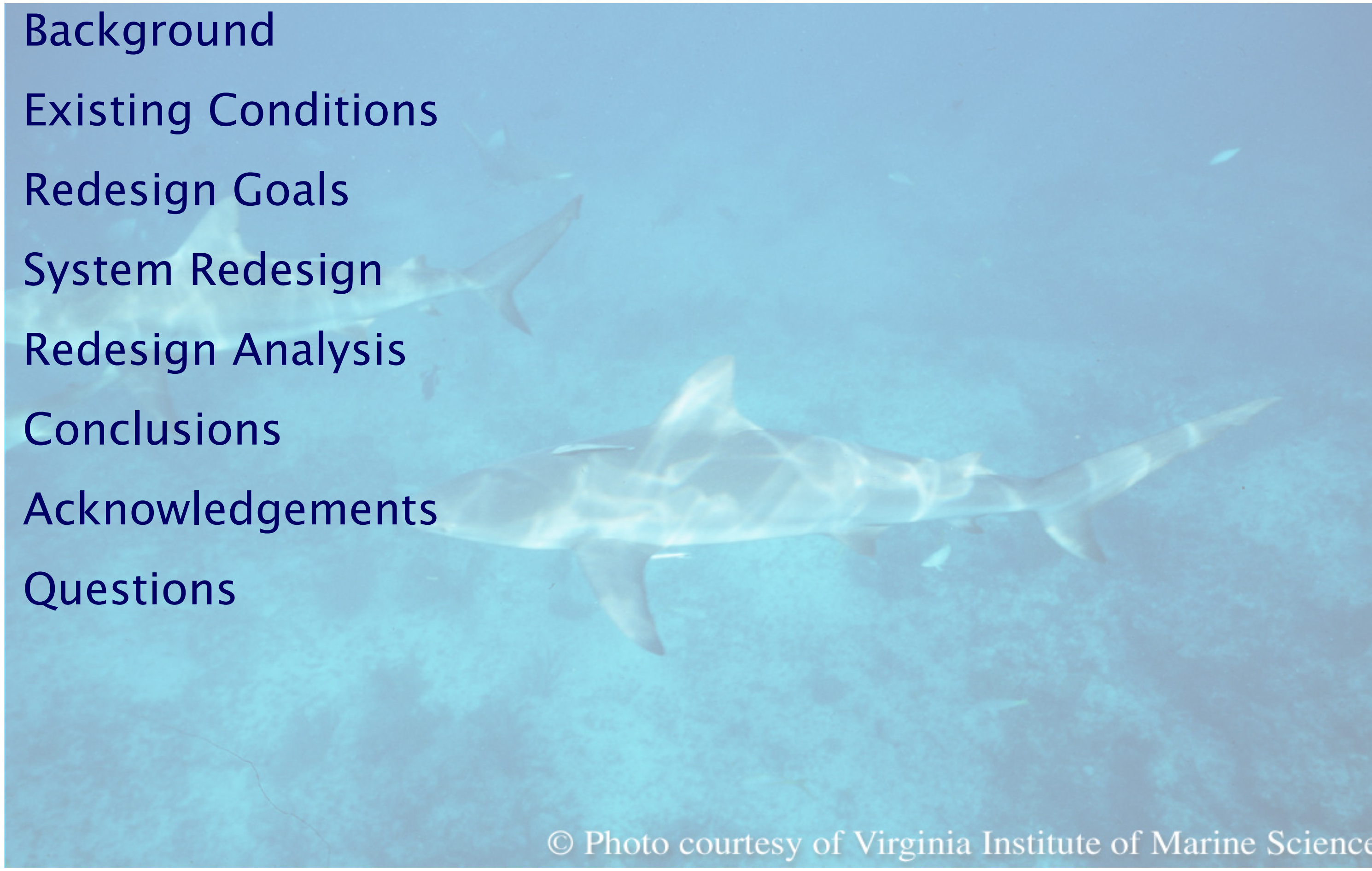
VIMS Seawater Research Laboratory

Dan DiCriscio
AE Senior Thesis
Mechanical Option
2007

Outline



- Background
- Existing Conditions
- Redesign Goals
- System Redesign
- Redesign Analysis
- Conclusions
- Acknowledgements
- Questions

Background-Building Stats

Building Size:

40,000 ft^2

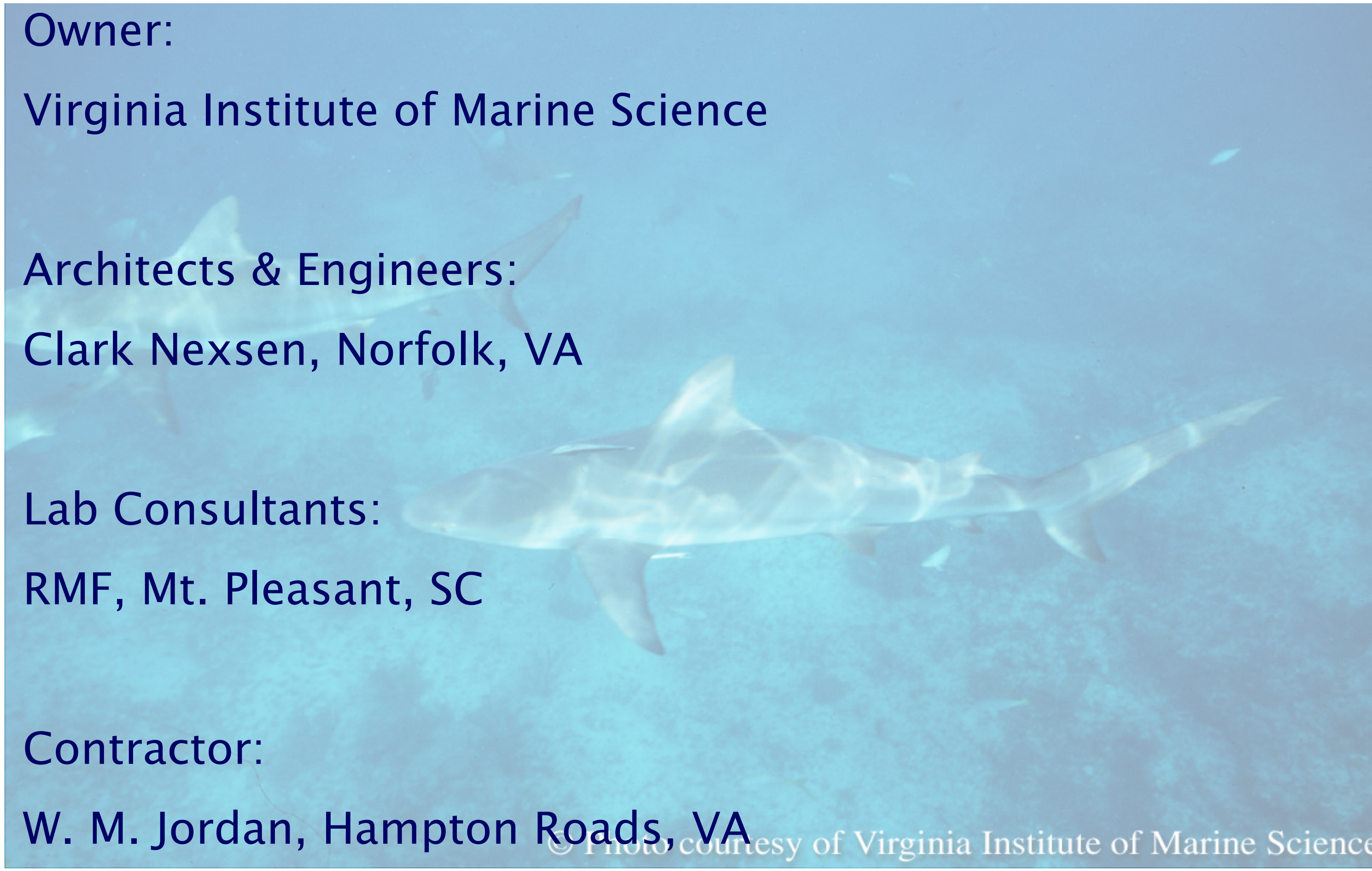
Building Type/Occupancy:

Laboratory

Construction Dates:

2005 – 2007

Background-Project Team



Owner:

Virginia Institute of Marine Science

Architects & Engineers:

Clark Nexsen, Norfolk, VA

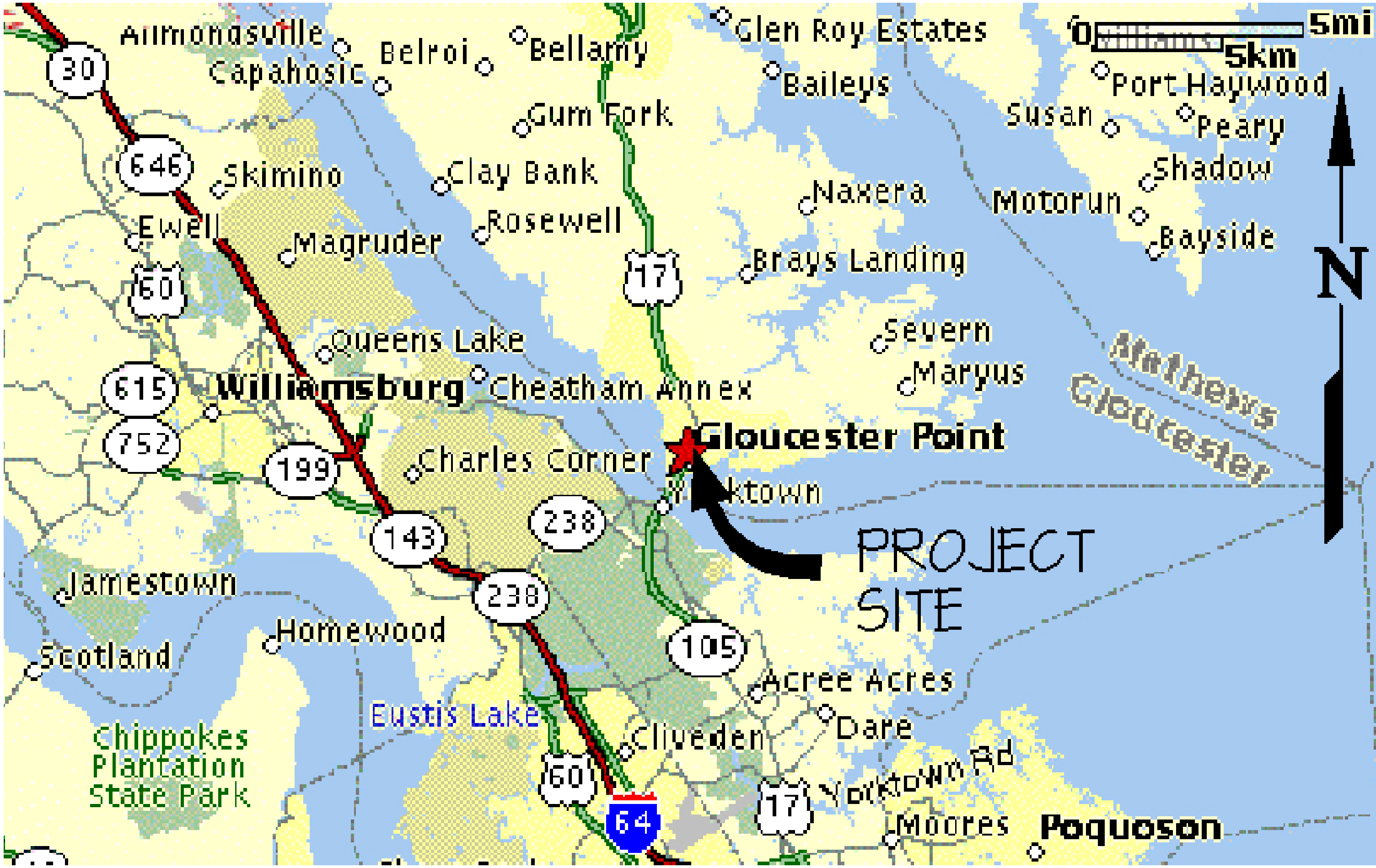
Lab Consultants:

RMF, Mt. Pleasant, SC

Contractor:

W. M. Jordan, Hampton Roads, VA

Background-Location



Background-Location

Existing Conditions

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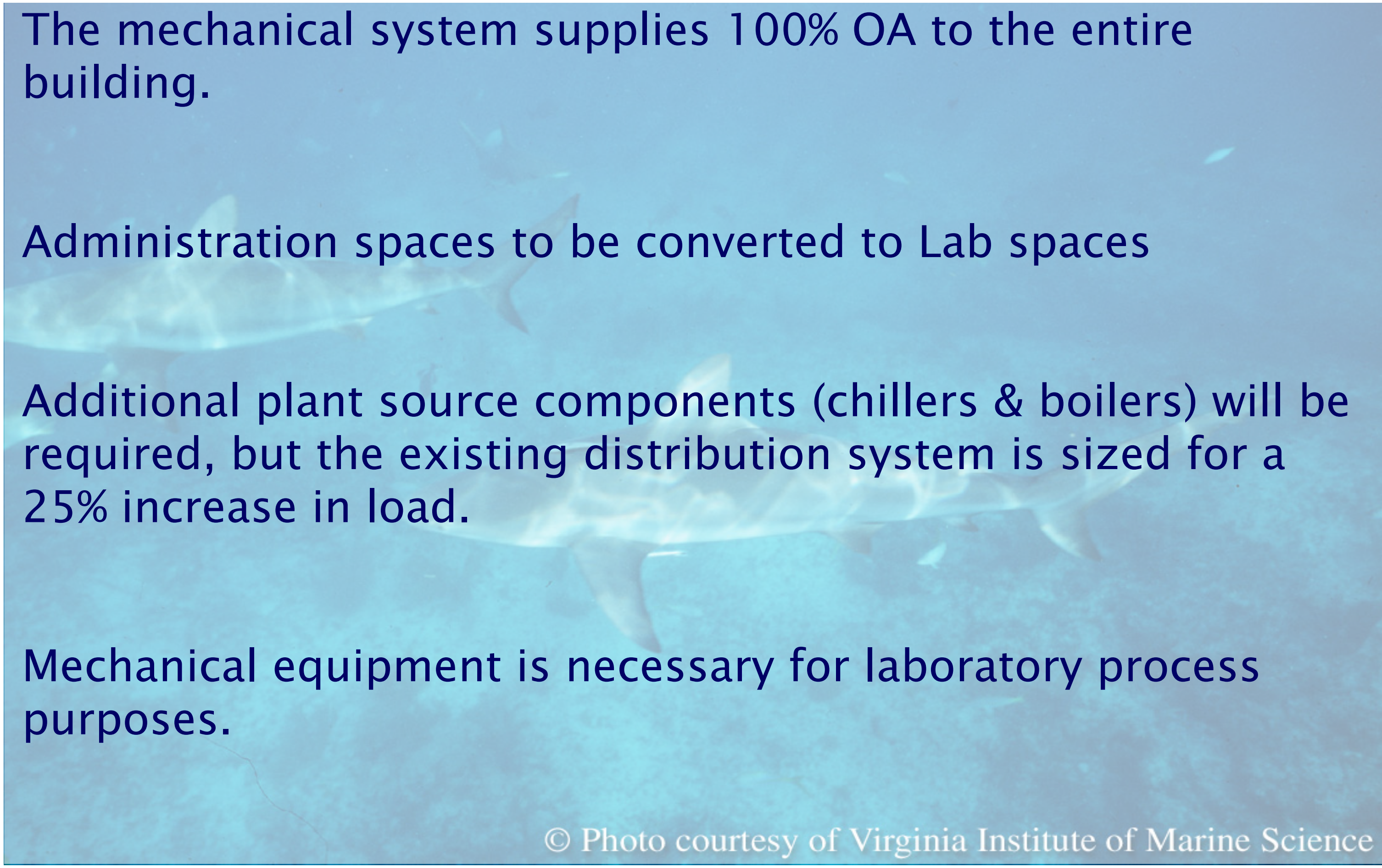


The mechanical system supplies 100% OA to the entire building.

Administration spaces to be converted to Lab spaces

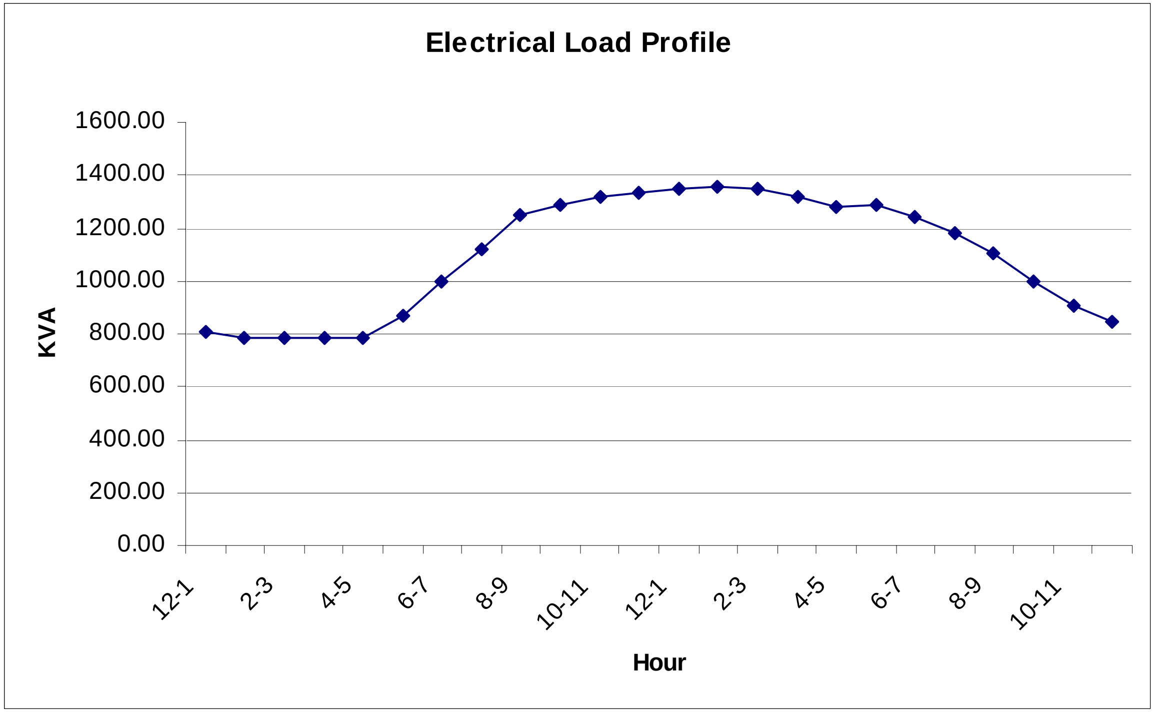
Additional plant source components (chillers & boilers) will be required, but the existing distribution system is sized for a 25% increase in load.

Mechanical equipment is necessary for laboratory process purposes.

