HYDROACOUSTIC SURVEY METHODS

FISH BIOMASS, SIDE-LOOKING SURVEYS

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ABOUT US

Infofish Australia has been operating for 30 years in the recreational fishing and natural resource management sectors. We are the country's leading operator of BioSonics Inc. scientific echo sounders. BioSonics is a company in Seattle WA, who, for over 30 years have been developing this technology. The DT-X Extreme echo sounder is able to detect and count fish in real time via their Auto Track software package. Infofish Australia has taken the work of BioSonics even further and brings leading edge habitat, fish stocks and behavior assessment to Australia, incorporating advanced data analysis, modelling and machine learning techniques. Habitat and fish targets can be classified, GPS located and size graded (fish only). Surveys are completed using a combination of side-looking and down-looking techniques, depending on the aims of the survey, and can be completed from distances of up to 200m away. In addition, Infofish incorporates side scan imaging to provide the best possible picture of the underwater environment.

SURVEY DESIGN

The common question(s) that typically prompt a survey are:

- How many fish are in the waterbody?
- How big or what range of sizes are the fish are in the waterbody?
- How are fish distributed throughout the waterbody and what habitats are they associating with?
- Are fish mobile or relatively still?
- What part of the water column are fish occupying?
- How many species of fish make up the assemblage or community within a site / waterbody?

The waterbody is commonly an estuarine / riverine environment or enclosed waters e.g. dam / impoundment and the survey approach can vary slightly between the two. Survey reaches in a riverine environment are typically 1km in length but can be increased as necessary. Surveys in enclosed waters typically cover the whole body of water. See Figure 1 and Figure 2 for examples survey transects for a riverine reach survey and a section of dam / impoundment survey. In larger impoundments or open water surveys, predefined survey transects are generated in ReefMaster and installed into the fish finder to aid in vessel navigation. Once a survey reach (riverine) or zone (impoundment) has been defined, the survey methods for each are as follows:

Riverine

- two longitudinal transects (one upstream and one downstream) with the vessel travelling parallel to the right / starboard bank, and
- where the river is greater than 50m wide, a number of transects across the waterbody spaced 100m apart (water depth dependent), are surveyed.

Enclosed waters / impoundment

- a number of transects across the waterbody, spaced 100m apart. Transect are aligned so that the majority run perpendicular to the dam alignment and / or submerged river channel.

Figure 1. Typical riverine survey transects.

Figure 2. Typical enclosed waters survey transects.

SURVEY FREQUENCY

The survey frequency is typically project specific and dependent on the aims of the survey. Surveys can be as little as hours or up to months apart.

TRANSDUCER CONFIGURATION

For side-looking surveys, all data is collected with the transducer aimed to the port side of the vessel, angled downwards to -2 to -6 degrees below horizontal (Figure 3). The optimum angle is calculated prior to survey, based on pre-survey bathymetry modelling and will vary with depth e.g. shallower angles are used in shallower waters. With the transducer in this configuration, pings are sent, and echoes received from up to 200m away. The farther the range surveyed, the greater portion of water column is covered as the ping cone becomes wider. See Table 1 for estimates of ping cone width and water volumes surveyed in commonly used survey ranges.

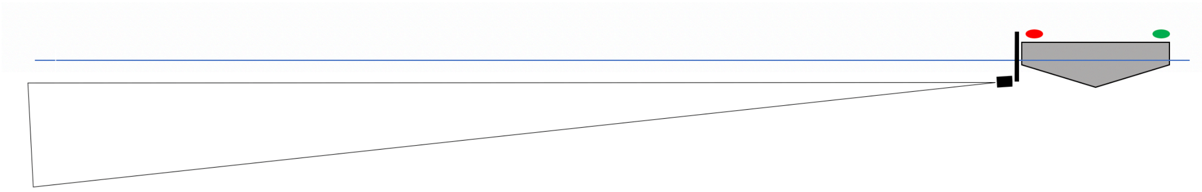


Figure 3. Transducer mounted to vessel in side-looking configuration.

Table 1. Calculated single ping cone widths and water volumes (m^3) surveyed at commonly used survey ranges.

