3.2 From fish ponds to oceans: real-time monitoring of water environments

In many cases, changes in water environment monitoring came quietly rather than through any clear turning point. Across aquaculture operations, long-used practices were usually kept in place, with new tools added around them rather than replacing them outright. Low-cost sensors were introduced gradually and, over time, became part of everyday management routines. Once installed in ponds, they began to record basic conditions such as water temperature and dissolved oxygen on a continuous basis. Compared with earlier methods that depended heavily on manual checks, this approach reduced repeated measurements and, when problems occurred, left behind records that could be reviewed later instead of relying solely on experience or recollection (Kharabsheh and Bdour, 2025; Sharma, 2025).

As data continued to build up, the way they were used began to change almost without being noticed. In some systems, monitoring gradually moved beyond simply recording conditions and started to offer rough indications of survival rates, or to issue warnings when key indicators were approaching critical levels. Under relatively stable management settings or controlled trials, reported accuracy can be very high, sometimes above 99%. In a few cases, systems are also able to react automatically to changes in weather by adjusting water quality parameters, which has helped ease daily workloads and made routine management a little more efficient for farmers (Baena-Navarro et al., 2025). At the same time, results are far from consistent. Differences in data quality, local environmental conditions, and management practices still play a major role, and performance can vary markedly from one farm to another.

Related approaches are now being tested outside pond-based aquaculture as well. At a larger scale, projects such as those carried out in the Gulf of Aqaba have combined sensor networks with machine learning tools to track water quality in real time and assess the risk of coral bleaching. Available reports suggest that this setup has maintained monitoring effectiveness while reducing overall costs by around 30% (Kharabsheh and Bdour, 2025). Satellite remote sensing has also been drawn into this process. Although its spatial resolution is limited and the results are not always precise, it remains one of the few workable options for observing large marine areas at the same time. When satellite data are used together with nearshore sensor observations, monitoring begins to span multiple scales, gradually linking aquaculture management with broader assessments of ecosystem conditions.

3.3 Intelligent detection of illegal, unreported, and unregulated fishing

When it comes to dealing with illegal fishing, intelligent technologies are often appreciated because they make monitoring possible over a much wider area than manual inspection alone. In real situations, however, using these tools is rarely simple. Machine learning systems are typically applied to vessel movement data alongside satellite observations, with AIS signals used to identify routes or behaviors that appear unusual in timing or pattern. In Southeast Asia, for instance, studies have relied on vessel trajectory data to highlight zones where the risk of illegal fishing is relatively high, rather than to confirm individual violations outright (Sharma, 2025).

Some systems go a step further by assigning risk scores to vessels, suggesting whether they may be operating outside permitted waters. Others focus on identifying particular patterns, such as extended periods of loitering, through tools sometimes described as a “fishery prediction guardian.” These systems can issue timely alerts that help enforcement agencies decide where closer attention may be needed (Sharma, 2025). They are not intended to replace inspectors working on the ground, but rather to filter large amounts of information and highlight cases that warrant further checking.

Despite these advances, a number of limitations remain difficult to avoid. One long-standing issue is that some vessels intentionally switch off their AIS transmitters, leaving sizeable gaps in monitoring coverage. To work around these blind spots, researchers have increasingly experimented with remote sensing and the joint use of multiple data sources. The INSURE system deployed in Ghana is often cited in this context, reporting an identification accuracy of around 91%. Even so, existing studies indicate that close to 75% of observed vessels still lack AIS records, which highlights how incomplete current surveillance efforts remain. As monitoring tools continue to be introduced more widely, other challenges have also become harder to ignore. Access to reliable data