In-Situ Ichthyoplankton Imaging System
Deep-Focus Particle Imager

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What is it?
ISIIS plankton imagers are based on a very specific back-illumination imaging technique. It is a focused shadowgraph system that captures silhouettes of plankton. It uses a pseudo collimated beam of light ensuring projections/shadows of organisms that are **telecentric**: the size of an object is not dependent on their position within the field of view.

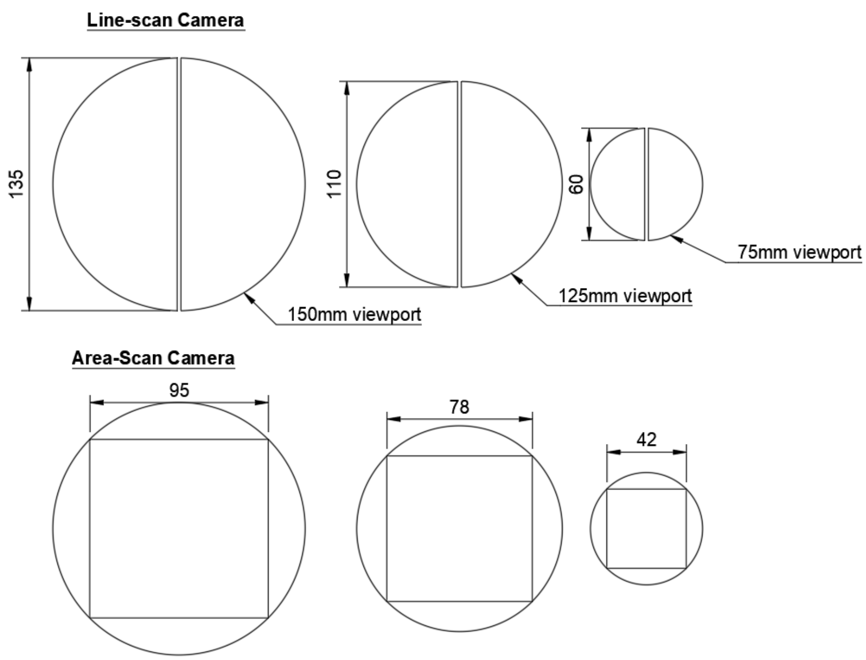
Why are there two names?
ISIIS (In Situ Ichthyoplankton Imaging System) was first developed to image large volumes of water to survey ichthyoplankton patchiness in the Gulf Stream off the coast of Florida, back in 2005.
And shortly after, the terror group we all know of became the center of attention of our everyday lives.
Since the imager strength is its ability to image over a large depth of field, we thought to give users another option for its name: "ISIIS" is still the preferred name and most recognized over "DPI".

What kind of camera do you use?
We use industrial cameras, with either a USB3 or GigE interface, monochrome only since we image shadows. A line-scan camera is ideal for application with constant speed in the 3 to 5 knots range.
An Area-scan camera allows the user to deploy at highly variable tow speed, do vertical profiling or stationary set up like moorings.

What's the main advantage of a line-scan camera?
A line scan camera takes a continuous image and therefore you need not worry about overlapping images (counting taxa twice for example) or subsampling.
The line-scan camera also allows us to use the entire enclosure viewport diameter as opposed to fitting a "square image" inside a viewport.
If you match the scanning rate of the camera with the water speed flowing in between the pod you obtain a true image, neither stretched nor compressed.

What about motion blur?
The light enclosure shines lots of light onto the camera, and therefore we are always very close to the smallest exposure time allowed by the camera sensor. Motion blur has never really been an issue so far.

Can you explain pixel-resolution?
The maximum resolution that a GigE or USB3 camera has, today (it may improve), is 2048 pixel (for a line-scan camera) or approx. 2048 x 2048 for an area-scan camera with a frame rate of 25 frames per seconds.
We offer enclosures with three viewport sizes, nominally, 150mm, 125mm and 75mm. They provide a clear imaging area of approx. 135mm, 110mm and 60mm respectively.



Since the image is projected onto the camera sensor, the overall pixel resolution increases as we decrease the imaging area:

	Line-scan Camera	Area-scan Camera
150mm viewport	135mm / 2048 = 66µm	95mm / 2048 = 46µm
125mm viewport	110mm / 2048 = 54µm	78mm / 2048 = 38µm
75mm viewport	60mm / 2048 = 29µm	42mm / 2048 = 21µm

And therefore you can control the overall pixel resolution, by deciding the size of the image you want to capture.

What can I image with this resolution?
Our rule of thumb is to consider 100-200 square pixels to identify organisms.
So a 66μm pixel resolution is really good for organisms that are 1mm and bigger
A 21μm pixel resolution is good for organisms that are 300μm and up

What about depth of field?
We found that identification of organisms larger than 1 mm can be done over 30cm depth of field. However, if your interest is in smaller taxa, in the 300 to 500μm range, you will probably limit the depth of field to 3cm (really good) up to perhaps 5cm maximum.

How do I calculate the volume of water imaged per second?
This comes down to simple maths.
If your boat speed is 5 knots (2.57m/sec), then the water volume imaged per second, for a line-scan camera is, using the 150mm viewport example:
2.57 (Speed) x 1000 * 135 (FOV) x 300 (DOF) = 104 L /sec

For an area-scan camera, with our 75mm viewport example, it would be:
42 (FOV) x 42 (FOV) x 30 (DOF) x frame rate per second of the camera

What about imaging different size taxa altogether?
To tackle this issue, several groups have used two imagers side by side. One imager would focus on smaller organisms over a shallow depth of field while the other would image much larger taxa over a larger depth of field.

Do you provide analysis services?
We do not. However, several scientists have open-source codes and are happy to collaborate or share their experience.
We can also recommend private entities to develop custom algorithms for your application.

How do you save/view images?
USB-3 cameras cannot send data over long distances. A USB-3 camera, however, can easily interface with common board computers (Raspberry-Pi or Jetson Nano) and solid-state hard drives. They are great candidates for a logger and an autonomous unit.
GigE cameras have a longer range and they are the preferred choice if you can use a very short tether (less than 200ft) to view and log images in the field onto your laptop.
For deeper deployments, especially when using an oceanographic winch, we convert GigE media into fiber-optic signals and use an opto-electric cable. Data can then travel thousands of meters and be ported to the ship where a desktop station is used to log and view images.