Survey Range (m)	Cone Diameter at End Range (m)	Water Volume Surveyed (m^3)
10	1.1	3.17
50	5.8	440
75	8.7	1,490
100	11.6	3,520
200	23.3	28,400

DATA COLLECTION

BATHYMETRY

Bathymetry data is collected using Humminbird Helix Mega SI GPS fish finders (Helix) during pre-survey and the fish biomass surveys. Pre-survey bathymetry is typically more detailed to better define channel shape and other form such as aggressive bank slopes, submerged points, point bars and islands.
To avoid accidental data corruption or loss, two helix units are networked with a primary and slave unit both set to record. Recorded bathymetry data is saved to standard SD cards in the Helix units and backed up and reviewed daily, during surveys. See Bathymetry methodology statement for detailed descriptions and examples of bathymetric survey methods and outputs.

AQUATIC HABITAT

Aquatic habitat side imaging is recorded along each transect using the Helix units. The sidescan frequency most commonly used is 455kHz and set to a range of 60m either side of the boat. The side imaging provides qualitative information on the types and locations of habitats in a survey reach or zone e.g. wood / snags, rock bars, seagrass beds, freshwater aquatic plant beds, natural and anthropogenic structures and bottom types, etc. As with the bathymetric data, recorded habitat data is saved to standard SD cards in the Helix units and backed up and reviewed daily, during surveys. Refer to Aquatic Habitat methodology statement for detailed descriptions and examples of aquatic habitat survey methods and outputs.

FISH BIOMASS

Fish biomass and distribution data collected with the BioSonics DT-X split beam echo sounder is generated using the Visual Acquisition[1] software package. The software enables the user to adjust parameters such as:

- the ping rate (pings per second) - can be set between 1 and 10 and is dependent on the aims of the survey and types of data being collected.
- the decibel threshold - the threshold below which echoes are rejected (small objects return low decibel echoes; larger objects return higher decibel echoes and hard surfaces return very high decibel echoes).
- the number of echoes an object needs to return to be classified as a 'track' – the sequential stitching together of echoes that are above the decibel threshold (the software counts only accepted tracks), and
- the maximum number of echoes an object needs to return for it to be deemed 'too many' – this setting is relaxed to allow all tracks to be counted. An object that is too big is accepted but not counted by the software.

[1] BioSonics Inc., 2017. Visual Acquisition - Real Time Data Acquisition, Storage and Playback Software for BioSonics Echosounder Systems, v6.3.1.10980.

During surveys, data collection parameters are always set to allow the greatest number of echoes and therefore tracks to be accepted by the Visual Acquisition software, termed ‘raw data’. For example, at a range of 200m, the following settings are used: 5 pings per second, a threshold of -60dB and at least 3 echoes received from an object to be classified as a track and counted. Five pings per second is the standard by which data is collected in all surveys.

DATA ANALYSIS

ECHOGRAM REVIEW AND RE-ANALYSIS

The stages of the echogram review process are displayed in Figure 4, and show;