Existing Conditions

Calculated Building Loads & Load Profile

(based on typical medium commercial load profile data from Pacific Electric & Gas Company)



Existing Conditions

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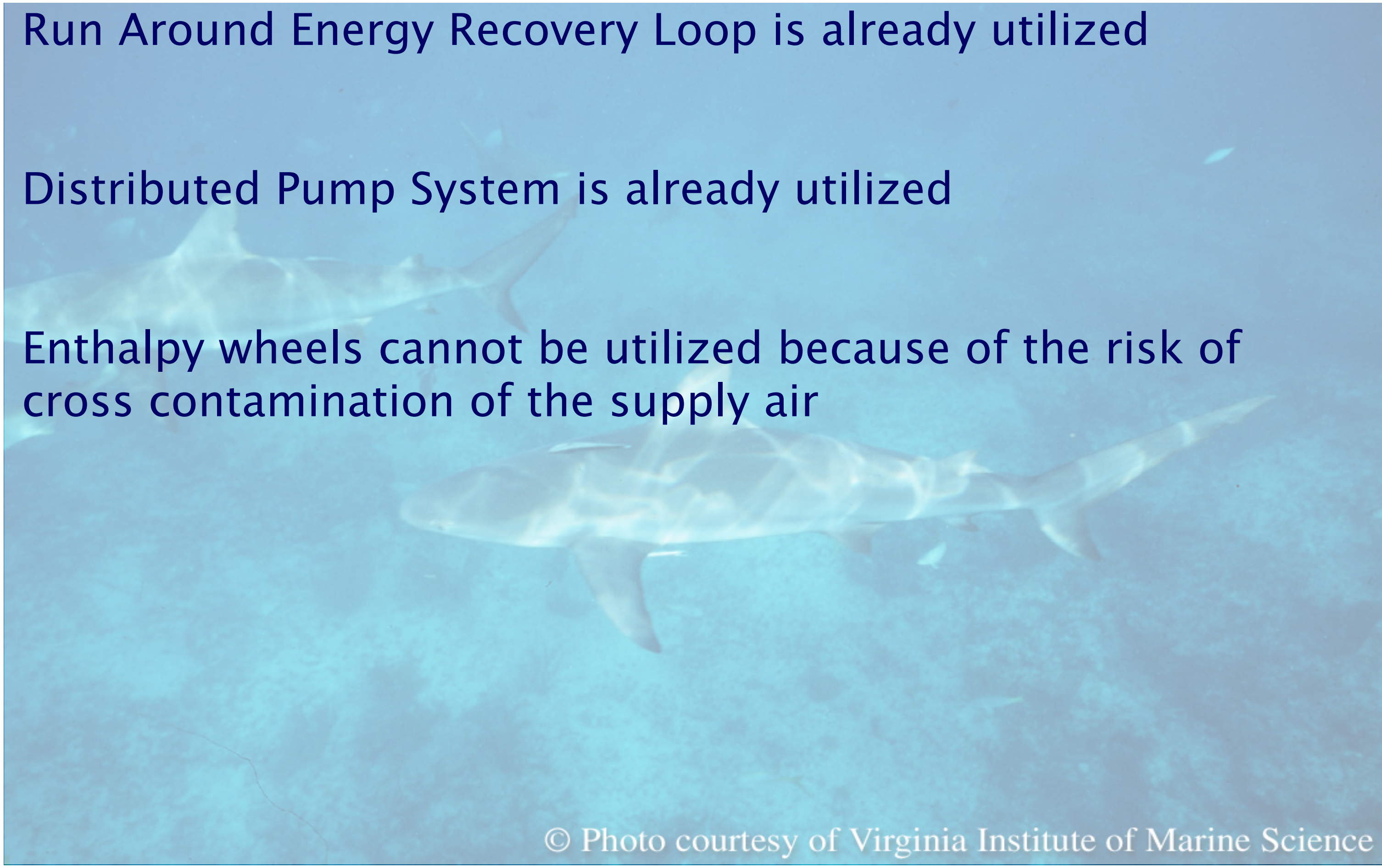
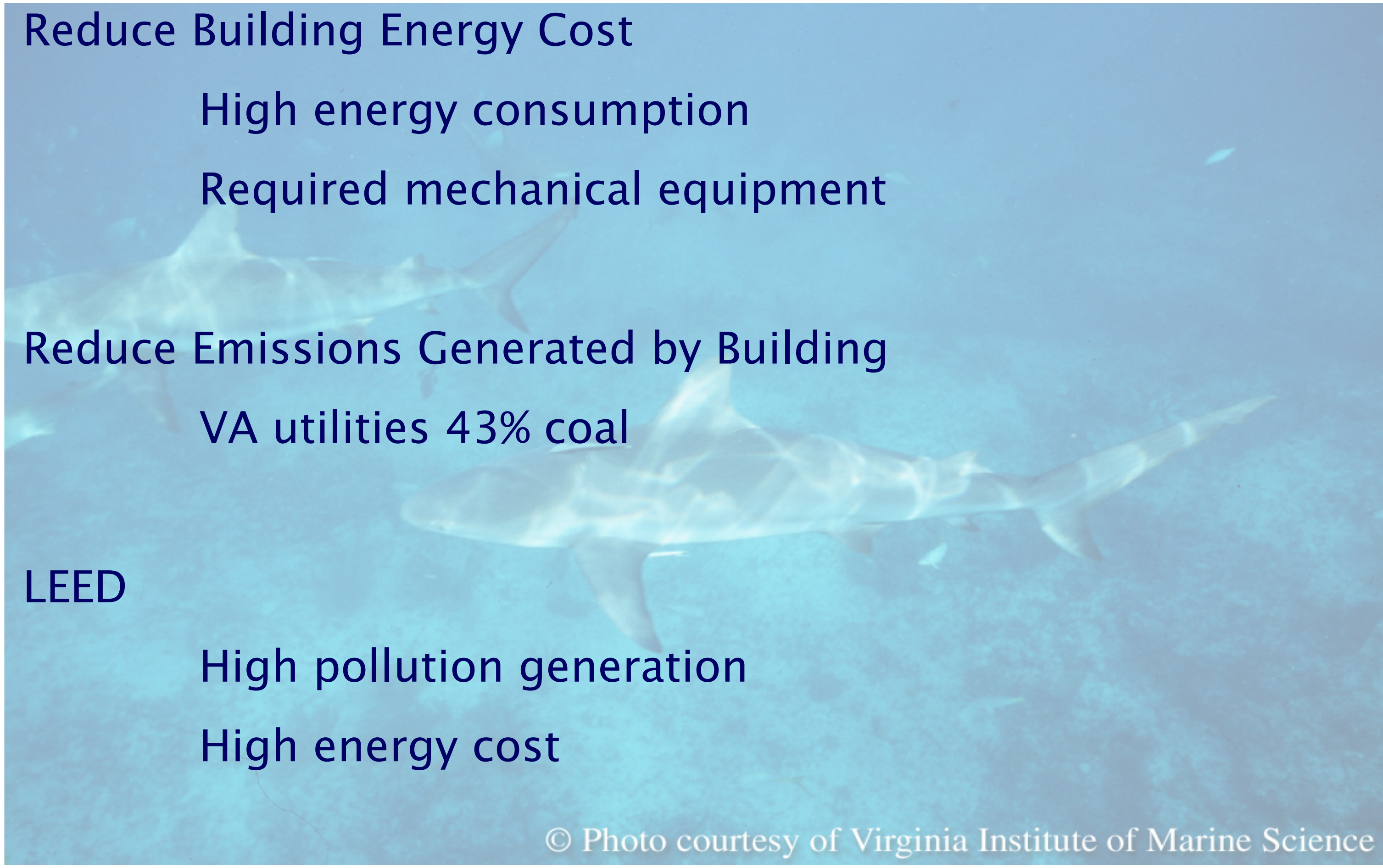
Run Around Energy Recovery Loop is already utilized

Distributed Pump System is already utilized

Enthalpy wheels cannot be utilized because of the risk of cross contamination of the supply air



Redesign Goals



Reduce Building Energy Cost

- High energy consumption
- Required mechanical equipment

Reduce Emissions Generated by Building

- VA utilities 43% coal

LEED

- High pollution generation
- High energy cost

System Redesign

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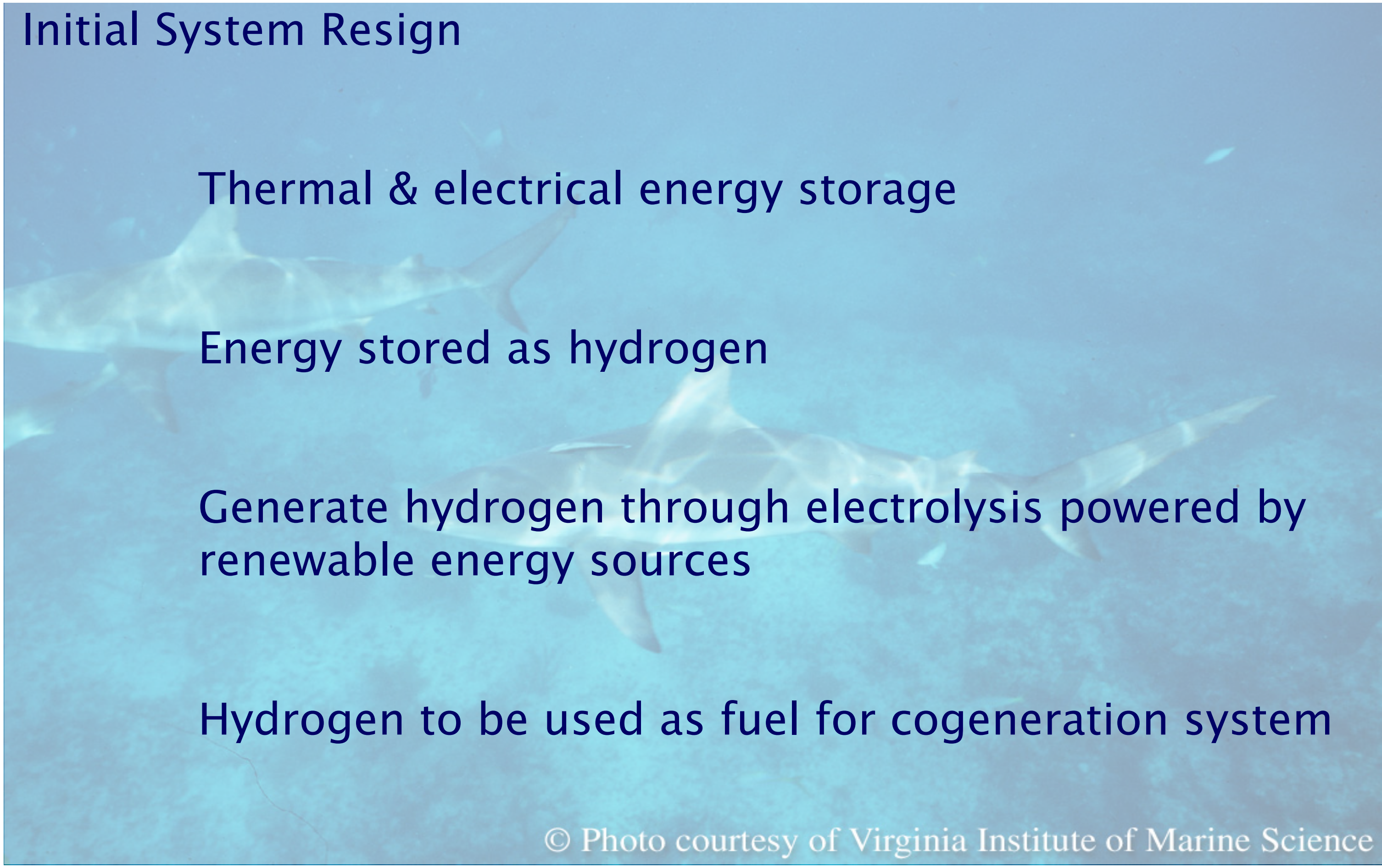
Initial System Resign



