

RECLAMATION

Managing Water in the West

**Developing Underwater Video Technology for
Sampling Pelagic Delta Fishes.**

“SmeltCam II”

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U.S. Bureau of Reclamation***



U.S. Department of the Interior
Bureau of Reclamation

SureWorks LLC

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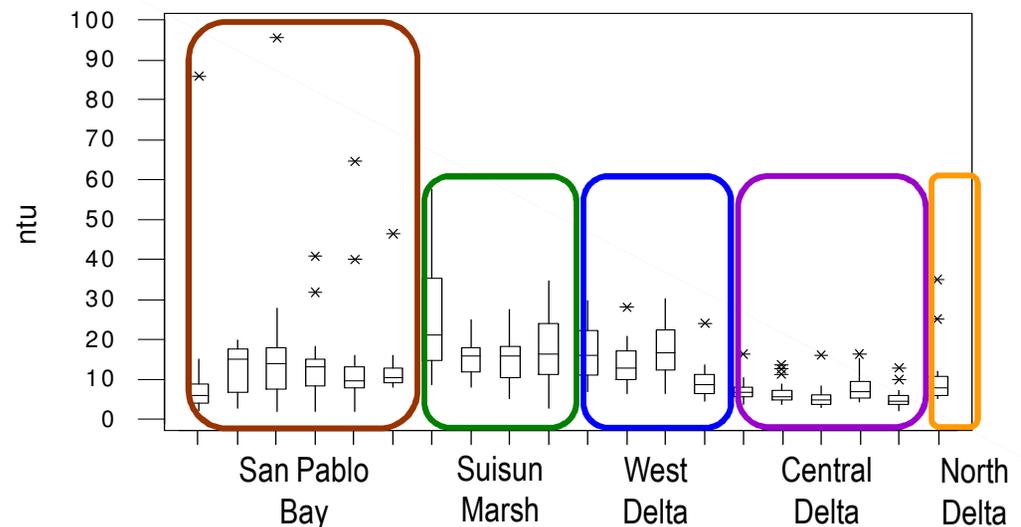
Bureau of Reclamation



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Objective: Design a video imaging systems for sampling fish in turbid water that would compliment current population monitoring without harm.

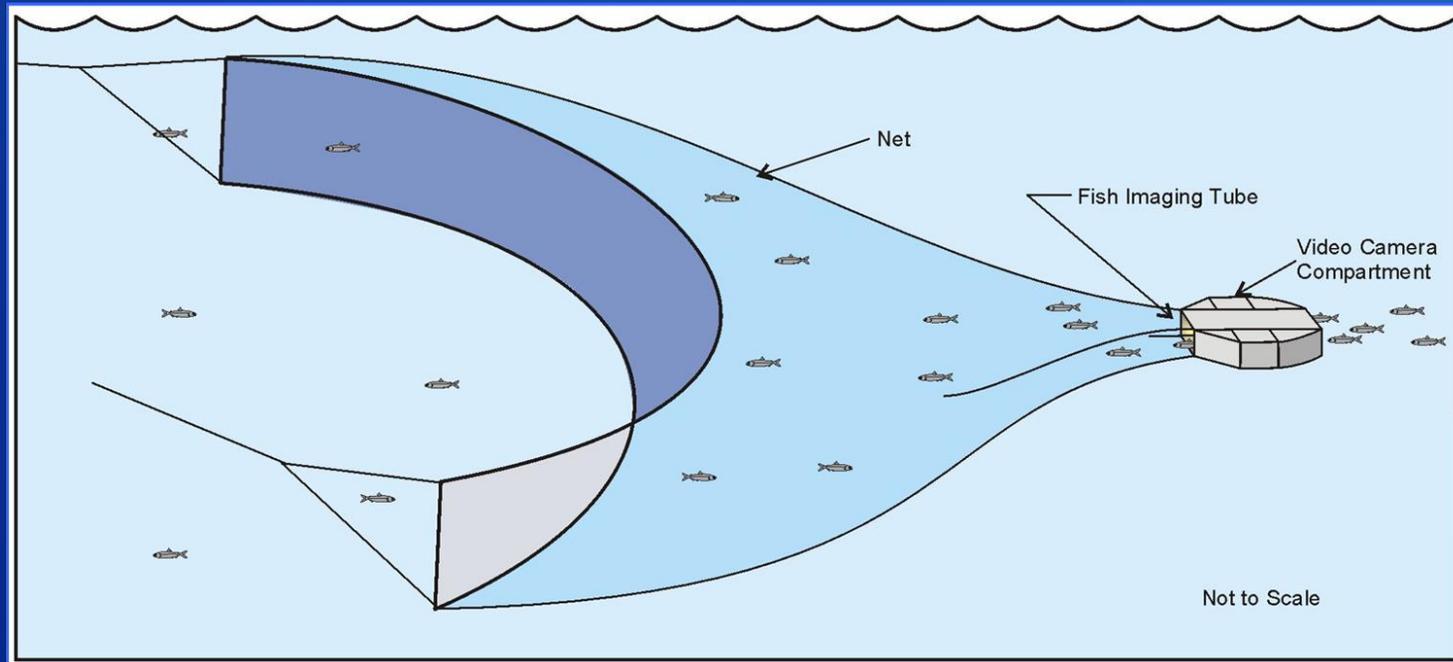
Turbidity data for different Delta regions
fall (September – December) 2000-2006



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WHY?:

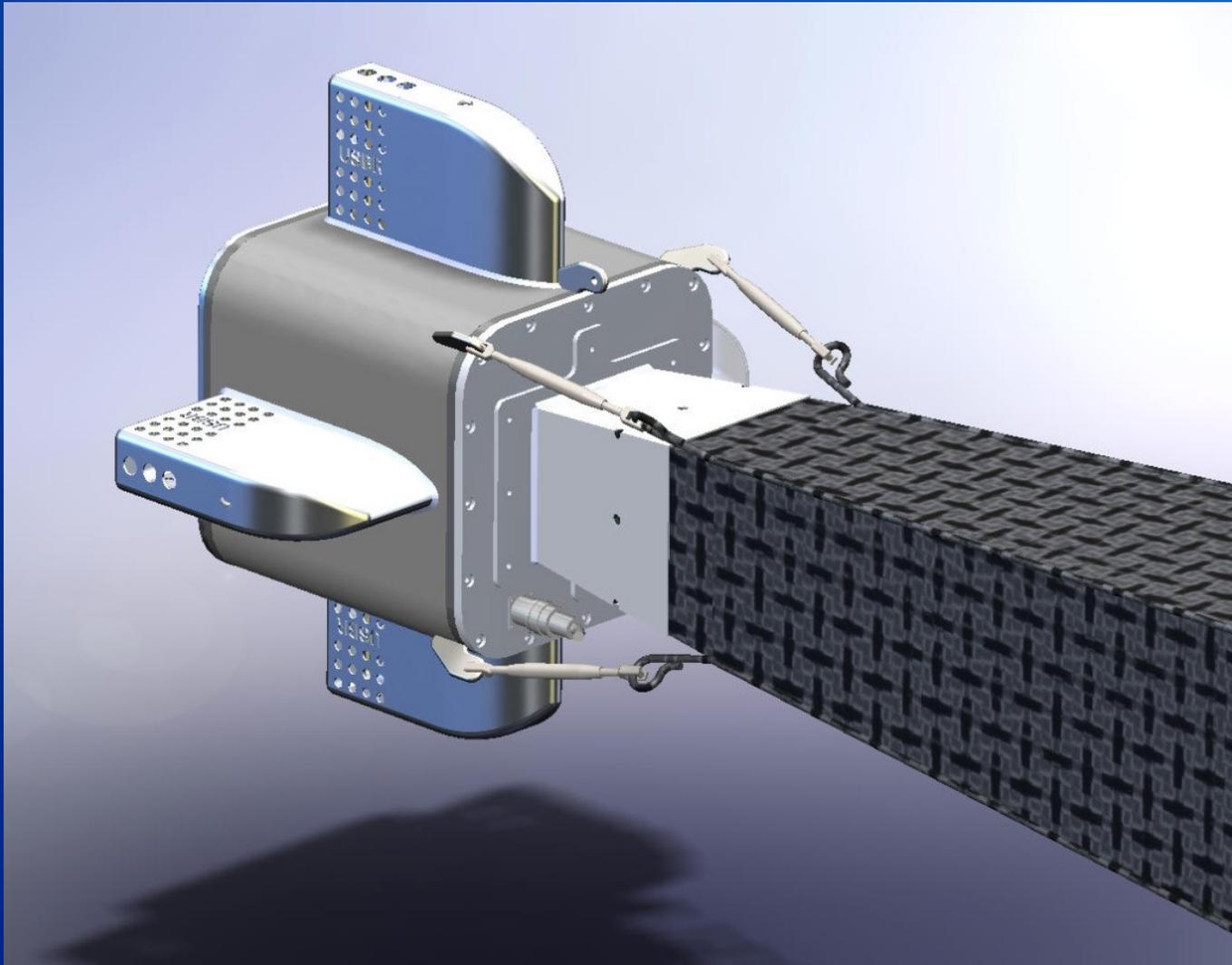
Long term sampling data have been exceptionally useful in detecting POD and monitoring population trends, additional sampling is necessary to gain further understanding of rare and patchy species' life histories



Underwater video technology could allow researchers to supplement current sampling without increasing lethal take of threatened and endangered species

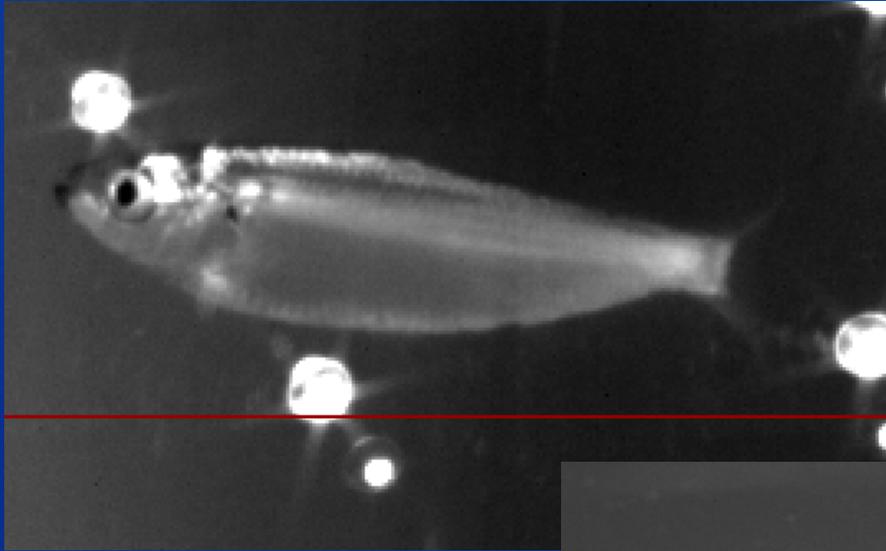
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Smeltcam – Phase one



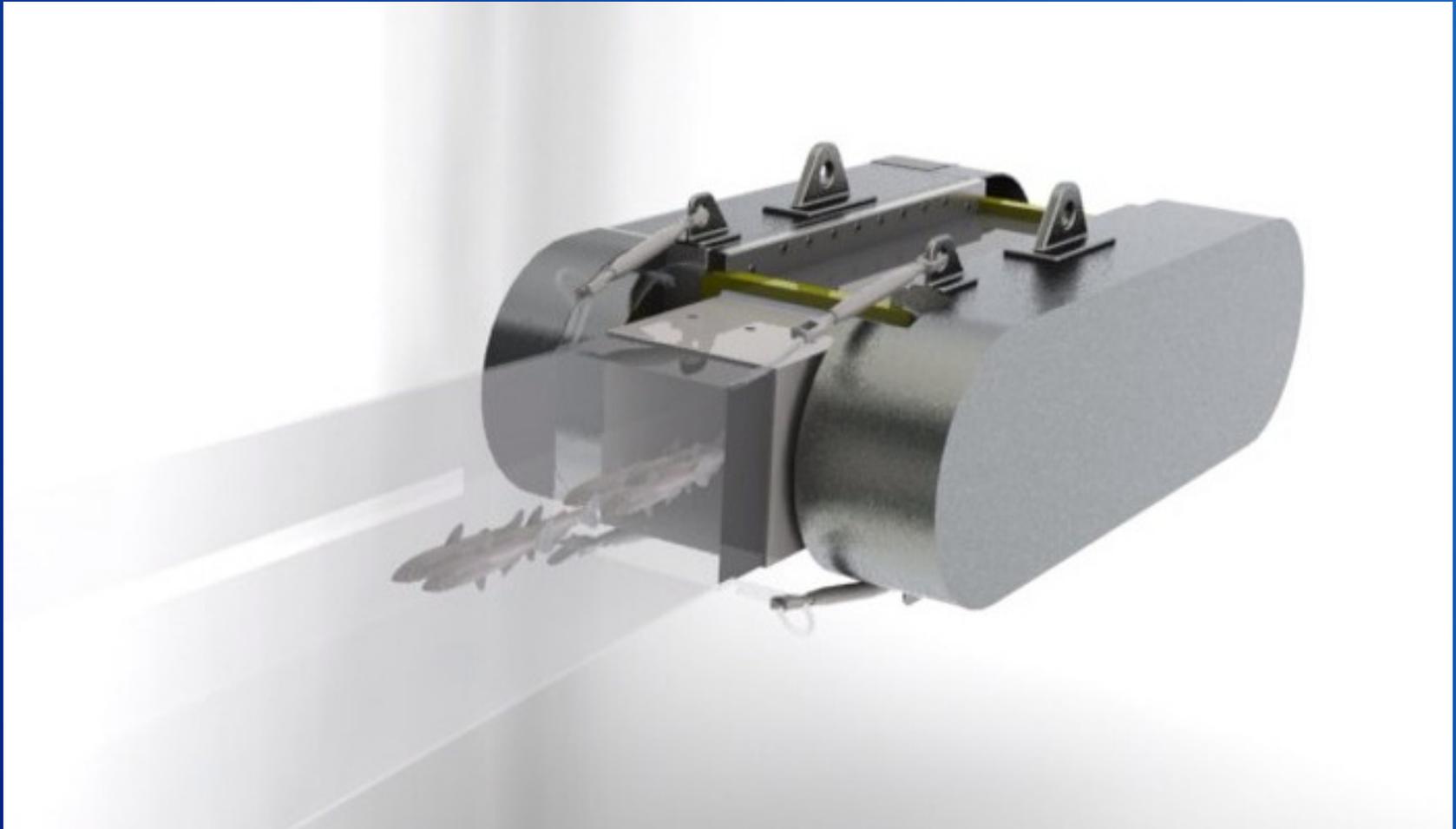
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Smeltcam I: Field Test Image Samples