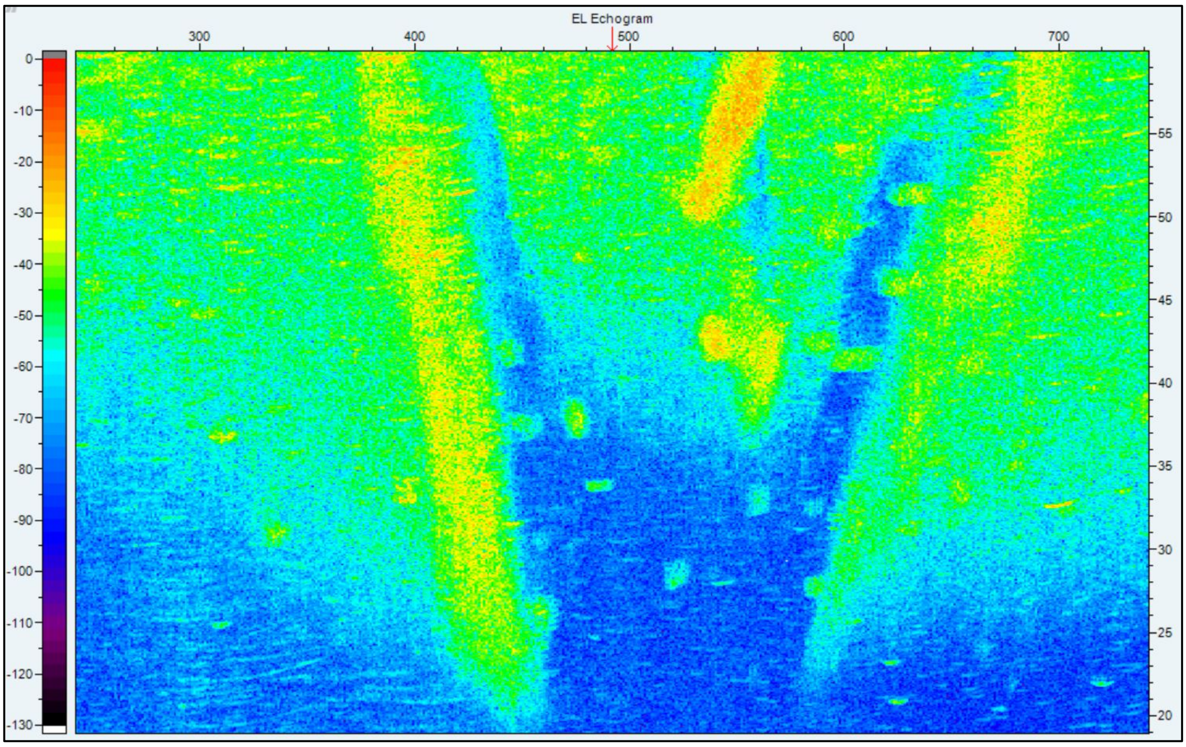
a) a raw echogram
b) the number of accepted raw tracks (in green) as collected during a survey
c) the manual reduction of 'noisy' bottom echoes and how a fish track appears in a cross-section view of the echo sounder beam, sitting above the softer bottom noise (inset), and
d) a re-analysed echogram where the noisy signals have been rejected (red pings) and the objects that returned at least 4 echoes (in this instance) have been accepted as a fish, or other object of interest.

Once the re-analysed echogram has been reviewed and the results are deemed acceptable the metadata for each echogram is exported from Visual Acquisition. The primary aim of review and re-analysis is to provide the post processor with a cleaner dataset. Other objects (wood, rocks, anthropogenic structures, etc.) will also meet the re-analysis echo criteria however, deciphering and classifying those included objects is where the machine learning based post processing is relied upon. It should be noted that in some instances, structure maps which single out harder objects are generated and included in the post processing to provide further points of reference, which improve the machine learning classifications, especially around larger fish.

Echogram re-analysed involves increasing the number of echoes that an object needs to return to be accepted. Typically, the raw data is re-analysed up to four times to separate more accurately:

- fish <200mm;
- fish >200mm; and
- structure.

