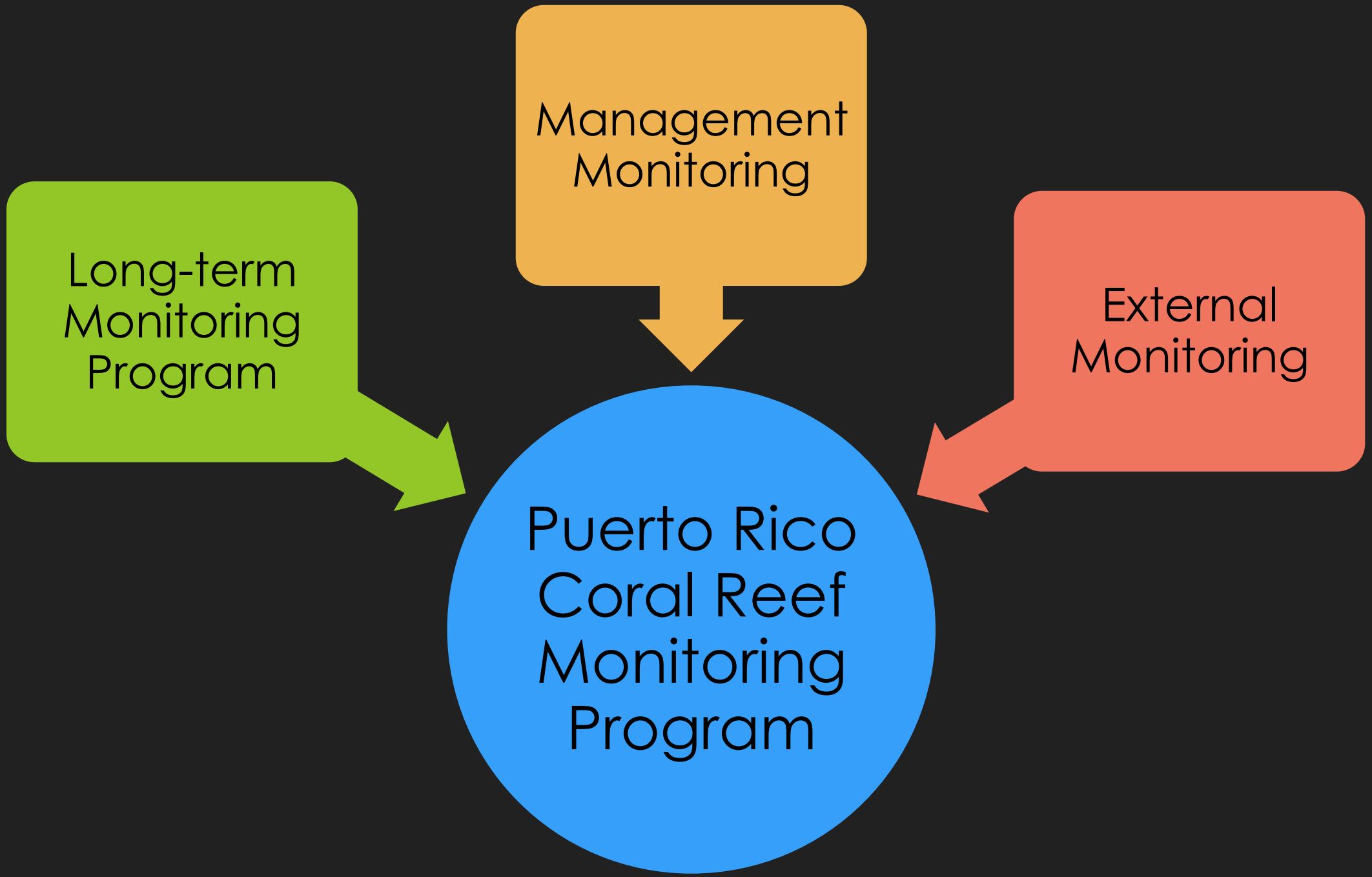
Compilation of publications about coral reef characterizations and monitoring efforts in Puerto Rico