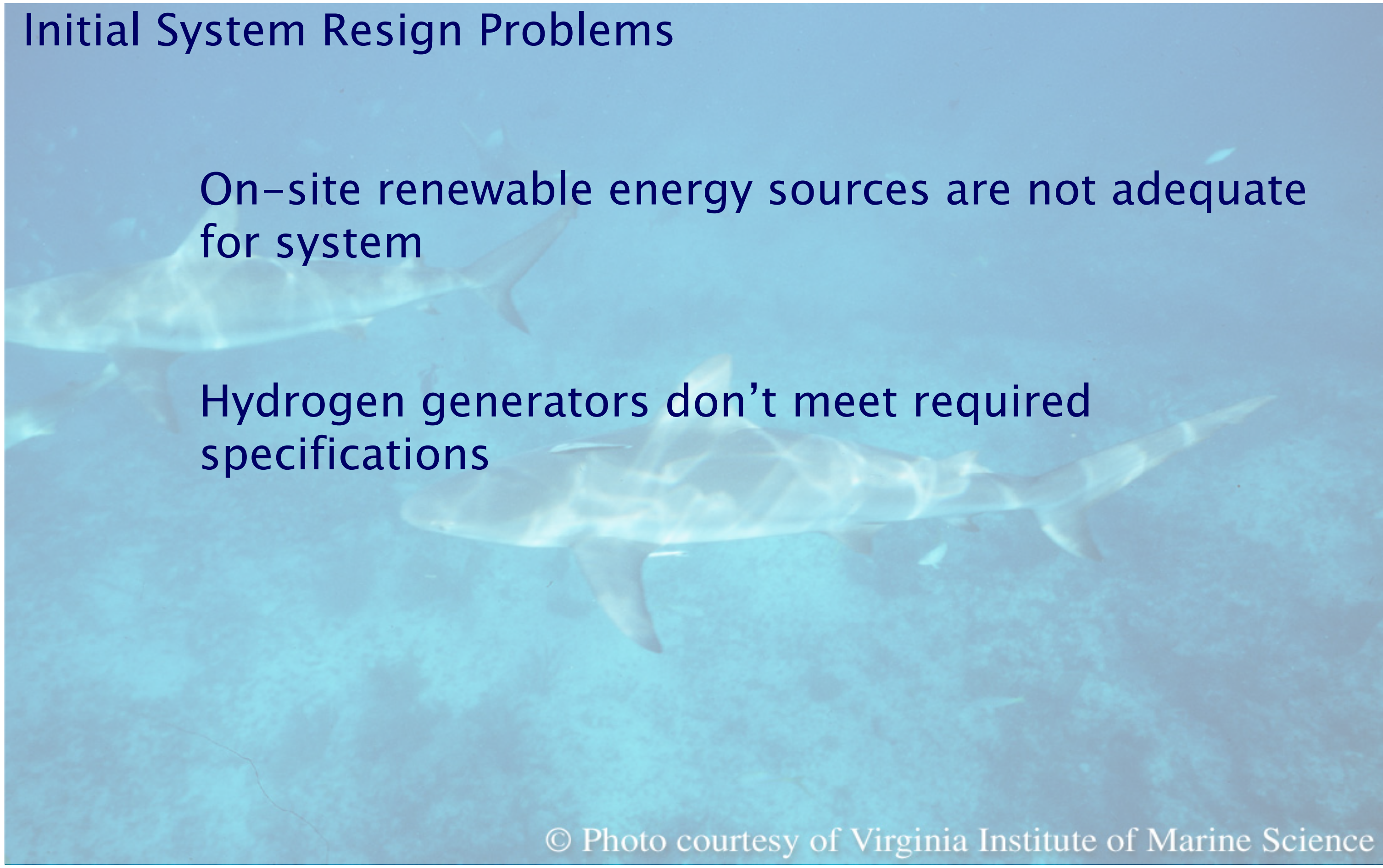
- Thermal & electrical energy storage
- Energy stored as hydrogen
- Generate hydrogen through electrolysis powered by renewable energy sources
- Hydrogen to be used as fuel for cogeneration system

System Redesign

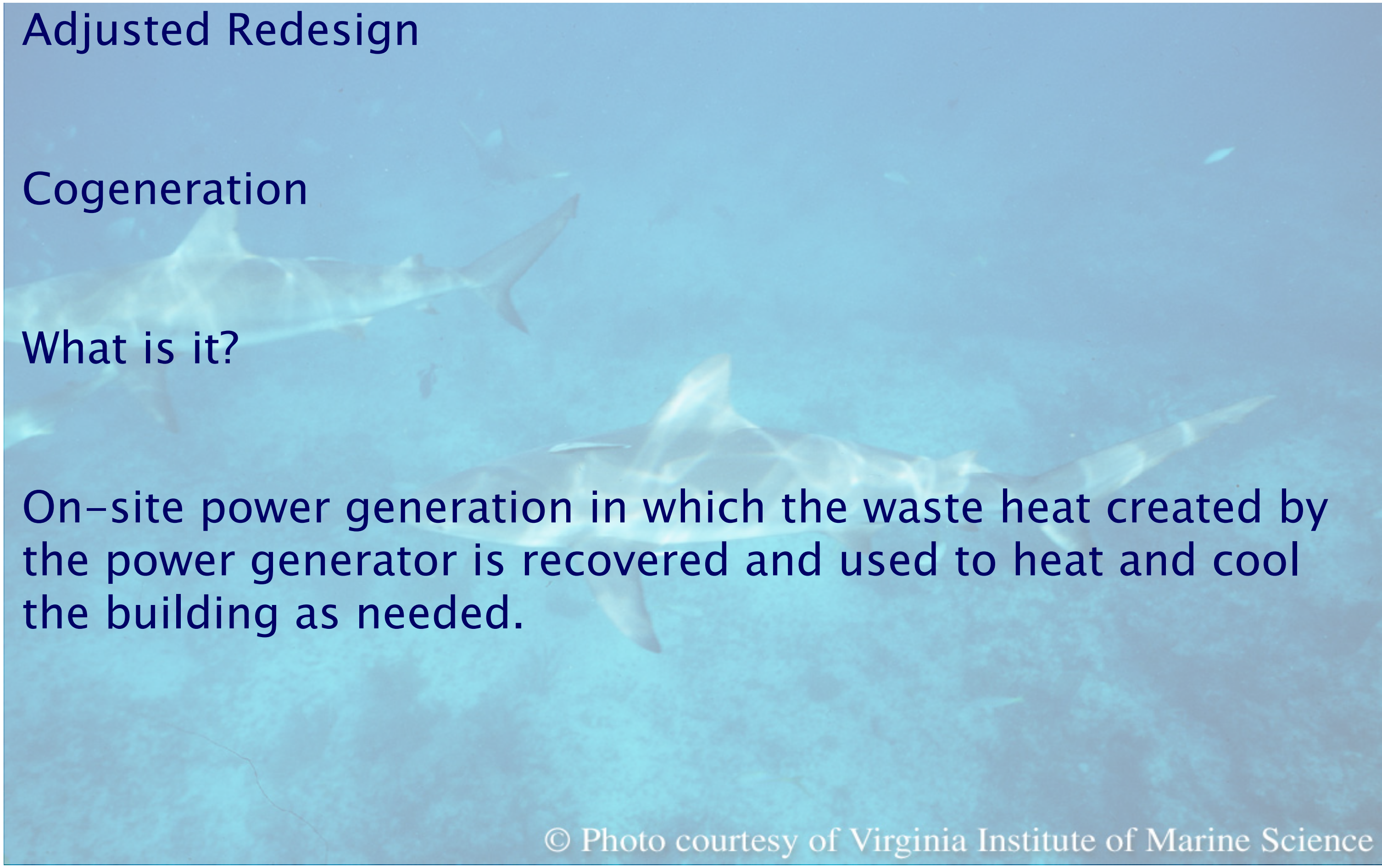
Initial System Resign Problems

- On-site renewable energy sources are not adequate for system

- Hydrogen generators don't meet required specifications



System Redesign



Adjusted Redesign

Cogeneration

What is it?

On-site power generation in which the waste heat created by the power generator is recovered and used to heat and cool the building as needed.

System Redesign - Equipment

Cogeneration

Equipment Options?