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Smeltcam – Phase II



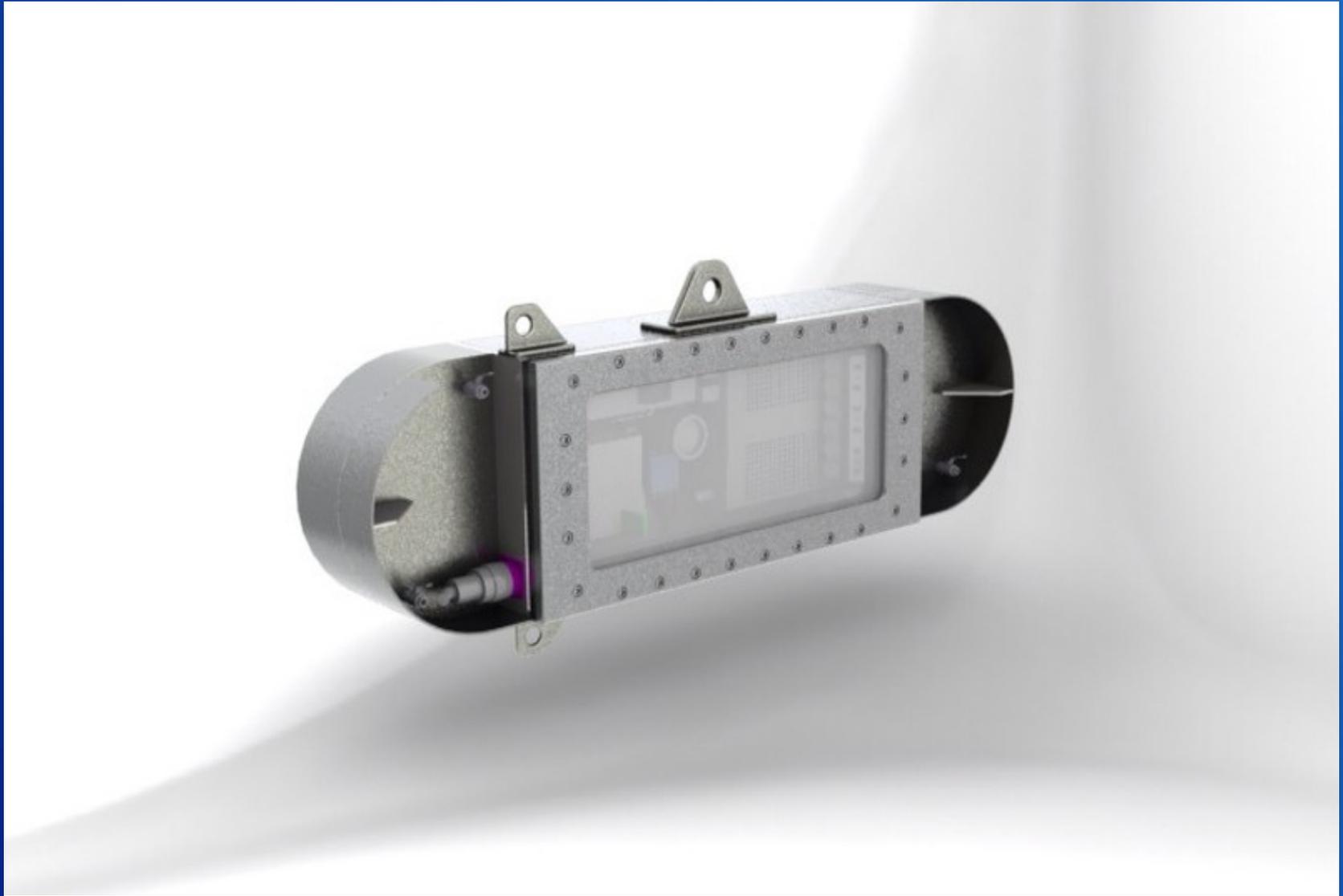
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System overview