The structure analysis provides location data on objects that return higher decibel (-5 to -19dB) echoes. This analysis is combined with the fish >200mm analysis to assist in querying and differentiating the larger objects which all return louder echoes.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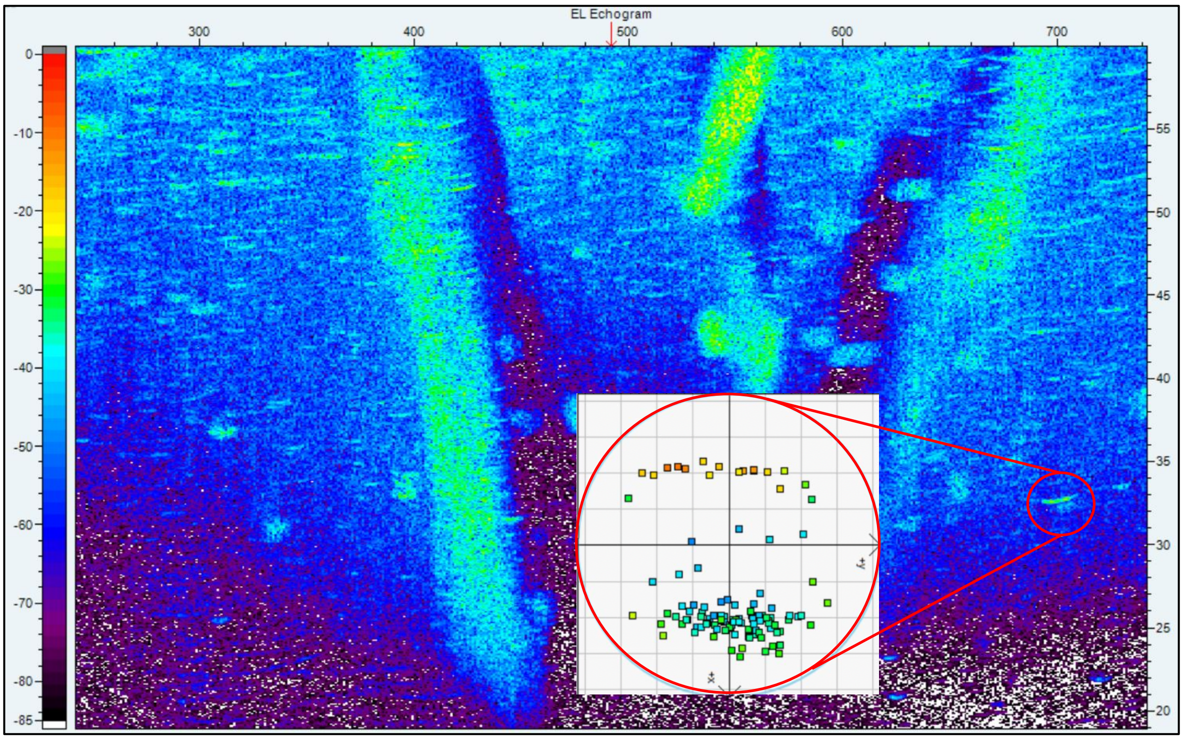

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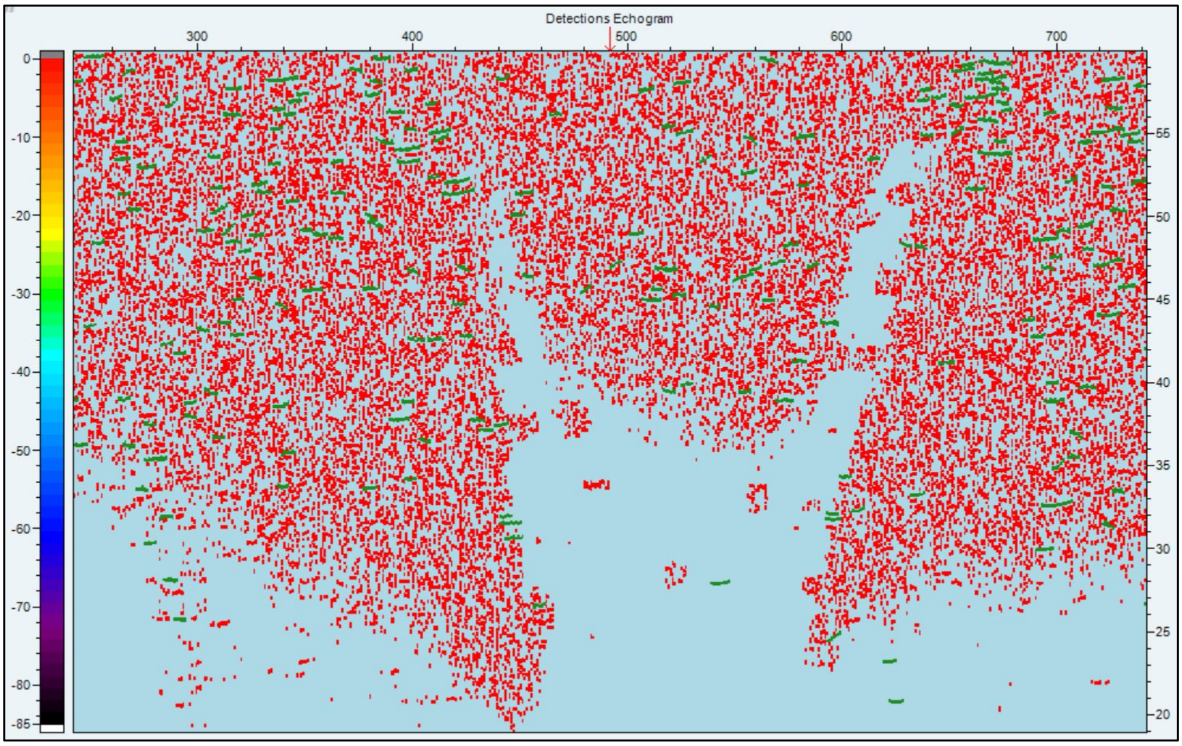

d)

