Improved HSEQ and survey efficiency demonstrated with a new remotely operated streamer cleaning tool

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SUMMARY

Barnacle growth on seismic streamers creates noise on the recorded signals. Keeping a low noise level in barnacle areas is challenging to seismic crews: Frequent workboat trips are required for streamer cleaning, and workboat operations are weather-dependent and considered undesirable from an HSE perspective. In 2007 a purely mechanical and autonomous streamer cleaning unit (SCU) was introduced that is launched and recovered from the workboat. In 2016 we subsequently developed a remotely operated streamer tool (ROST) that is capable of launching and recovering SCUs to/from the streamer without the use of a workboat, and which is therefore less affected by weather. The ROST is operated from a support vessel that is independent of the seismic vessel. We present experiences from four surveys that were subject to different operating conditions. Operation in high sea states is demonstrated on a survey offshore Namibia, and operation in extreme currents is demonstrated on another survey east of South Africa. A noise removal method is also presented that allows operation of the ROST while online during seismic recording. The method was first applied on the offshore South African survey, and later on two surveys in offshore Angola. It is demonstrated that work boat exposure hours can be reduced by 70-80%, and a 14 streamer spread can be cleaned twice a week while acquiring seismic in all types of operating conditions.

Key words: barnacles, noise, HSE, seismic, automation.

INTRODUCTION

Following the introduction of multisensor streamer technology in 2007, PGS pursued several associated engineering projects to fully utilize the potential of the new platform. Some of the initiatives have been related to barnacle prevention and mitigation. All clamp-on devices have been replaced or are in the process of being replaced by in-streamer substitutes, hence minimizing the number of barnacle anchoring points. Notably, a streamer cleaning unit (SCU) was also introduced in 2007 that is a purely mechanical, autonomous, self-propelled device deployed onto the streamer from workboats. It travels down the streamer while removing barnacles. In 2011, a new version was introduced that is also able to pass three-wing birds. SCUs were initially used only during line changes and no data recording, but the introduction of a noise removal algorithm has enabled online operation which has now become standard (Widmaier *et al*., 2015). Although this device has served us well, its usage depends on allowable workboat weather. In periods with sea states beyond safe workboat weather, barnacles may grow beyond what the SCU can handle. A worst-case consequence may be full recovery of the streamers for manual scraping. Frequent SCU deployments are therefore essential for barnacle-free operations.

A desire to mitigate those limitations and a desire to minimize the amount of work boat hours used for SCU launches and manual barnacle scraping led to the development of the remotely operated streamer tool (ROST) presented by Tønnessen and Skadberg (2016). This is a remotely controlled underwater vehicle carrying the SCUs and capable of deploying and recovering SCUs to/from the streamer independent of weather, and without involving workboat operations.

During the technology validation stage the system was exposed to a large variety of operational conditions that demonstrated the operational range. In 2018 the system was used for the first time as an integral part of commercial operations. We describe our experience from four surveys and present a noise removal method that allows the ROST to be operated over the streamer spread while acquiring seismic data in 'online' mode.

THE UNDERWATER VEHICLE AND ITS OPERATIONAL MODE

The underwater ROST vehicle (Figure 1) is controlled remotely from a support vessel through a tether cable. Unlike traditional ROVs having thrusters in multiple directions, the vehicle's degrees of freedom are controlled by control surfaces. It is deployed at seismic operational vessel speed from the side of a support vessel (see the left side of Figure 2). The right side of Figure 2 shows the support vessel positioned just behind the streamer front end while having the ROST deployed.

The launch and recovery system (LARS) is key to the success of the system. The ROST is deployed into the sea while being latched into a TMS (Tether Management System); a heavy unit that has the dual function of pushing the ROV through the splash zone and to feed the tether in and out. The TMS is towed by a painter line, allowing deployment at speed, and can also be steered by a rudder. This allows safe deployment in strong shear currents often present in regions such as offshore West Africa (refer to the discussion below).

