CLAIMS

1. A system for monitoring the condition of a mooring chain, the system comprising:

at least one emitter in fixed relation to a first link of the chain, the emitter being configured to emit a signal;

at least one receiver on any link of the chain, configured to receive the signal; and

a processor configured to measure a time lapse between emitting and receiving the signal to determine a distance between the emitter and a link of the chain other than the first link.

2. A system according to Claim 1, in which the emitter and the receiver are on the first link of the chain.

3. A system according to Claim 2, in which an acoustic transducer serves as the emitter and as the receiver.

4. A system according to Claim 2 or 3, in which the emitter and the receiver are each opposed to an intermediate reflecting surface on a second link of the chain.

5. A system according to Claim 4, in which the emitter is configured to emit the signal toward an opposed reflecting outer end surface of the second link of the chain, that surface of the second link being disposed within an inner opening of the first link.

6. A system according to Claim 4, in which the emitter is configured to emit the signal toward an opposed reflecting outer end surface of the second link of the chain, that surface of the second link being disposed within an inner opening of an intermediate link that couples the first link to the second link, and optionally in which the emitter is also disposed within the inner opening of the intermediate link.

7. A system according to any preceding claim, in which the emitter and the receiver are implemented together in a sensor unit that is attached or attachable to the first link of the chain, and optionally in which the sensor unit spans the inner opening of the first link from one longitudinally-extending side to another.

8. A system according to Claim 1, in which the receiver is in fixed relation to a second link of the chain.

9. A system according to Claim 8, in which: (a) the receiver is disposed within an inner opening of the first link, or (b) the receiver is disposed within an inner opening of an intermediate link coupling the first link to the second link, or (c) the receiver and the emitter are disposed within an inner opening of an intermediate link coupling the first link to the second link.

10. A system according to Claim 8 or 9, in which the processor is in data communication with the emitter and the receiver via a connection that extends between the first and second links.

11. A system according to any preceding claim, in which the emitter is attached or attachable to the first link at a central longitudinal position, and optionally in which the emitter is attached or attachable to at least one longitudinally-extending side of the first link.

12. A system according to any preceding claim, in which the emitter is aligned with a central longitudinal axis of the first link, and optionally in which the emitter is oriented to emit the signal in a direction substantially parallel to the central longitudinal axis of the first link.

13. A system according to any preceding claim, in which the emitter is disposed within an inner opening of the first link.

14. A system according to any of Claims 1 to 11, in which the emitter is offset laterally from a plane of the first link, and optionally in which the emitter is oriented to emit the signal in a direction converging with the central longitudinal axis of the first link.

15. A system according to any preceding claim, comprising first and second emitters in mutually-opposed orientation, and optionally in which the first and second emitters are in fixed relation to the first link being an intermediate link disposed between and conjoining a pair of outer links each with a reflecting outer end surface that is opposed to a respective one of the emitters and is disposed within an inner opening of the first link.

16. A system according to any preceding claim, in which at least the first link is a stud link that comprises a stud dividing an inner opening, and optionally in which the emitter is mounted on the stud.

17. A system according to any preceding claim, in which the emitter is disposed on an outer end surface of the first link.

18. A system according to any preceding claim, further comprising a processor configured to determine time of flight of the signal from the emitter to the receiver and to generate distance data accordingly and optionally further comprising: (i) a data store for storing the distance data and/or (ii) a communication module for conveying the distance data to a monitoring or relay station.

19. A system according to any preceding claim, further comprising a reference reflector, configured to reflect at least a portion of the signal emitted by the emitter to the receiver as a reference signal for use by the processor in calibration of the determined distance.

20. A system according to any of Claims 1 to 18, further comprising a reference reflector and a reference emitter, in which the reference emitter is configured to emit an auxiliary signal and the reference reflector is configured to reflect at least a portion of the auxiliary signal to the receiver as a reference signal for use by the processor in calibration of the determined distance.

21. A system according to any of Claims 1 to 18, further comprising a reference receiver and a reference emitter, in which the reference emitter is configured to emit an auxiliary signal and the reference receiver is configured to receive the auxiliary signal as a reference signal for use by the processor in calibration of the determined distance.

22. A system according to Claim 19, 20 or 21, in which the processor is configured to:

measure a reference time lapse that occurs prior to receiving the reference signal; and

determine a reference velocity of sound in water using the reference time lapse.

23. A system according to Claim 19, comprising first and second sensor modules in communication with one another, in which the emitter and the receiver are implemented together in the first sensor module, and the processor is implemented in the second sensor module.

24. A system according to Claim 20, comprising first and second sensor modules in communication with one another, in which the emitter, the receiver, and the reference emitter are implemented together in the first sensor module, and the processor is implemented in the second sensor module, and optionally in which the reference reflector corresponds to a portion of a housing of the second sensor module.

25. A system according to Claim 23 or 24, in which the first sensor module is configured to be inserted or insertable into an inner opening of the first link.

26. A method for monitoring the condition of a mooring chain, the method comprising:

emitting a signal from an emission location fixed relative to a first link of the chain;

receiving the signal at a receiving location on any link of the chain; and

measuring a time lapse between emitting and receiving the signal to determine a distance between the emission location and a link of the chain other than the first link.

27. A method according to Claim 26, comprising reflecting the signal to the receiving location from a second link of the chain.

28. A method according to Claim 27, comprising: (a) reflecting the signal from a location within an inner opening of the first link; or (b) reflecting the signal from a location within an inner opening of an intermediate link that couples the first link to the second link; or (c) reflecting the signal from a location within an inner opening of an intermediate link that couples the first link to the second link and emitting the signal within the inner opening of the intermediate link.

29. A method according to Claim 26, in which the receiving location is fixed relative to a second link of the chain.

30. A method according to Claim 29, comprising: (a) receiving the signal within an inner opening of the first link, or (b) receiving the signal within an inner opening of an intermediate link coupling the first link to the second link, or (c) receiving the signal within an inner opening of an intermediate link coupling the first link to the second link and emitting the signal within the inner opening of the intermediate link.

31. A method according to any of Claims 26 to 30, comprising emitting the signal along a central longitudinal axis of the first link, or emitting the signal in a direction converging with the central longitudinal axis of the first link.

32. A method according to any of Claims 26 to 31, comprising emitting the signal from within an inner opening of the first link, or emitting the signal from an outer end surface of the first link.

33. A method according to any of Claims 26 to 32, comprising emitting signals in mutually opposed directions from first and second emission locations fixed relative to the first link, and optionally emitting the signals at different times, with different phases or with different frequencies.

34. A method according to any of Claims 26 to 33, comprising generating data representative of the distance at the first link and communicating that distance data from the first link to a receiving station remote from that first link, and optionally further comprising: (a) relaying the distance data along the chain to the receiving station or (b) conveying the distance data to the receiving station via an underwater vehicle stationed beside the first link.

35. A method according to any of Claims 26 to 34, comprising any one of the following:

(a) reflecting at least a portion of the signal emitted by the emitter to the receiver as a reference signal for use by the processor in calibration of the determined distance;

(b) emitting an auxiliary signal, and reflecting at least a portion of the auxiliary signal to the receiver as a reference signal for use by the processor in calibration of the determined distance; or

(c) emitting an auxiliary signal, and receiving at least a portion of the auxiliary signal by a reference receiver as a reference signal for use by the processor in calibration of the determined distance

36. A method according to Claim 35, further comprising

measuring a reference time lapse that occurs prior to receiving the reference signal; and

determining a reference velocity of sound in water using the reference time lapse.