Figure 4. Example (plan view) of; a raw data echogram (a), raw, accepted and counted tracks in green (b), filtered bottom noise revealing fish tracks above the bottom (c) and re-analysed data to extract fish tracks from bottom noise noting the rejection of smaller fish by red pings in the open water.

MACHINE LEARNING AND MODELLING

Machine learning based post processing and modelling is completed in RStudio[2] and involves the following:

- Data is imported in its re-analysed format and aggregated into groups of transects collected in the same habitat type (e.g. open water impoundment), survey reach or zone. For example, if there are 10 tracks and all in the same region with the same habitat they are processed as one block. If two habitats types (e.g. open water / impoundment and riverine) have been surveyed, they are processed separately.
- Spatial information and the parameters used to assess individual objects e.g. signal standard deviations, signal angularity, etc., for identification purposes are generated.
- Individual objects are then assessed by a machine learning model, that is selected from a reference library of signal types. Once the object signal has been assessed, objects are assigned a classification e.g., sand, mud, rock, wood, fish, etc.
- Anomalous objects e.g., where pings have been stitched together erroneously by the Visual Acquisition software or where an object was detected beneath or deeper than the bathymetry in an area, are classified as such and removed from the data.
- Validation graphics and datasets are generated for individual transects, groups of transects, and whole surveys for review purposes.
- Client usable datasets are output, including pointcloud data, accepted fish tracks and summaries of detected fish and other objects of interest.

FISH BIOMASS ESTIMATES AND SIZE GRADING

The strength of the echo that an object returns, in decibels, is referred to as the target strength. The calculated average decibels of all echoes returned by an object is referred to as mean target strength (MTS). A relationship between fish length and mean target strength exists and it is from Love's[3] equation that the length of a fish can be calculated from its mean target strength. Love's equation is as follows:

$$Length = 10^{\left(\frac{MTS+a}{b}\right)}$$

Where MTS is the mean target strength of an object and a and b values are constants derived from the linear regression equation describing the log transformed and plotted mean target strength data. Currently, many species of fish have been sampled hydracoustically in controlled environments and species-specific MTS to length relationship data is available and used when possible.

[2] RStudio, 2018. RStudio v1.1.456.

[3] Love, R. H., 1969. An Empirical Equation for the Determination of the Maximum Side-Aspect Target Strength of an Individual Fish. Informal Report, Naval Oceanographic Office, Washington D.C.

DATA OUTPUTS

FISH DISTRIBUTION MAPPING

Fish distribution pointcloud data is reviewed in QGIS[4]. The objects classified as fish are displayed over the bathymetry map (Figure 5) and habitat map (Figure 6) from a survey area. Where large numbers of fish are detected in a survey, heat maps may also be generated to define fish biomass aggregation or skewed distribution more clearly (Figure 7). All mapping is displayed in Mapbox Studio[5] with links made available.

TWO DIMENSIONAL AND VOLUMETRIC CALCULATIONS

The percentage coverage of fish from survey results are calculated per m^2 and in m^3. The coverage of fish per m^2 is derived by dividing the number of fish counted per transect by the area of water that each survey transect covered (echosounder range x transect length). This approach is often preferred as the area of surveyed water, in two-dimensions / m^2, can be expressed as a percentage of the total area of each zone and the calculated fish / m^2 in the surveyed area could be extrapolated to provide an estimate for 100% of each zone.

Volumetric calculations (fish per m^3) are derived by dividing the number of fish counted per transect by the volume of water ensonified by a single ping ($V = 1/3x\pi(3.35^{o}$ x range)) by the length of a transect. This is referred to as the ‘swept volume’. This calculation is an approximation as it is difficult to factor in undulating bathymetry along the survey transect.