To cope with the large relative motions between the ROST and the TMS in rough weather a robust latching system and deployment method was developed. The crane on the support vessel is heave compensated, and in the process of latching the vehicle in/out from the TMS the ROST is towed from the tether cable. This method is very robust and also ensures that in case of a power black-out the ROST will be towed as a tow fish in a stable manner. This feature has been proven to minimize operational risks.

OPERATIONS IN ROUGH WEATHER

Namibia is affected by seasonal barnacle growth and generally rough weather conditions. The first time the ROST system was used as part of seismic operations was during a project acquired in offshore Namibia during January-March 2018. For several weeks the workboats could not be deployed, thereby providing an opportunity to demonstrate the usefulness of the ROST.

Figure 3 shows wave height (dotted orange, right axis) and wind speed (dotted red, left axis) throughout the duration of the project. Wave and wind limitations for workboat operations (blue) and for the new system (green) are indicated. It is observed that the system was weather-wise operational throughout the entire period in seas up to 3.5 m and wind of 25 kn. Analysis of weather statistics from other areas show wave and wind peaks above the ROST operational limits, but only for short periods not long enough to affect the cleaning mission.

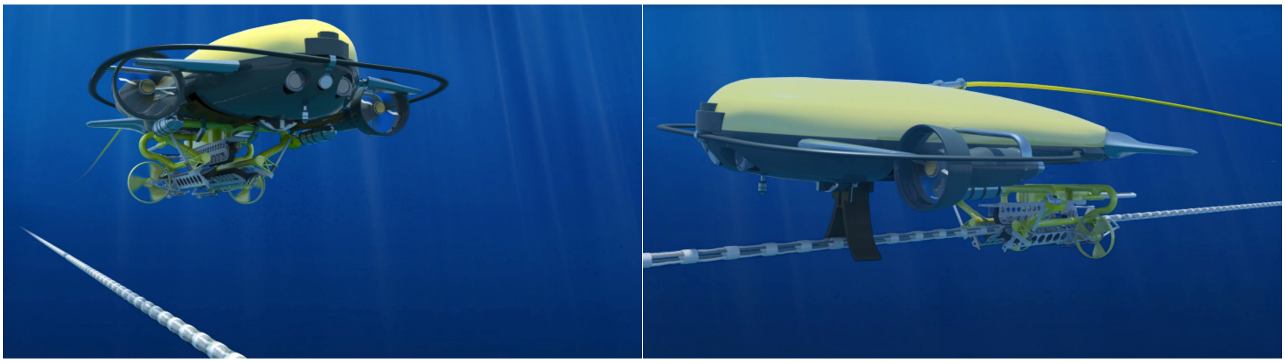

Figure 1. (left) Landing on a streamer; and (right) The ROST after having deployed an SCU on the streamer.

Figure 2. (left) The ROST deployed off the side of a support vessel while latched into a TMS; and (right) Support vessel positioned over the streamer front while the ROST is deployed.