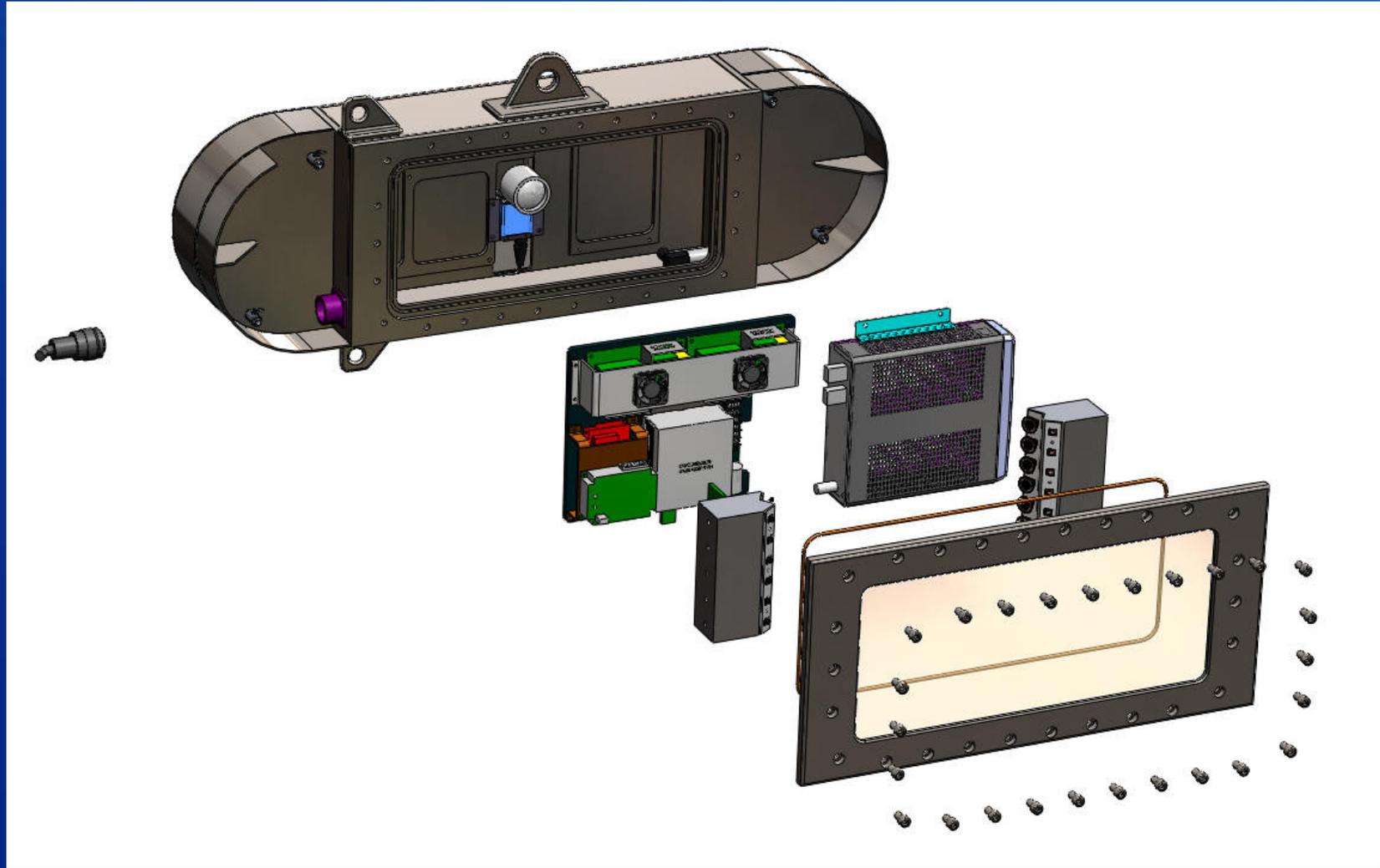
- ✓ Design decisions
 - ✓ Mechanical design
 - ✓ Electrical/Computing platform
 - ✓ Software system
- ✓ Future enhancements

Mechanical Design Considerations

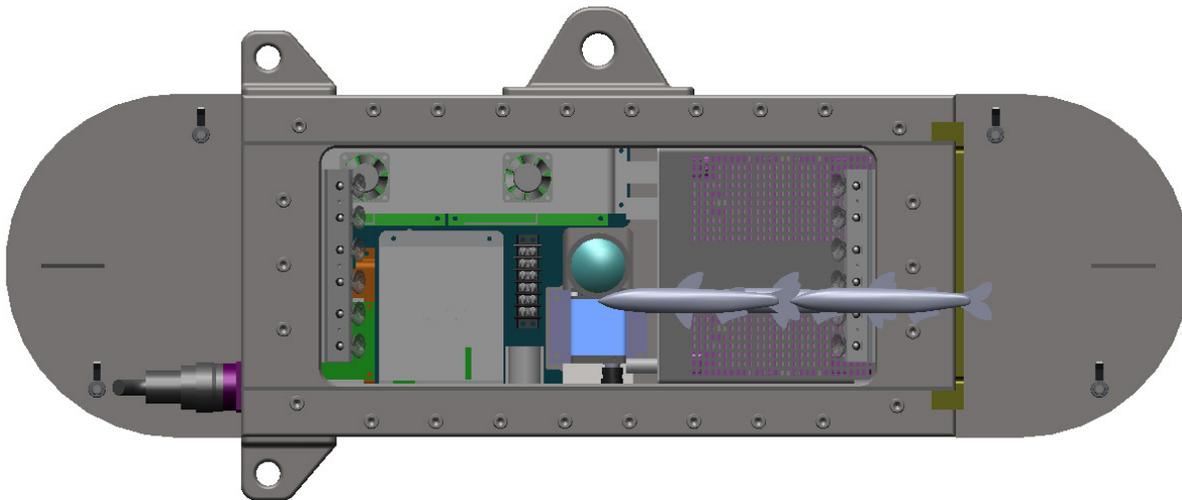
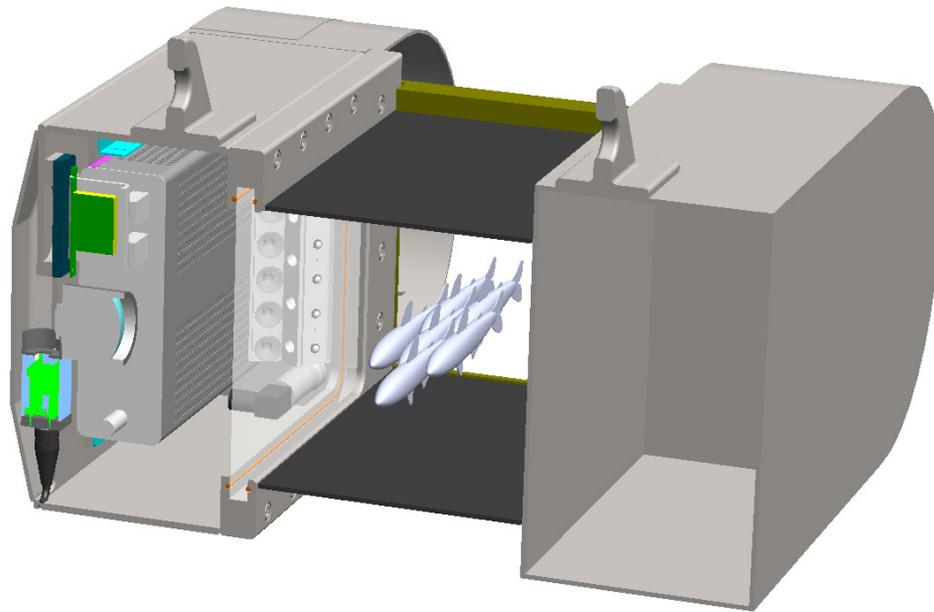
- ✓ Image quality first: form follows function
- ✓ Submersible, airtight, neutrally buoyant enclosure.
- ✓ Displace least amount of water as possible, keep weight to minimum.