Monitoring tab in the DNER webpage

- Interactive map
- All PRCRMP annual reports
- Summary of PRCRMP data
- Other publications of interest


What the database will be about?
All coral reef monitoring and characterizations efforts in Puerto Rico (past and/or current)
All coral reef monitoring efforts in Puerto Rico (past and/or current)
Only DNER coral reef monitoring efforts (past and/or current)
What information and how it will be showed?
Publications (e.g. reports, scientific papers)
Raw data (e.g. % cover of *Dendrogyra cylindrus*)
Products (e.g. sites with high coral % cover)
Query enabled data (e.g. sites dominated by algae where *Diadema antillarum* is absent)
Where it will be published?
CROP Portal
DRNA Webpage
Fish-landings portal of CFMC
Other web portal

Recommendations…


Management Monitoring
Long-term Monitoring Program
External Monitoring
Puerto Rico Coral Reef Monitoring Program

Education PR-CRCMP

Puerto Rico Coral Reef Monitoring Program

Monitoring within PR-CRCMP projects

Long-term Monitoring

-assess the condition and trends of coral reef communities

high detail/medium to broad spatial scale

- Monitor the status and trends in the distribution and abundance of reef organisms in selected sites around Puerto Rico
- Provide managers with a context for assessing anthropogenic impacts and for the establishment of management strategies

Management Monitoring

-assess effectiveness of management strategies and anthropogenic impacts on coral reef communities

medium to high detail/fine to medium spatial scale

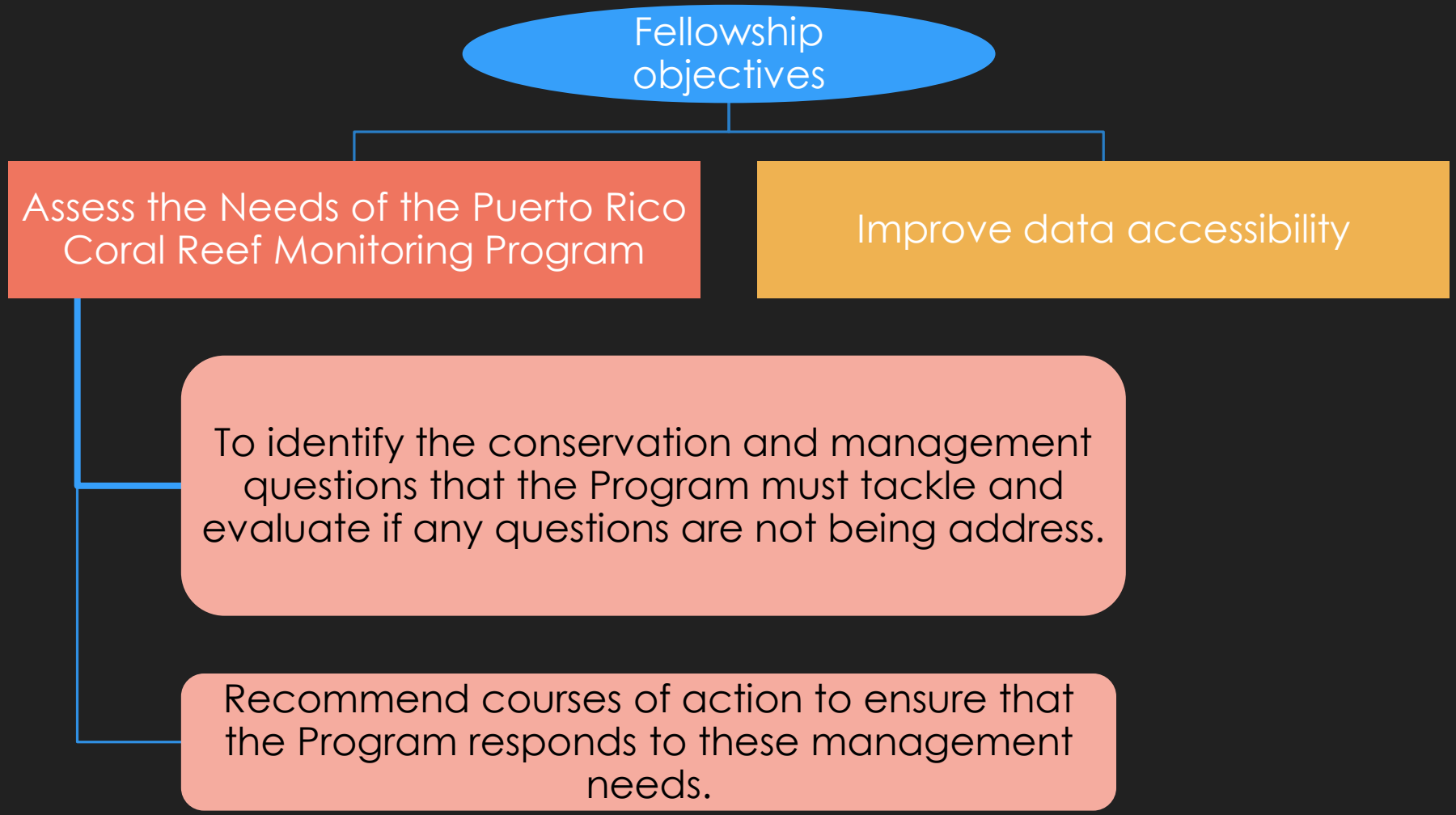
- Identify and prioritize localized management questions
- Coordinate monitoring efforts (contracts/internally/collaborations) to answer those