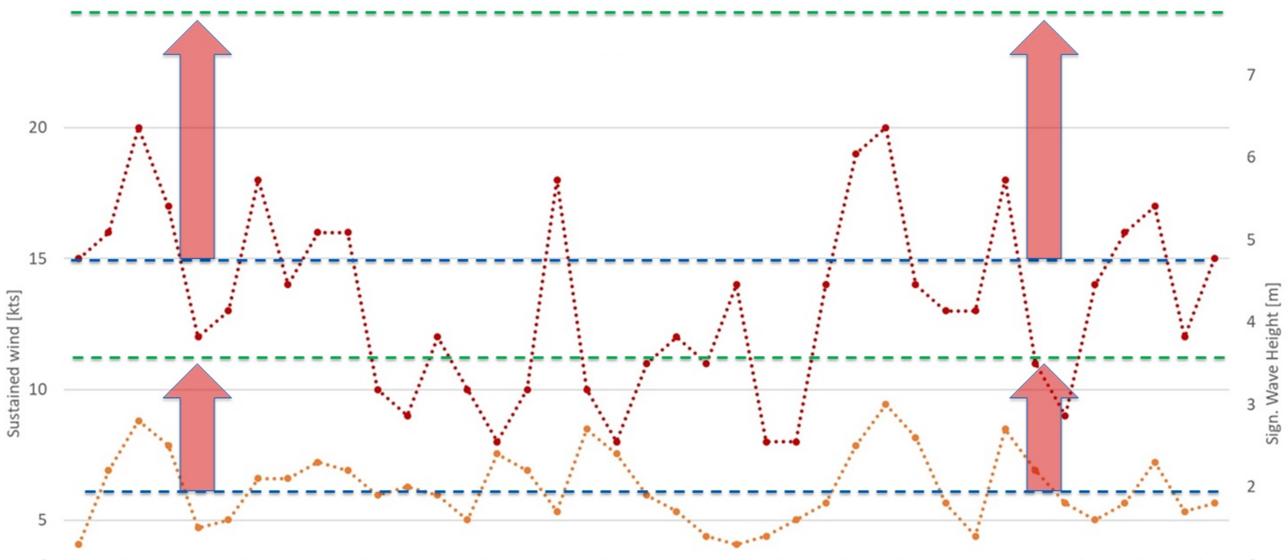

Figure 3. Wave and wind statistics for a period of 1.5 months in offshore Namibia during 2018. The blue dotted lines indicate the workboat operational cut off limits of 2m wave height 15 kn wind. The green dotted lines show the ROST system operational limits of 3.5m wave height and 25 kn wind. The red arrows highlight the extended operating windows for ROST.

Noise from barnacle growth is often compensated by reducing seismic vessel speed. Figure 4 shows that once the ROST became unavailable the seismic acquisition speed went down, but rapidly came back up again once the ROST came back to the prospect and commenced cleaning. Prior to start-up of the Namibian project it was a requirement to have clean streamers. With limited workboat availability the contribution from the ROST avoided a full recovery of the streamer spread for manual scraping and cleaning; thereby saving time and cost.

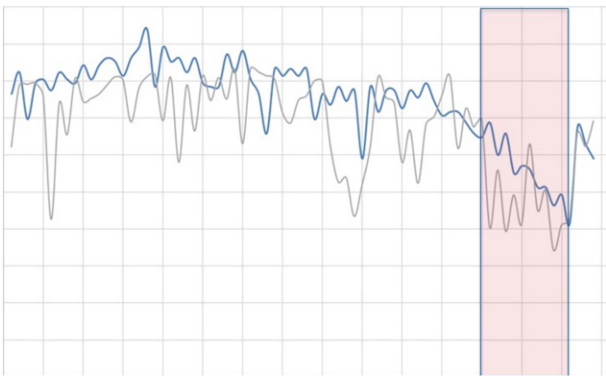

Figure 4. Vessel speed versus time for a 1.5 month period (blue is water speed, grey is bottom speed; each vertical increment = 0.2 kn). The pink area is the interval where the system was unavailable when the support vessel carrying the ROST went to port.

MANAGING SHEAR CURRENTS

The preferred nature of seismic operations is to stay on a defined racetrack regardless of changing wind and current directions. Hence, there will most likely never be a lee side for deployment of the ROST as the support vessel follows the streamer track. Strong currents were experienced during a project in offshore eastern South Africa where the strong Mozambique/Agulhas current is present, combined with the Agulhas return current coming in from the Indian Ocean (see Figure 5). Rapid current changes and shear currents up to 3 kn affected the entire seismic operation. Raising streamers to the surface for cleaning with a workboat in such conditions involves a high risk of streamer tangling. By utilizing the ROST, SCU deployment without surfacing the streamers minimized the risk of tangling and made a great difference for a successful barnacle-free data acquisition. Hence, seismic data quality and crew safety were maintained in these challenging conditions.