Typically the 4 most common types of generators are:

I.C.R. Engines	Too Noisy
Fuel Cells	Too Expensive
MicroTurbines	Lacks Adequate Thermal Capacity For District Applications
Gas Turbines	Good Fit For Design

System Redesign - Equipment

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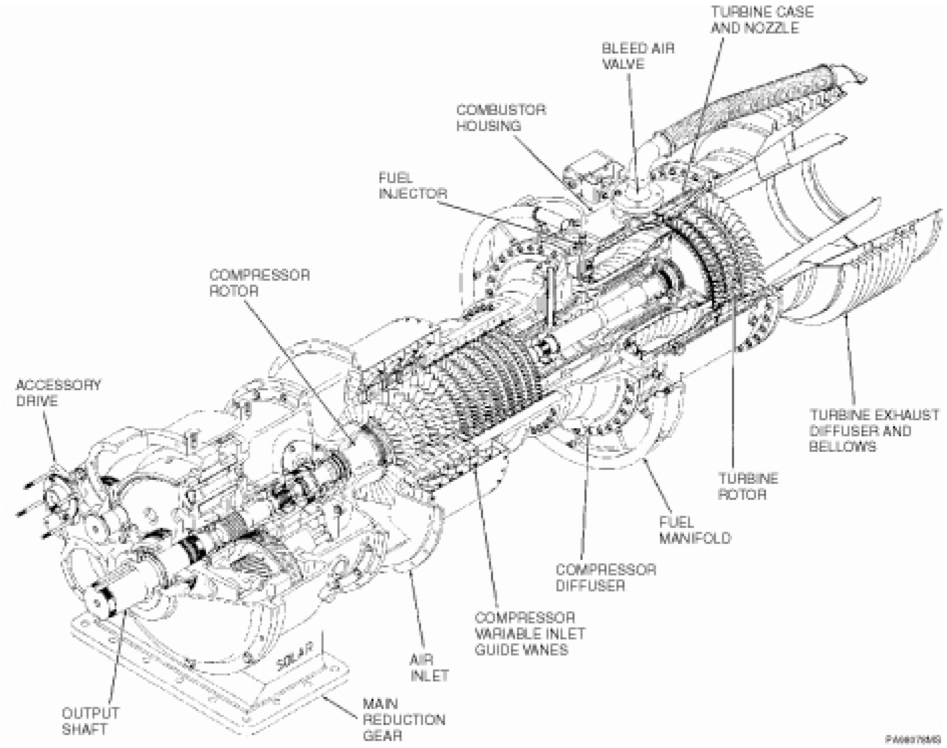
Cogeneration – Generator Equipment Used

CAT Solar Centaur 40 Gas Turbine

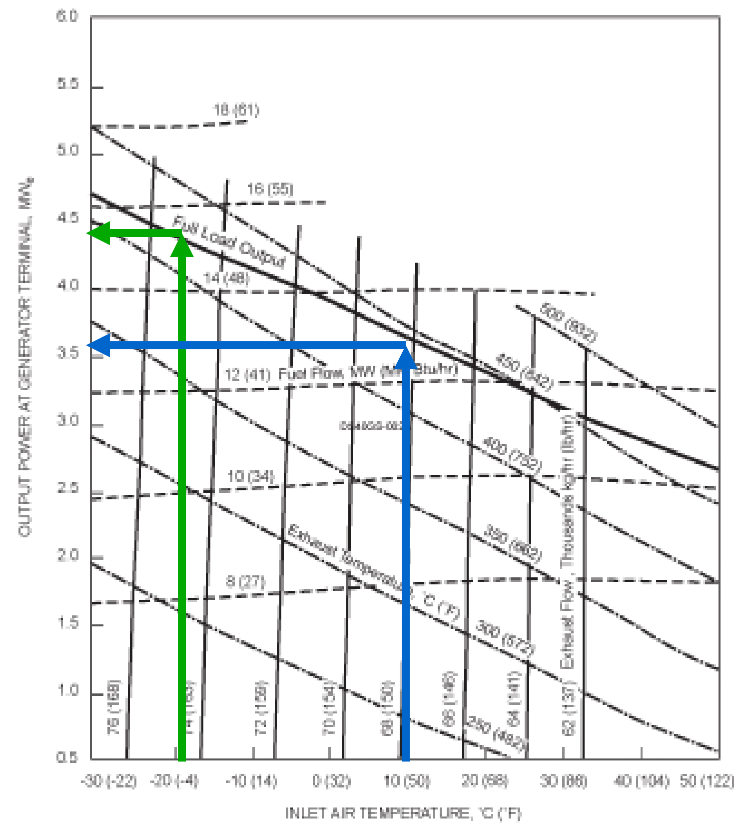


System Redesign - Equipment

Cogeneration – Generator Equipment Used

CAT Solar Centaur 40 Gas Turbine

	e^- Output (MW)	Fuel (MMBTU/hr)
ISO (59^{o}F)	3.53	48.64
Design (99^{o}F)	2.59	42.01



System Redesign - Equipment

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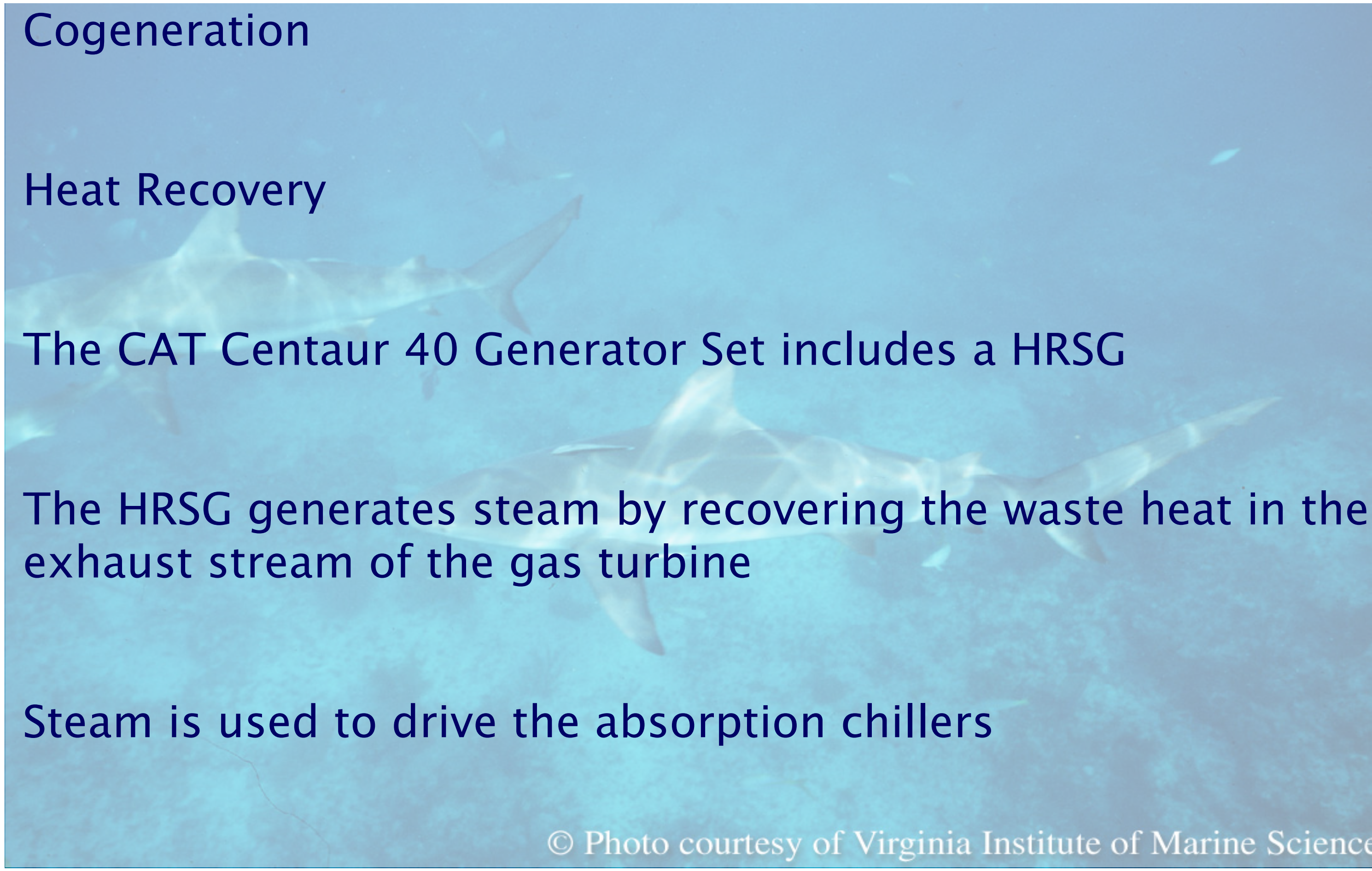

Cogeneration

Heat Recovery

The CAT Centaur 40 Generator Set includes a HRSG

The HRSG generates steam by recovering the waste heat in the exhaust stream of the gas turbine

Steam is used to drive the absorption chillers

© Photo courtesy of Virginia Institute of Marine Science

System Redesign - Equipment

Cogeneration

Additional Equipment

To get the most use of the recovered heat from the generator Absorption Chillers should be used.

Absorption Chillers use steam created from the HRSG and can be used to heat and cool a building.