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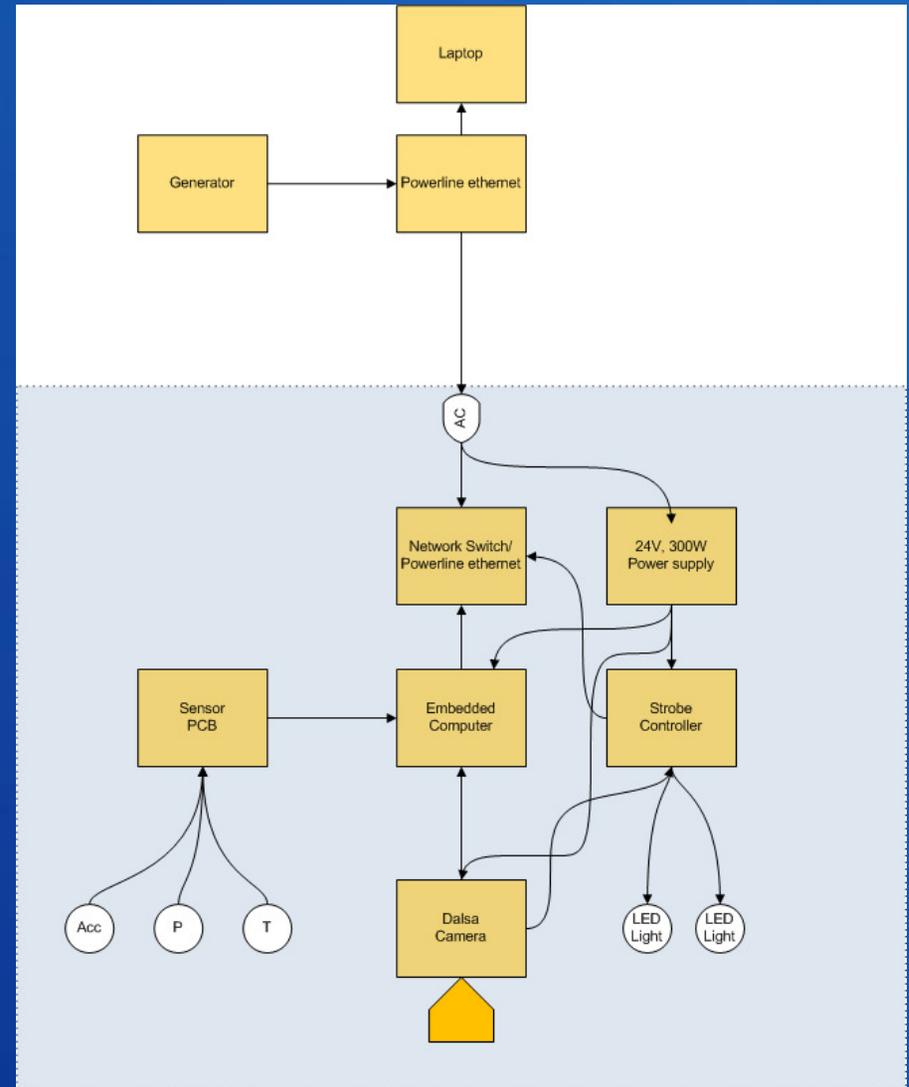
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Electrical Design

- ✓ Embedded computer does tracking and image queuing.
- ✓ Laptop does high-level classification.
- ✓ Single flexible cable on slip-ring reel

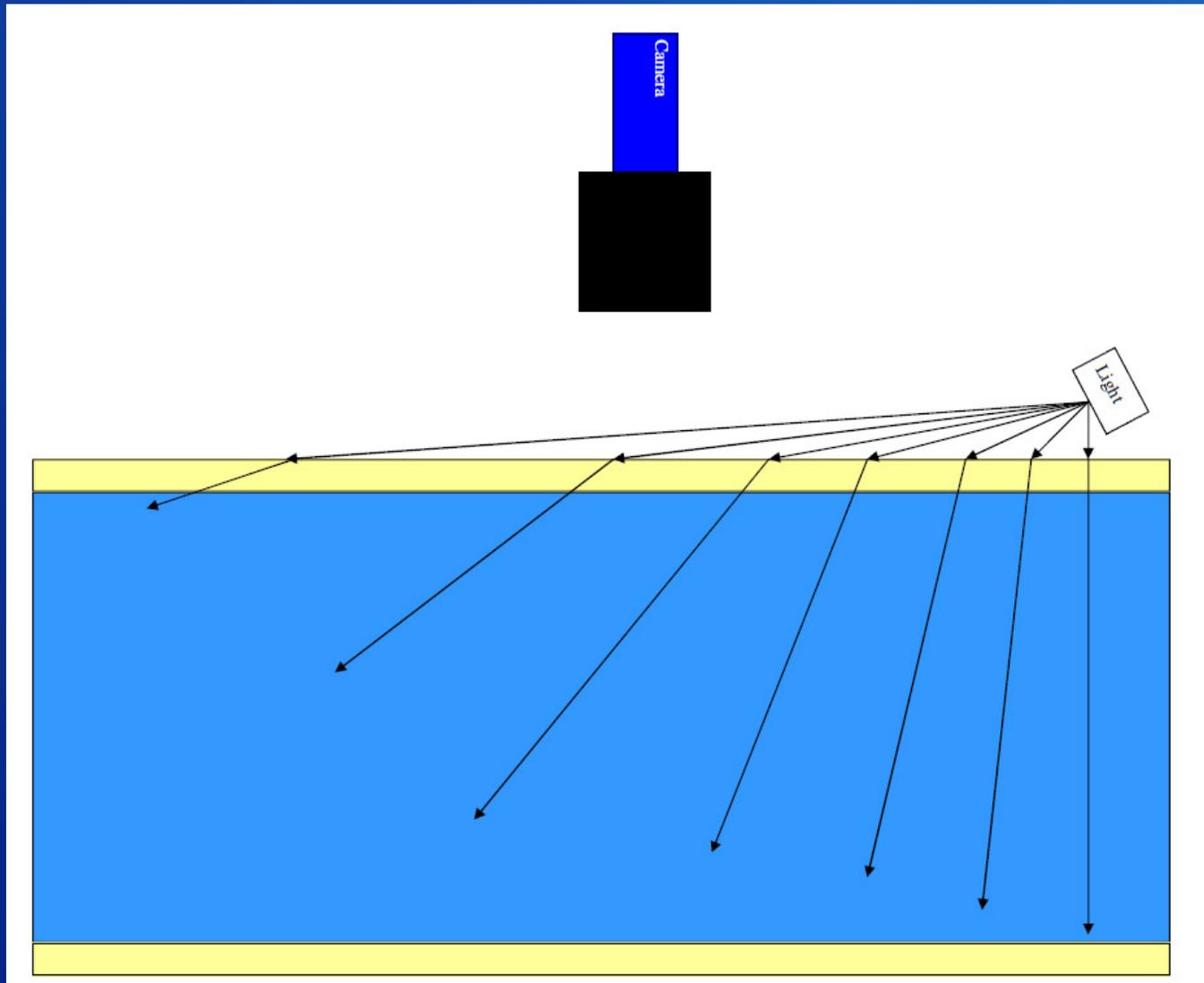


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Lighting Challenges

- ✓ Lessons learned:
 - ✓ Lighting placed near camera causes reflections on acrylic and unnecessary image noise.
 - ✓ Strobe LEDs in sync with camera to reduce power and freeze moving objects better.
 - ✓ Much of white light gets absorbed by water, use blue where camera is most sensitive.
 - ✓ Wide angle of disparity reduces turbidity (backscattering).