Water quality

External Monitoring

low to high detail/fine to broad spatial scale

- Align external monitoring efforts (eg. Reef Check, CICA, NCRMP, CFMC, EPA, SEAMAP, EQB, PREPA, CariCOOS, academy, etc.) to the DNER coral reef monitoring needs, as possible
- Coordinate new community monitoring efforts, as needed
- Provide financial and/or technical support to these efforts
- Maintain a georeferenced database of other coral reef monitoring efforts


Fellowship objectives
Assess the Needs of the Puerto Rico Coral Reef Monitoring Program
Improve data accessibility
To identify the conservation and management questions that the Program must tackle and evaluate if any questions are not being address.
Recommend courses of action to ensure that the Program responds to these management needs.

Important data compilation and analysis by the PRCRMP

Existing

- Changes and trends in the benthic and fish community structure through the years
- Presence and abundance of motile megabenthic invertebrates
- Trends in the benthic community structure through a turbidity, depth and coastal-oceanic gradient
- Presence and impacts of coral bleaching events
- Size frequency of ecologically and commercially important fish species
- Presence and prevalence of coral diseases
- Trends in the fish community structure through a depth gradient
- Relationships between benthic characteristic and fish community composition
- Relationships between rugosity, live coral cover, and fish abundance and diversity
- Changes and trends in the *Orbicella annularis* complex
- Percent cover of ESA species

Needed

- Relationship between water temperature changes and changes in the coral reef community structure
- Coral recruitment in monitored sites and other areas of interest
- Relationship between turbidity dynamics and changes in coral reef communities
- Relationship between sediment dynamics and changes in coral reef community structure
- Effectiveness of some management strategies implemented
- Other benthic categories through time
- Changes and trends in coral reef community structure at different spatial levels
- Fish biomass
- Population analysis of motile megabenthic invertebrates
- Stock assessment (fisheries biology models)
- Status and trends of herbivore fish populations
- Exotic species

Needs of the PRCRMP

Improving data accessibility

- Contract the PRCRMP Coordinator
- Expand sources of funds and collaborations
- Include temperature within the long-term monitoring unit
- Make a list and prioritize the monitoring needs by nature reserve and areas of interest
- Work with the academia to develop research questions based on DNER monitoring needs
- Database creation and statistical analysis
- Create a PRCRMP data explorer, which will allow users to see, interact and ask questions about the data. In the long-term include external monitoring efforts.
- Organize future PRCRMP data in Excel worksheets (template created)


¡Gracias!
JP Zegarra