The absorption chillers require a condenser water loop

System Redesign - Equipment

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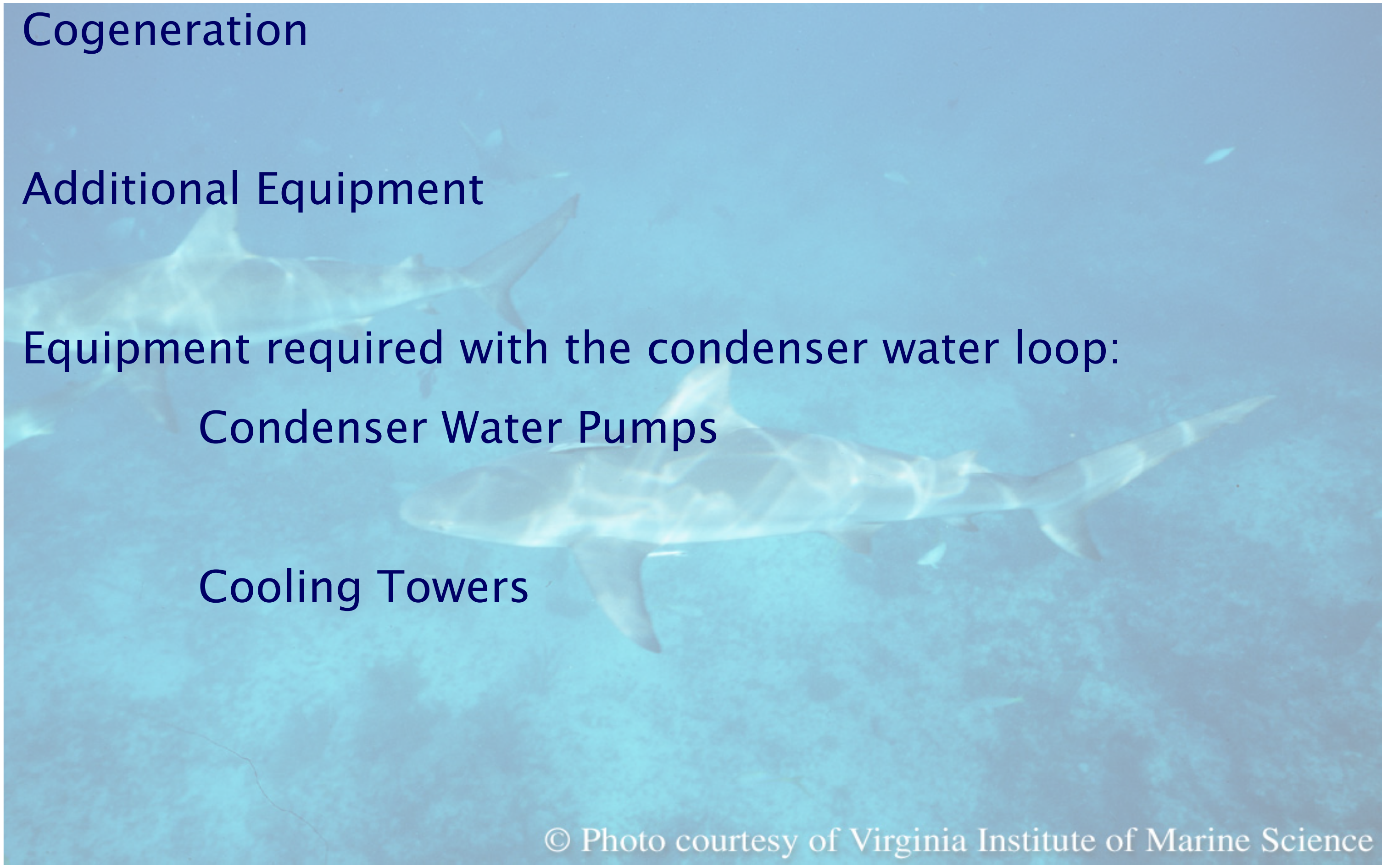
Cogeneration

Additional Equipment

Equipment required with the condenser water loop:

- Condenser Water Pumps
- Cooling Towers



System Redesign - Equipment

Cogeneration – Absorption Chiller Equipment Used

York YIA-ST-2A3 Single Stage Absorption Chiller

	Condenser	Evaporator
Flow Rate (gpm)	620	413
Temperature (^{o}F)	101.4 - 85	54 - 44
Pressure Drop (ft)	13	12
Input Electrical (kW)	5.9	
Input Steam (lbm/hr)	3140	
Output (tons)	172	
Rated COP	0.72	

System Redesign - Equipment

Cogeneration – Condenser Water Pump Equipment Used

Bell & Gossett

DETAIL SUMMARY			
Pump Series:	1510	Pump Size:	6G
Flow Rate: (USGPM)	620	Total Head: (ft.)	50
Pump Speed (RPM)	1150	NPSH req (ft)	3.5
Weight: (lbs)	970	Cost Index:	185
Suction Size: (in)	8	Suction Velocity (fps)	4
Discharge Size: (in)	6	Discharge Velocity: (fps)	6.9
Impeller Diameter: (in)	11.125	Efficiency: (%)	75.32
Max Impeller Dia (in)	13.5		
Max Flow (USGPM)	1491	Duty Flow/Max Flow (%)	0.42
Flow @ BEP (USGPM)	1010	Min. Rec. Flow: (USGPM)	400
Motor Power, HP:	15	Frame Size:	284T
Pump Power (BHP)	10.58		
Max Power (BHP)	15.49		

System Redesign - Equipment

Cogeneration – Cooling Tower Equipment Used

Marley NC8303FL1 Cooling Tower

Flow Rate (gpm)	620
Temperature (^oF)	101.4 - 85
Wet Bulb (^oF)	76
Range (^oF)	16.4
RPM	356
Fan Motor Output (BHP)	15

Redesign Analysis

- Reduced Emissions
- Reduced Energy Cost
- Pay Back
- LEED Credits

Redesign Analysis - Emissions

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Emissions Generated by Existing Building and Surrounding Buildings

Building	MWh	Tons CO_2	Tons SO_2	Tons NO_x
Seawater Research Lab Daily	26.37	63.98	0.290139	0.084729
Seawater Research Lab Yearly	9387.94	22777.43	103.2895	30.16346
Watermen's Hall Daily	4.70	11.40	0.051706	0.0151
Watermen's Hall Yearly	1715.33	4059.18	18.40729	5.375447
Nunnally Hall Daily	5.22	12.66	0.057398	0.016762
Nunnally Hall Yearly	1904.17	4506.06	20.43378	5.96724
Wetlands Facility Daily	0.22	0.54	0.002431	0.00071
Wetlands Facility Yearly	80.64	190.83	0.865366	0.252711
Chesapeake Bay Hall Daily	18.67	45.31	0.205452	0.059998
Chesapeake Bay Hall Yearly	6815.80	16129.02	73.14078	21.35917
Geddings House Daily	0.17	0.41	0.00186	0.000543
Geddings House Yearly	61.70	146.01	0.662109	0.193354
Wilson House (CBNERR) Daily	1.17	2.84	0.012878	0.003761
Wilson House (CBNERR) Yearly	427.24	1011.02	4.584706	1.338864
DCOP Facility Daily	0.22	0.53	0.0024	0.000701
DCOP Facility Yearly	79.62	188.42	0.854412	0.249512
CBNERRVA Annex Daily	1.60	3.89	0.017628	0.005148
CBNERRVA Annex Yearly	584.82	1383.93	6.27573	1.83269

Redesign Analysis - Emissions

Emissions Generated by Buildings serviced by CHP System

Building	MWh	Tons CO_2	Tons SO_2	Tons NO_x
Seawater Research Lab Daily	23.44	7.52	5.47E-08	0.002244
Seawater Research Lab Yearly	8556.87	2743.11	1.99E-05	0.819087
Watermen's Hall Daily	4.70	1.51	1.1E-08	0.00045
Watermen's Hall Yearly	1715.33	549.89	4E-06	0.164196
Nunnally Hall Daily	5.22	1.67	1.22E-08	0.000499
Nunnally Hall Yearly	1904.17	610.43	4.44E-06	0.182272
Wetlands Facility Daily	0.22	0.07	5.15E-10	2.11E-05
Wetlands Facility Yearly	80.64	25.85	1.88E-07	0.007719
Chesapeake Bay Hall Daily	18.67	5.99	4.35E-08	0.001787
Chesapeake Bay Hall Yearly	6815.80	2184.97	1.59E-05	0.652427
Geddings House Daily	0.17	0.05	3.94E-10	1.62E-05
Geddings House Yearly	61.70	19.78	1.44E-07	0.005906
Wilson House (CBNERR) Daily	1.17	0.38	2.73E-09	0.000112
Wilson House (CBNERR) Yearly	427.24	136.96	9.96E-07	0.040896
DCOP Facility Daily	0.22	0.07	5.09E-10	2.09E-05
DCOP Facility Yearly	79.62	25.52	1.86E-07	0.007621
CBNERRVA Annex Daily	1.60	0.51	3.74E-09	0.000153
CBNERRVA Annex Yearly	584.82	187.48	1.36E-06	0.05598

Redesign Analysis - Emissions

Emissions Reduction

Building	% Decrease CO2	% Decrease SOx	% Decrease NOx
Seawater Research Lab Daily	88.25	100.00	97.35
Seawater Research Lab Yearly	87.96	100.00	97.28
Watermen's Hall Daily	86.79	100.00	97.02
Watermen's Hall Yearly	86.45	100.00	96.95
Nunnally Hall Daily	86.79	100.00	97.02
Nunnally Hall Yearly	86.45	100.00	96.95
Wetlands Facility Daily	86.79	100.00	97.02
Wetlands Facility Yearly	86.45	100.00	96.95
Chesapeake Bay Hall Daily	86.79	100.00	97.02
Chesapeake Bay Hall Yearly	86.45	100.00	96.95
Geddings House Daily	86.79	100.00	97.02
Geddings House Yearly	86.45	100.00	96.95
Wilson House (CBNERR) Daily	86.79	100.00	97.02
Wilson House (CBNERR) Yearly	86.45	100.00	96.95
DCOP Facility Daily	86.79	100.00	97.02
DCOP Facility Yearly	86.45	100.00	96.95
CBNERRVA Annex Daily	86.79	100.00	97.02
CBNERRVA Annex Yearly	86.45	100.00	96.95