Lighting testing



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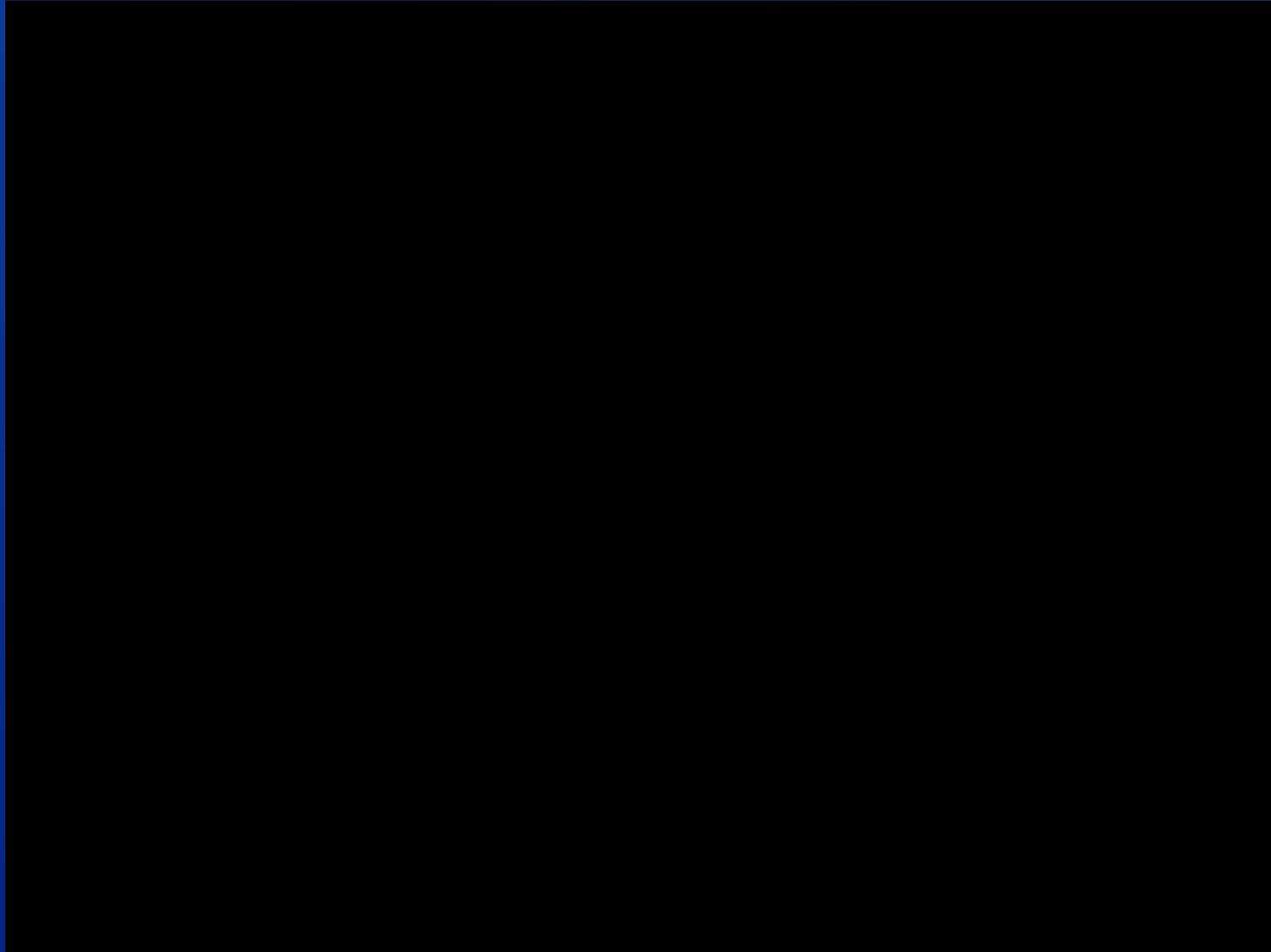
Software Algorithms

- ✓ Tracking
- ✓ Fish / non-fish detection:
- ✓ Fish classification
- ✓ User interface

Software Algorithms-Tracking

- ✓ Tracking consists of:
 - ✓ Foreground segmentation
 - ✓ Image preparation
 - ✓ Blob detection
 - ✓ Object size filter
 - ✓ Object trajectory filter

Software Algorithms- Tracking

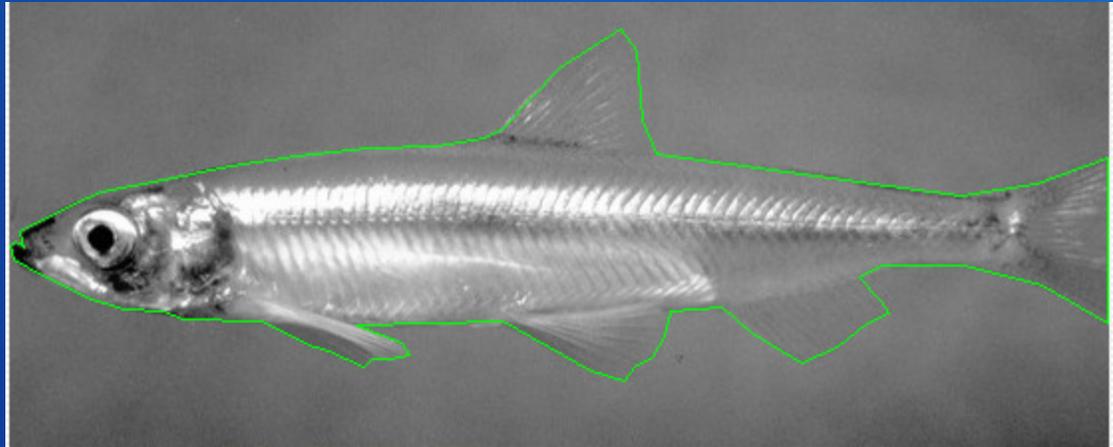


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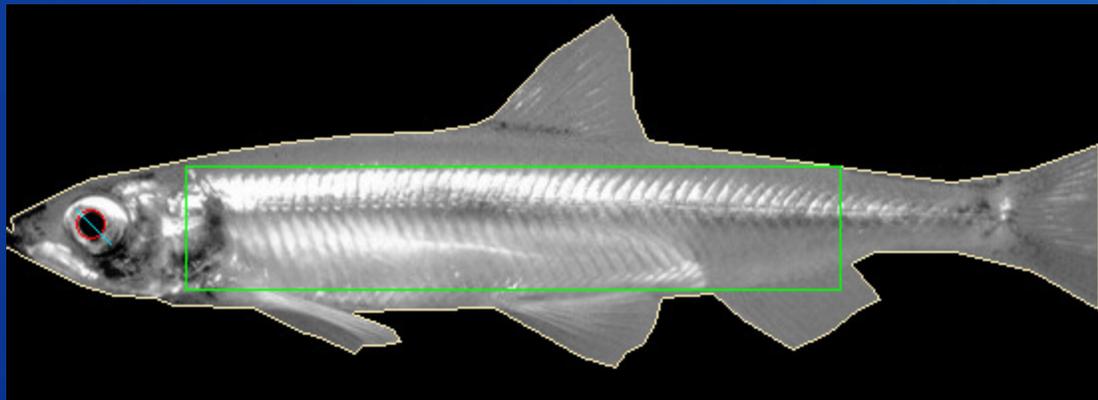
Software Algorithms