[4] QGIS, 2019. Version 3.8 (Zanzibar).

[5] Mapbox Studio, 2020.

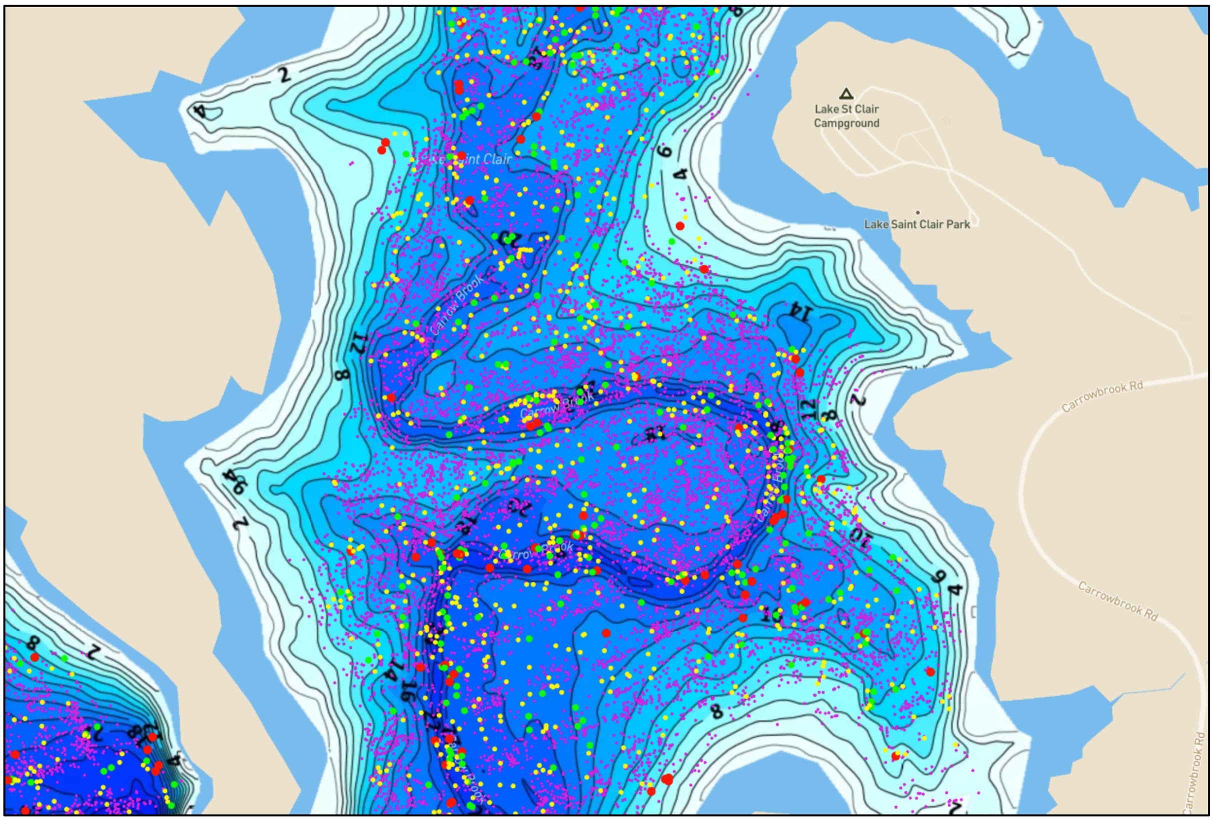

Figure 5. Mapping of fish data from a biomass survey displayed over a bathymetry map of Lake St Clair, NSW.