Redesign Analysis – Energy Costs

Reduced Energy Costs

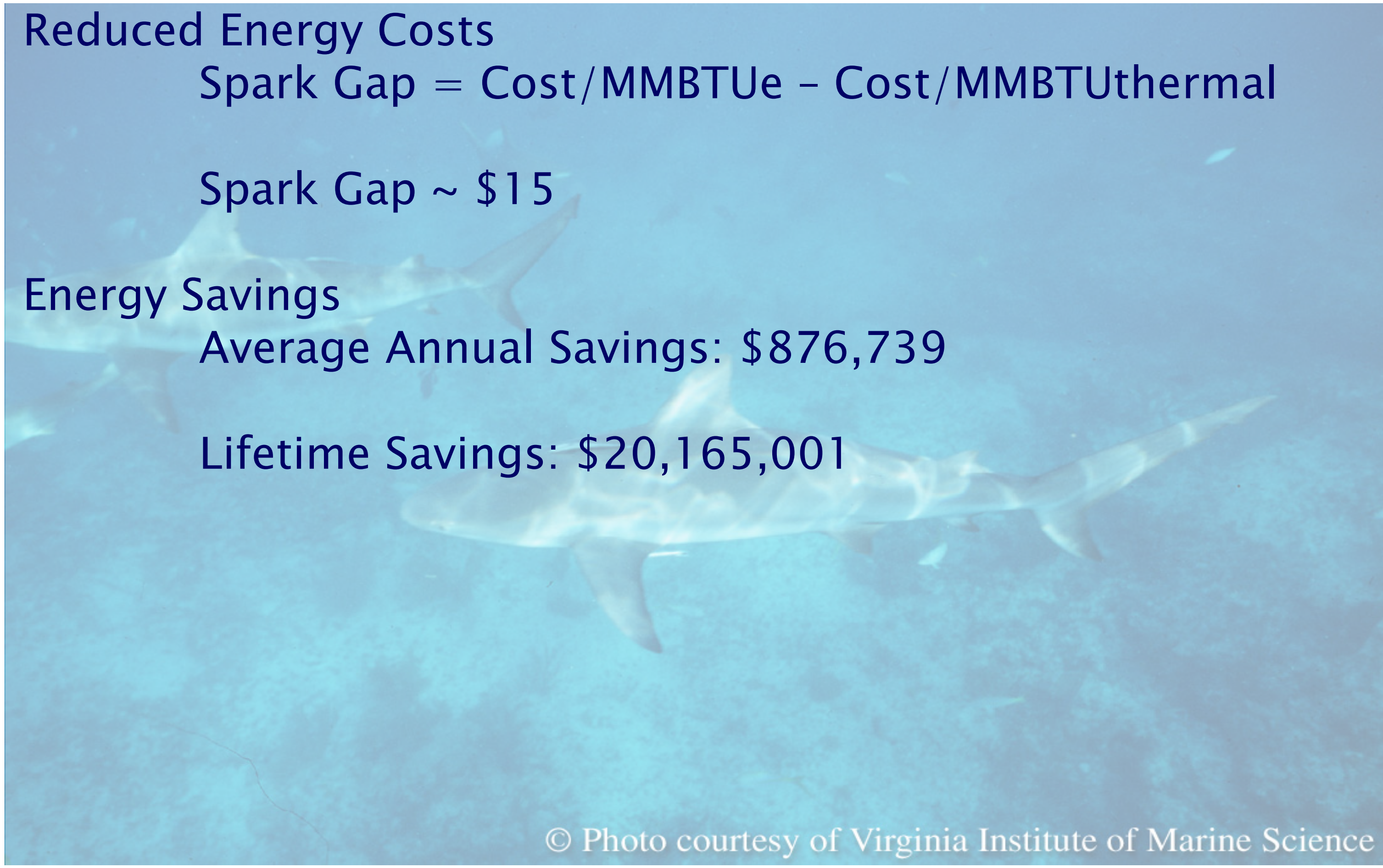
Spark Gap = Cost/MMBTUe – Cost/MMBTUthermal

Spark Gap ~ $15

Energy Savings

Average Annual Savings: $876,739

Lifetime Savings: $20,165,001



Redesign Analysis – Pay Back

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Equipment First Cost:

$6,020,920

Simple Pay Back Period (without power sell back to the utilities):

10 Years

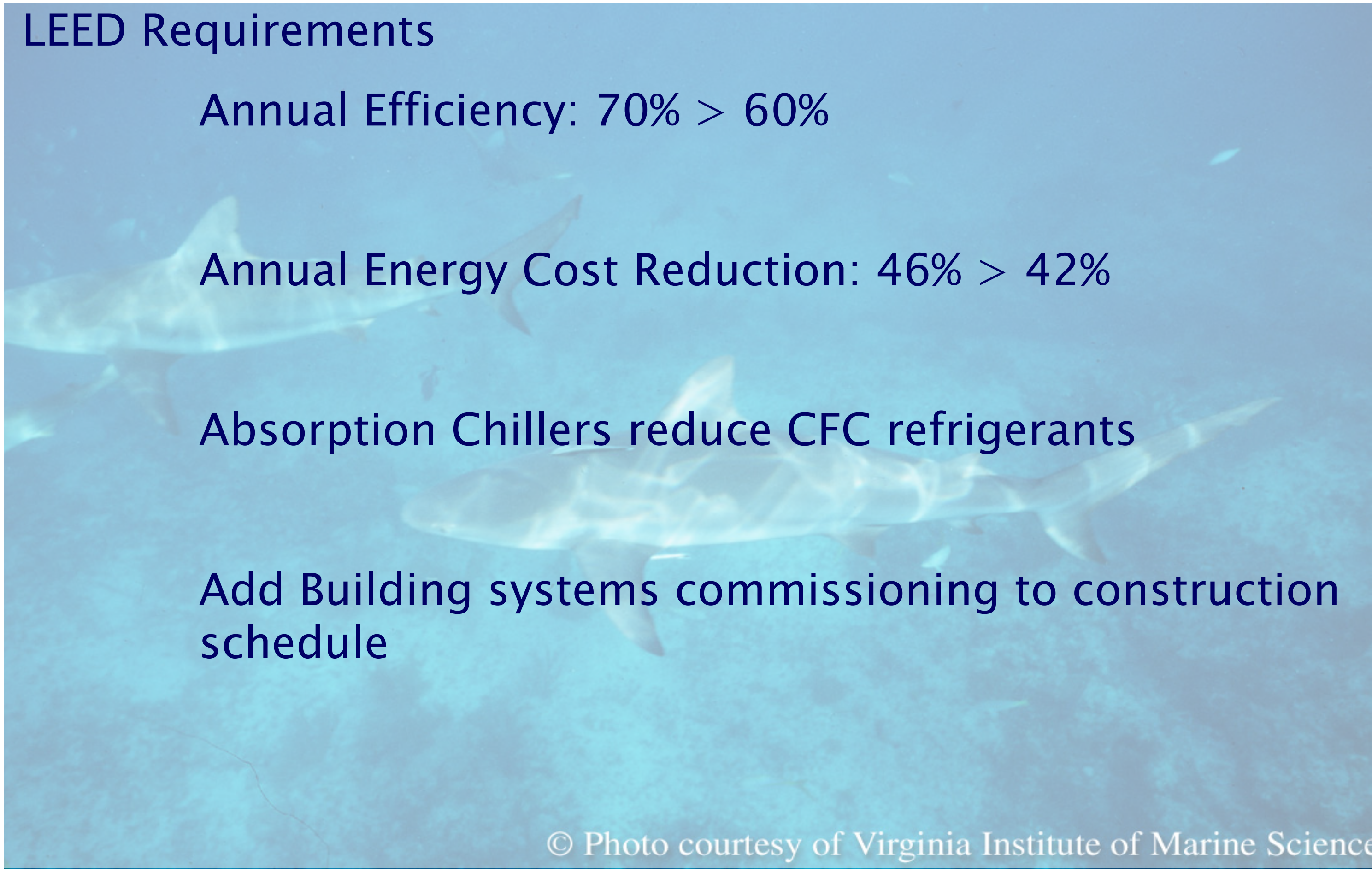
Total savings over 22 years:

