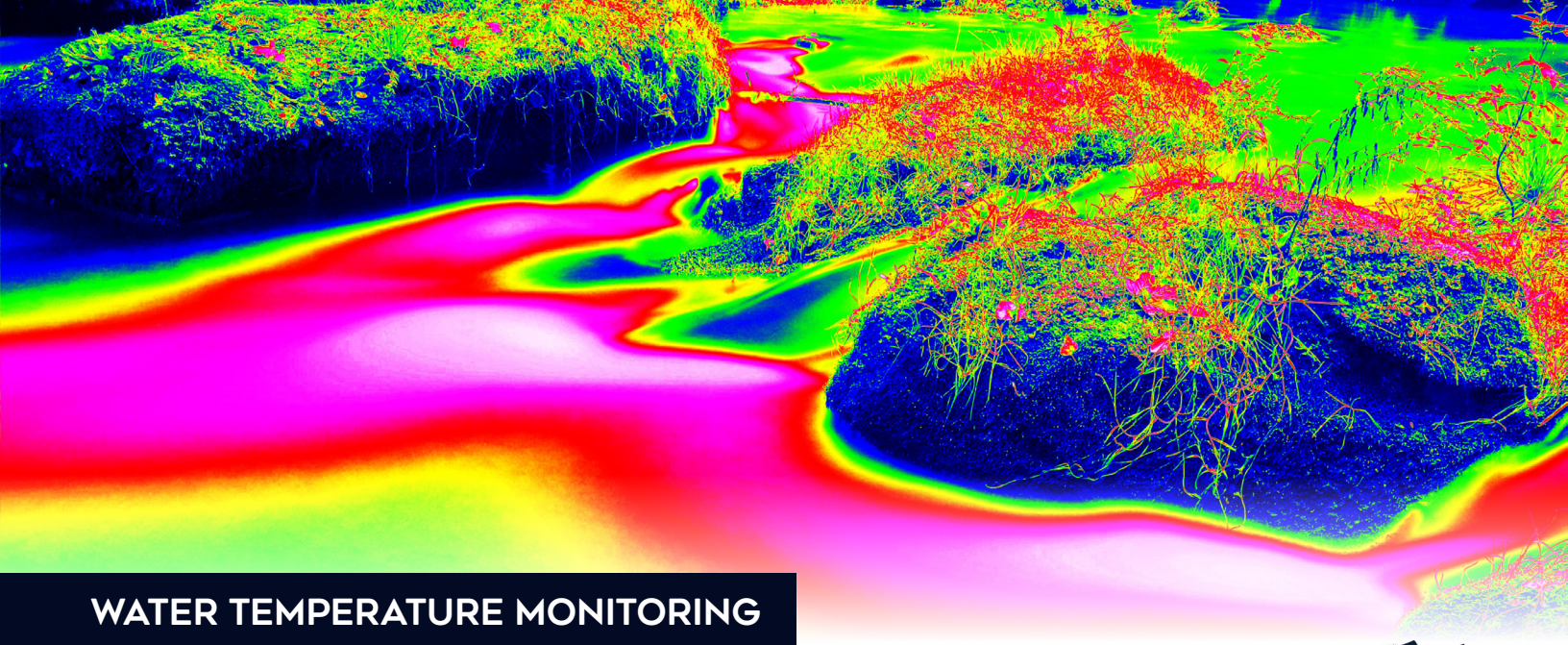

WATER TEMPERATURE MONITORING

# HANDHELD THERMAL CAMERA

PACIFIC SALMON FOUNDATION

**Water temperature monitoring** in streams using handheld thermal cameras (HTC) is an emerging method for capturing high-resolution spatial patterns of water temperature across the stream surface. Similar to Remotely Piloted Aircraft Systems (i.e., drones; see related summary), they use a thermal infrared (TIR) sensor to provide detailed temperature images that are difficult to obtain using traditional in-stream sensors; however, HTCs are more useful than drones for small streams with channel-obstructing vegetation. The approach is helpful for quickly identifying fine-scale temperature variability in streams, such as thermal refuges, cold-water inputs from groundwater or tributaries, or localized warming caused by reduced riparian shading or human activities.

## SUMMARY OF METHOD

There are four main steps involved with temperature monitoring using HTCs:

1. **Site selection:** Identify stream reach and access points based on study objectives.
2. **Calibration:** Calibrate the thermal sensor before and after surveying. Deploy in-stream temperature loggers or handheld thermometers at select locations for validating HTC-derived surface temperatures.
3. **Data acquisition:** Capture still images or short video transects from stream banks, bridges, or shallow wading positions, holding the camera in the nadir position (downward-facing). Record at predefined points or continuously along the stream reach.
4. **Data processing:** Use thermal analysis software to extract surface temperatures and generate spatial temperature images. Screen data for reflection, shading effects, or atmospheric interference. Compare HTC-derived temperatures with in-stream measurements to assess accuracy and correct for sensor drift.

Photo credit: rdonar

## IMPORTANT CONSIDERATIONS

It is important to use a high-quality radiometric TIR sensor (e.g., 128 x 96 spatial resolution or greater) and ensure proper calibration. Accurate temperature measurements depend heavily on sensor sensitivity and regular validation with in-stream temperature measurements at the time of image capture.

Conduct surveys during early morning or late afternoon (preferred for maximizing temperature contrast and identifying cold-water inputs), or under overcast skies. Surface turbulence, reflections, and varying atmospheric interference (e.g., water vapor, solar heating) can affect accuracy. Maintain a consistent distance from the water surface when comparing sites. Best to capture complimentary images with a regular camera (e.g., cell phone) to assist with data screening (e.g., identifying shading).

HTCs measure only surface water temperature, which can be problematic for pools that stratify. Images can be geotagged, but likely not combined to generate a spatial mosaic. Understanding these limitations and integrating HTC data with ground-based measurements may be important for accurate interpretation of stream temperature conditions.

## STREAM CHARACTERISTICS

- Extensive sun reflection or partial shading on water surface can be problematic
- Well suited to small streams and locations where flying a drone is not possible
- High turbulence may decrease accuracy

## MEASUREMENT CHARACTERISTICS

- Manual data acquisition (operating HTC)
- Distributed measurement across stream and along stream network
- Captures water surface temperature only
- Sensor accuracy typically ±2-3°C, but may be improved with calibration
- May have limited utility for repeat measurements or formal monitoring

## SITE ACCESSIBILITY FACTORS

- Suitable for remote foot access
- Can avoid entering stream
- Initial set up involves small equipment (e.g., in-stream temperature measurement for calibration)
- Ongoing monitoring involves small equipment (e.g., HTC)

## SCALE OF EFFORT: INITIAL SET UP

**Equipment cost:** very low or low, depending on HTC product

## SCALE OF EFFORT: ONGOING MONITORING

**Equipment cost:** negligible (pre-purchase)
**Field time:** low; <0.5 day
**Field expertise:** moderate; somewhat complex software
**Analysis time:** moderate; ~1 day
**Analysis expertise:** moderate; somewhat complex software

## PRODUCTS TO CONSIDER

**HTC:** FLIR C8 Compact Thermal Imaging Camera (320 x 240 resolution), FLIR C3-X Compact Thermal Imaging Camera (128 x 96 resolution)

**Software:** FLIR Thermal Studio Suite, consider open source GIS software

## ADDITIONAL RESOURCES

Antonelli et al., 2017
Iwasaki et al., 2022
Vatland et al., 2015