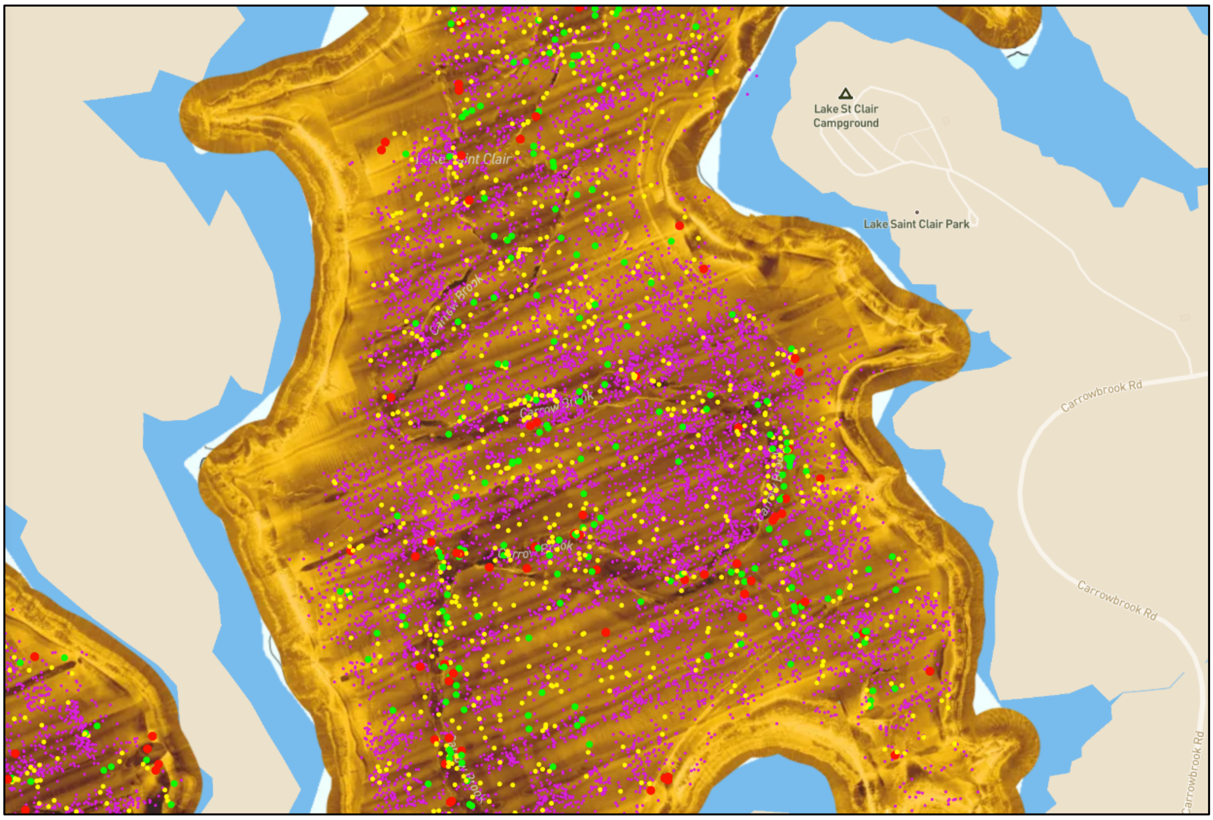

Figure 6. Mapping of fish data from a biomass survey displayed over a habitat map of Lake St Clair, NSW.