$13,837,958

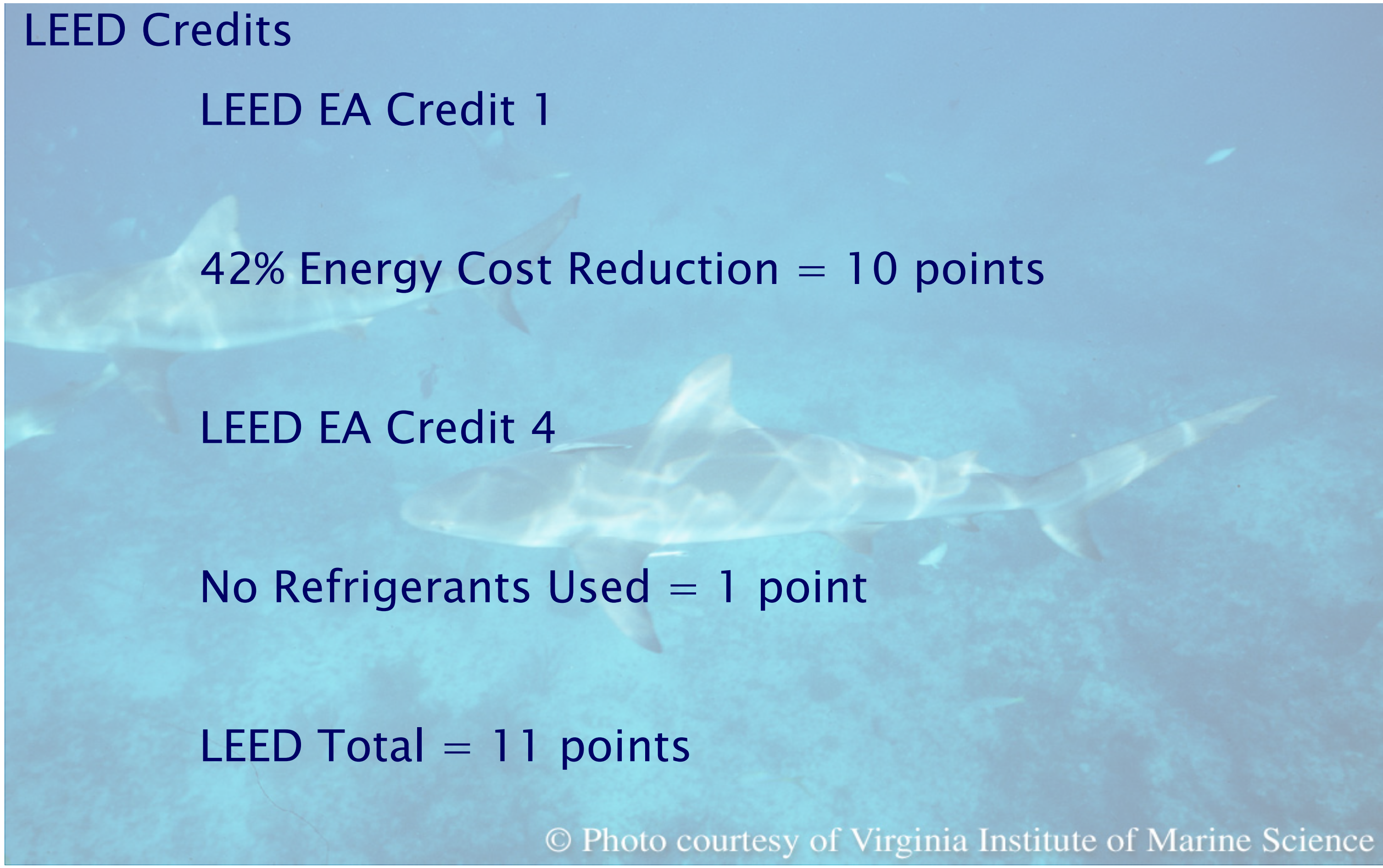
Redesign Analysis – LEED

LEED Requirements

- Annual Efficiency: 70% > 60%
- Annual Energy Cost Reduction: 46% > 42%
- Absorption Chillers reduce CFC refrigerants
- Add Building systems commissioning to construction schedule



Redesign Analysis – LEED



LEED Credits

LEED EA Credit 1

42% Energy Cost Reduction = 10 points

LEED EA Credit 4

No Refrigerants Used = 1 point

LEED Total = 11 points

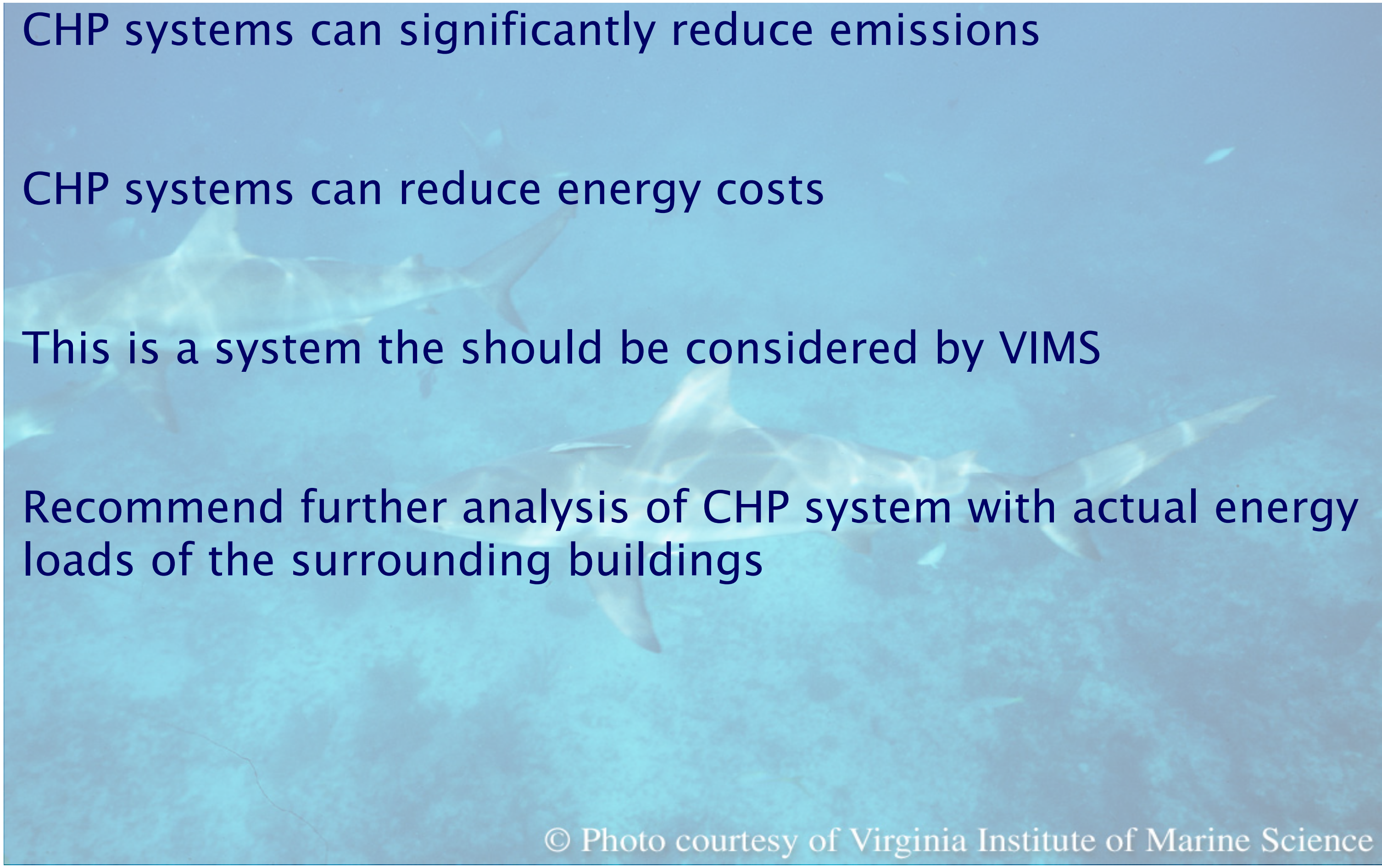
Conclusions

CHP systems can significantly reduce emissions

CHP systems can reduce energy costs

This is a system the should be considered by VIMS

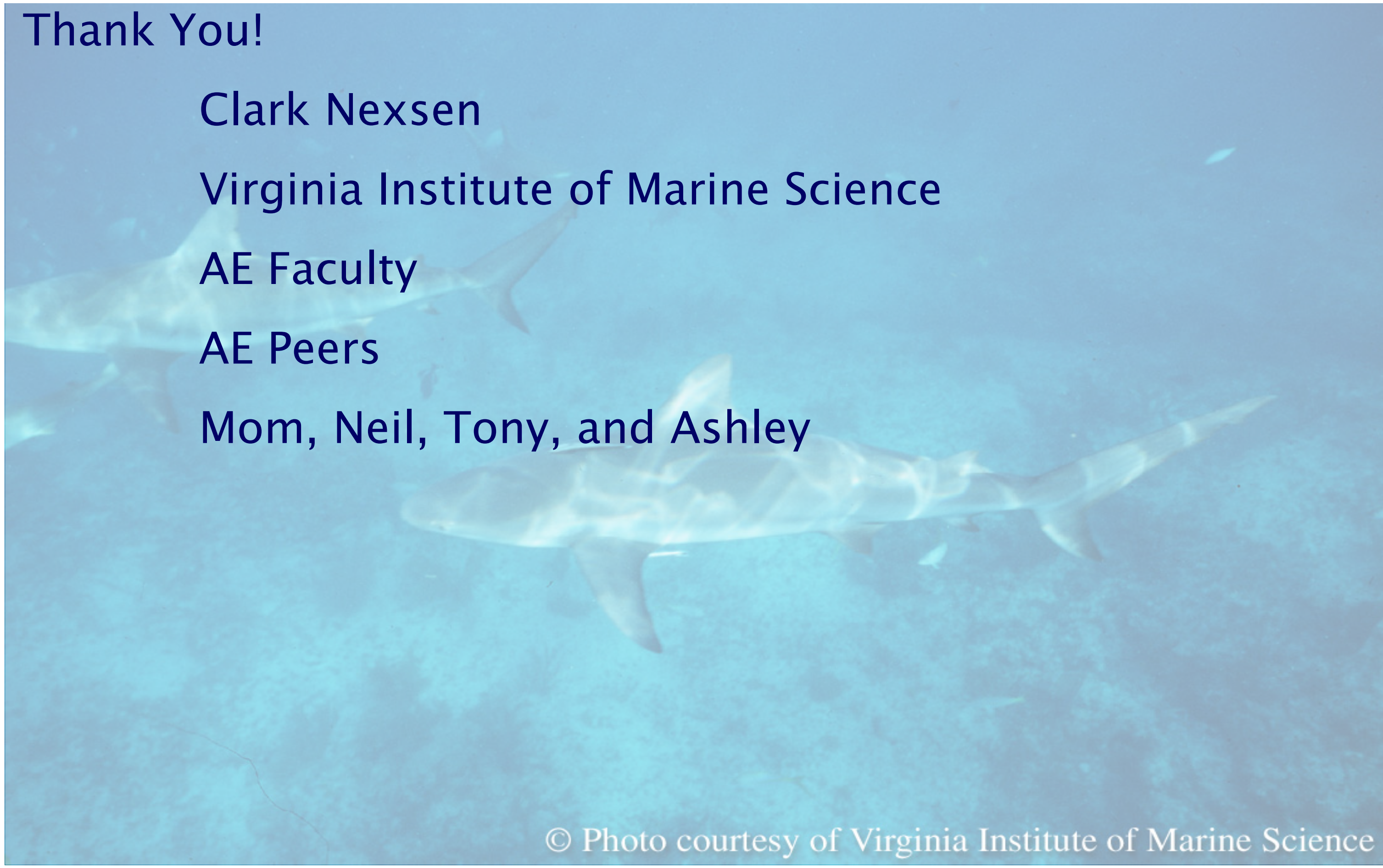
Recommend further analysis of CHP system with actual energy loads of the surrounding buildings



Acknowledgements

Thank You!

- Clark Nexsen
- Virginia Institute of Marine Science
- AE Faculty
- AE Peers
- Mom, Neil, Tony, and Ashley



Questions?