Fish / non-fish detector

✓ Shape classifier



✓ Eye & side view detector:

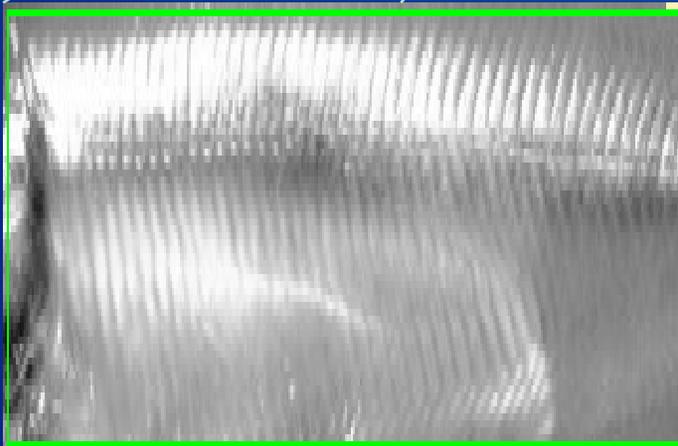
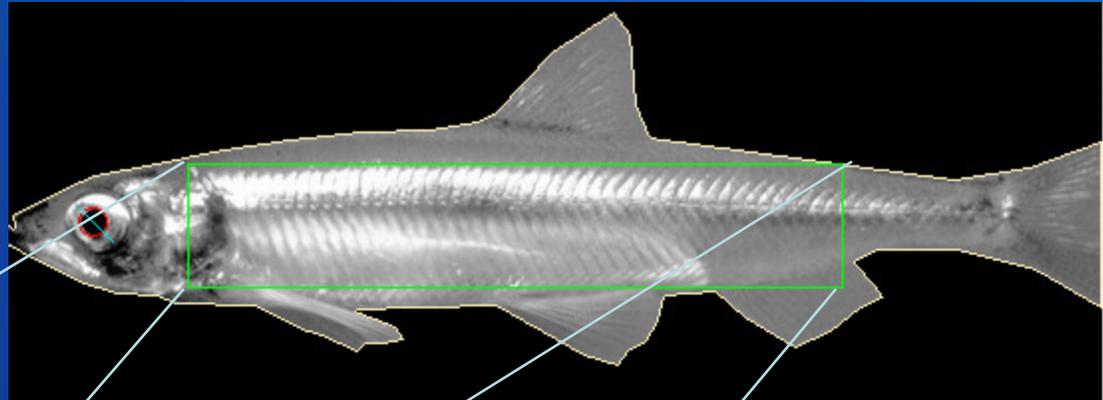


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Software Algorithms

Fish classification

✓ PCA
“eigenfish”



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Software: User Interface

✓ Goals

- ✓ Intuitive, responsive view of real-time data
- ✓ Rapid training and classification.
- ✓ Post processing, sorting, and data analysis

Software: User Interface

Gallery view | Data visualization | Vision setup and live view | Classifier setup

Sort by [dropdown] Zoom level [slider: 10, 8, 6, 4, 2, 1] Delete

Close-up

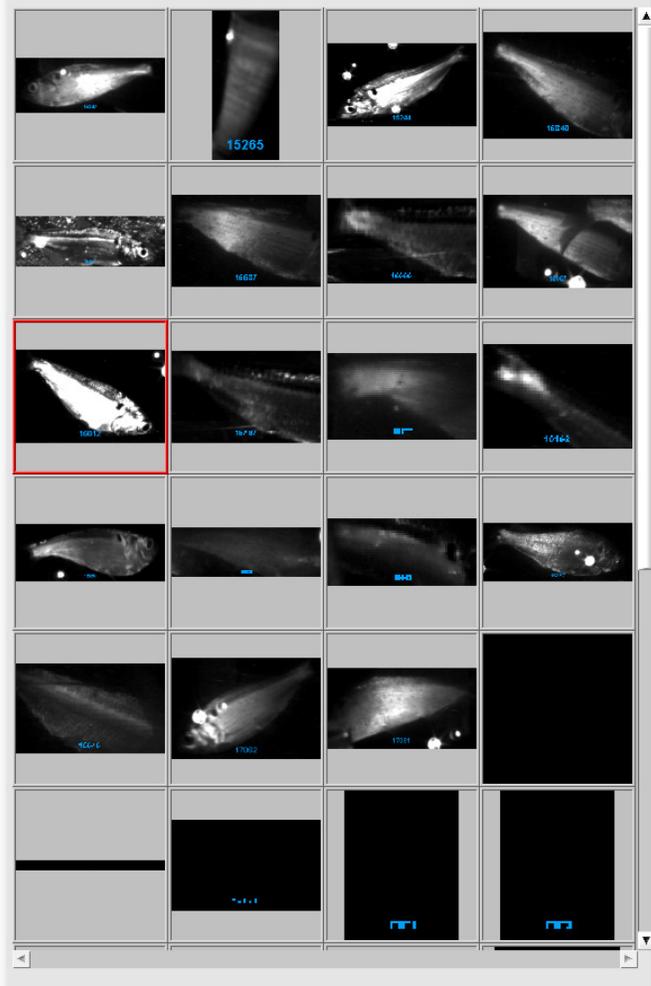


Classification score: 249.821 Class: Smelt Reclassify all: OK

Class: [dropdown] Add sample: OK

Preview image sequence. [slider: -1 to 14]

Browser



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Software: User Interface

Gallery view | Data visualization | Vision setup and live view | Classifier setup

Object metrics to measure

- Area
- Elongation Factor
- Heywood Circularity Factor
- Ratio of Equivalent Ellipse Axes
- Max Feret Diameter End X
- Bounding Rect Width
- Center of Mass X