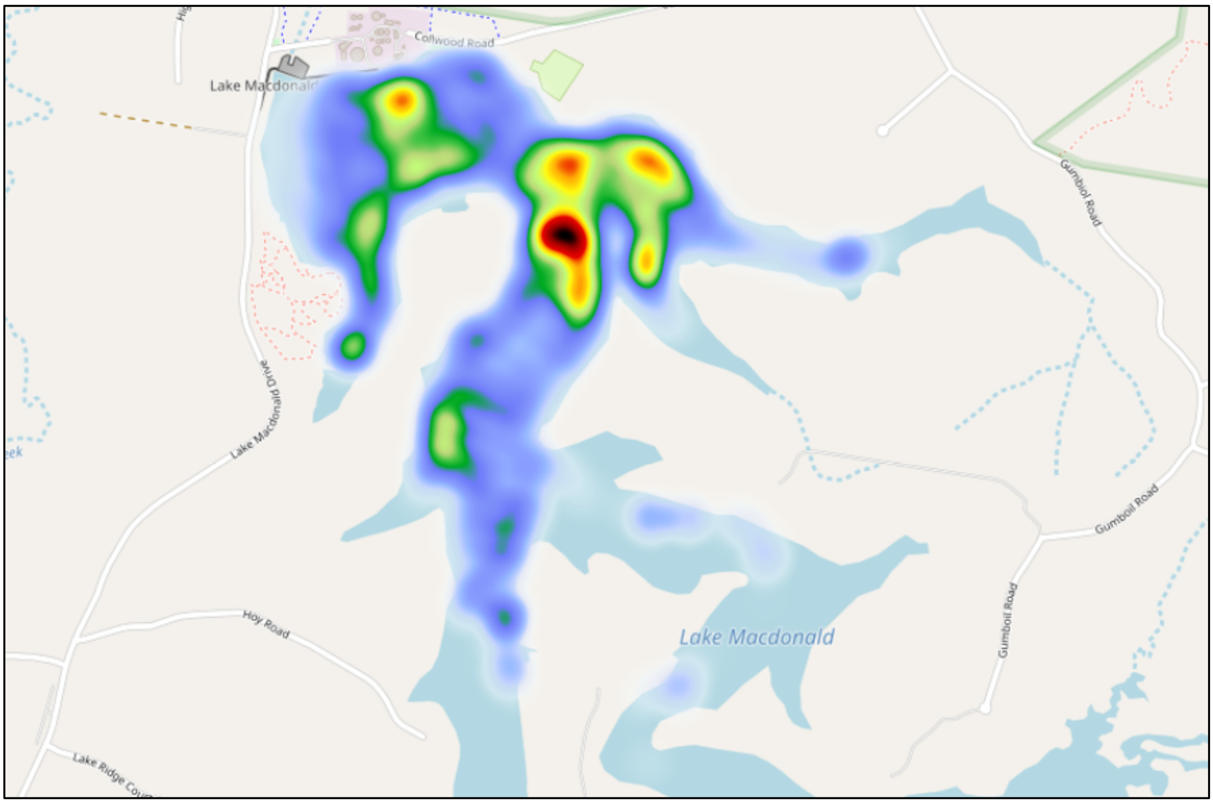

Figure 7. Heat mapping of fish >200mm in Lake Macdonald, QLD.

QUALITY ASSURANCE AND SAFETY

The survey team holds suitable tertiary qualifications and / or the necessary experienced to undertake surveys. Our team is highly experienced in completing scientific studies in field environments. They have the ability to fully assess any potential hazards prior to mobilising into the field and develop appropriate control measures. They also have the experience and authority to alter controls and procedures based on current field conditions, in order to ensure that risks are minimised on the ground. All field team members are required to be inducted into and sign all of Infofish's site safety documentation, per project.

Our survey vessels operate as domestic commercial vessels under the Australian Maritime Safety Authority (AMSA) EX02 – Marine Safety (Certificates of survey) Exemption, 2018, under the Marine Safety (Domestic Commercial Vessel) National Law Act 2012. Our survey teams hold current certification under EX38 - Marine Safety (Low complexity duties) Exemption 2017 (No. 2).

PROJECT EXPERIENCE

Infofish Australia has completed or is currently completing the following relevant projects using the survey methods stated herein:

- Fish Biomass Surveys (including habitat mapping) in lakes St Clair, Glenbawn, Copeton, Split Rock, Pindari, Tantangara, Blowering, Burrinjuck and Wyangala, NSW DPIF, 2020-2021
- Trout Biomass Surveys in Lake Jindabyne, NSW DPI, 2020
- Lake Somerset Fish Biomass Surveys in Lake Somerset, Infofish Australia, 2020
- Golden Perch Biomass Surveys in Lake Windamere, NSW DPI, 2019
- Fish Biomass Surveys in Lake Burrendong, NSW DPI, 2019

- Fish Biomass Surveys in Lake Copeton, NSW DPI, 2019.
- Lake Macdonald Fish Biomass Assessment, seqwater, 2019.
- Logan and Albert Rivers Fish Habitat Assessment, Logan City Council, 2019.
- Teemburra Dam Fish and Aquatic Habitat Surveys, Infofish Australia, 2018.
- Lake Awoonga Fish and Aquatic Habitat Preliminary Surveys, Gladstone Area Water Board, 2018.
- Trout biomass survey trials in Lake Jindabyne, NSW DPI, 2019
- Assessment of Fish Hotels, Fitzroy Basin Association, 2018.

For any queries on the above survey methodology and associated data analysis and outputs, don't hesitate to contact us at admin@info-fish.net.