Image

Area

Scatter plot

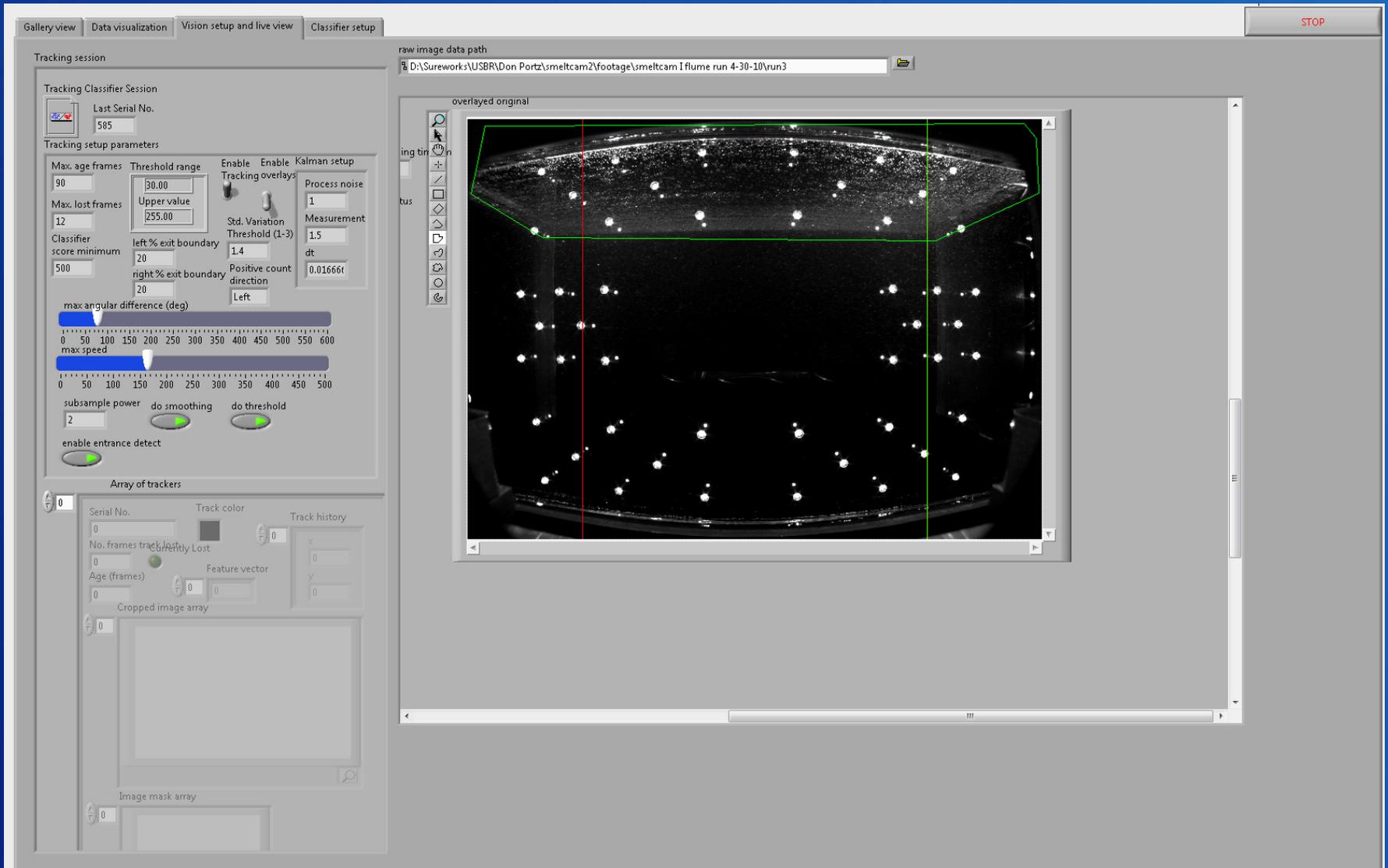
Data table

Index	Serial No	Time	Class	Class Sc	Area	Elongati	Heywood	Ratio of	Max Feret	Boundin
0	10116	4:56:45 F	Smelt	495.672	324.1666	17.81066	2.430655	12.62351	70.50000	79.50000
1	10126	4:56:45 F	Smelt	199.530	1650.666	4.274947	1.315915			
2	10106	4:56:45 F	Smelt	472.210	301.2500	16.25840	2.359563	11.59932	45.44444	69.02777
3	10124	4:56:45 F	Smelt	258.349	1781.538	3.481151	1.305334	3.089772	6.846154	41.07692
4	10103	4:56:45 F	Smelt	268.332	3117.709	4.294574	1.458760	4.067058	15.56363	101.9454
5	10199	4:56:46 F	Non-fish	332.007	590.3750	3.638598	1.405794	3.760028	43.37500	42.06250
6	10498	4:56:47 F	Smelt	792.750	334.3333	5.965343	1.635615			
7	10358	4:56:48 F	Unknown	0.000	1066.945	3.510757	1.271202	3.270940	57.53846	46.95604
8	10396	4:56:49 F	Unknown	0.000	684.7564	3.344047	1.333282	3.274212	46.88463	44.14102
9	10925	4:56:49 F	Non-fish	342.609	484.0000					
10	10926	4:56:49 F	Smelt	421.320	373.0000					
11	10871	4:56:49 F	Smelt	215.471	2417.400	4.642565	1.386673	3.598192	102.0666	96.60000
12	10626	4:56:50 F	Non-fish	300.228	1396.555	3.917279	1.441786	4.142011	74.28395	67.71604
14	11052	4:56:50 F	Unknown	0.000	83.50000	3.839034	1.125253	2.600239		
15	11036	4:56:50 F	Smelt	499.311	281.1250	3.740659	1.282429	2.958194	38.25000	26.50000
16	11051	4:56:51 F	Smelt	500.102	955.2500	5.646963	1.727853	6.493733	76.41666	69.50000
17	10809	4:56:51 F	Smelt	305.277	928.3086	5.587034	1.619092	5.352239	54.25925	61.41975
18	10848	4:56:51 F	Non-fish	448.539	560.4324	3.490176	1.299889	3.083198	32.33783	36.33783
19	11301	4:56:52 F	Smelt	744.009	123.3333	4.424485	1.370582			
20	11365	4:56:52 F	Smelt	26.507	92.00000					
21	11256	4:56:54 F	Non-fish	220.452	2327.550	3.273687	1.296448	3.126233	93.16250	82.30000
22	11499	4:56:54 F	Non-fish	266.826	455.0000	3.674473	1.451727	4.001070	42.07142	38.28571
23	11921	4:56:55 F	Smelt	202.455	1542.000	4.086268	1.391371	3.607585	6.666667	68.81481
24	11922	4:56:55 F	Non-fish	712.213	543.0416	2.442913	1.473708	4.106013	3.666667	34.45833
25	11938	4:56:56 F	Non-fish	303.170	1541.704	2.714188	1.247300	2.750557	8.647050	50.17647

Histogram

Export | histogram count | intervals 10

Software: User Interface



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Future Enhancements

✓ Software

- ✓ Improved object recognition database

✓ Physical

- ✓ Open frame 'rover' design with less wasted air space and less weight.
- ✓ Custom electronics
 - ✓ DSP based tracking and compression routines
 - ✓ Custom lighting and power