ROST EFFICIENCY AND FLEXIBILITY

The marine growth on seismic streamers varies with sea temperature and the amount of nutrients in the water, and is often categorized into three groups: low, medium and high. In areas with the most active growth the streamers must be cleaned daily. Experience in a high barnacle growth area showed a 14 streamer spread could be cleaned in 15 hours twice a week using ROST. The HSE uplift gained by reducing workboat exposure can thus obviously be significant.

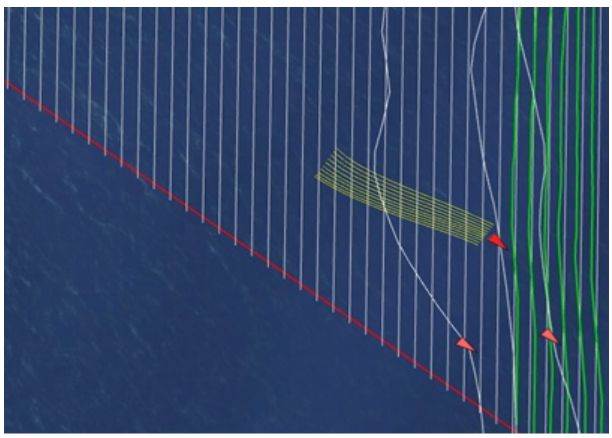

Figure 5. Seismic vessel affected by heavy shear currents in offshore South Africa as the Agulhas current hits the streamers. The vessel trajectory is N-S.

Flexibility in when to clean streamers is also important to maintain efficiency. The ROST design was specified for 24-hour operations. This capability was demonstrated in offshore Angola, operating on instrumentation and illuminated camera vision irrespective of light conditions or underwater visibility.

During these various surveys in 2018 it became clear that operating the system online during seismic acquisition provides a great contribution to improved efficiency.

NOISE REMOVAL DURING ONLINE OPERATIONS

Noise generated by the SCUs is (temporarily) seen on all sensor types as the unit travels along the streamer during online recording. Noise generated by the underwater ROST vehicle itself is usually a minor component of this SCU noise. The support vessel motors also act as a noise source (Figure 6 upper panel). Noise attenuation from these operations needs to be rigorous, but denoise processing is targeted as much as possible to limit any impact on the data signal. The location of the SCU on the streamer can be determined for each shot from analysis of the RMS noise levels. The location of the support vessel is known from the navigation system, so by using these data we limit (moving) SCU denoise to approximately +/- 40 traces from the noise generator, and for the support vessel a horizontal distance of 100-120 m is typically used (Figure 6 lower panel).

As with many other types of noise, we can isolate large amplitudes in the frequency-space (FX) spectrum compared to the surrounding signal. This works by using overlapping localized time-space (TX) windows that are Fourier transformed to the FX domain. The noisy amplitudes are first detected and then replaced by interpolated values using FX predictive filtering. If the support vessel noise is particularly intractable, we can also use an additional denoise that targets the harmonic frequencies generated by the vessel's motors.

HSE

One of the main objectives for ROST development was to improve crew safety by reducing workboat exposure hours. With increasing weather conditions comes increased risk to the crew, even if workboat operation limits are defined for safe operations. From the experience gained with ROST during commercial projects in 2018 the total workboat exposure related to barnacle cleaning was reduced by 70-80%. Ongoing routine client audits have also contributed to improvements in procedures and solutions, and the ROST solution has clearly met all development targets.

CONCLUSIONS

A method for efficiently cleaning a seismic streamer spread while acquiring seismic data and without human interaction with the streamer has been demonstrated using a remotely operated streamer tool (ROST). During its first season the system prevented full streamer recovery for cleaning and reduced the barnacle-related workboat exposure by 70-80%. Operability in 3.5 m seas, in extreme shear currents, and also in darkness has been safely and reliably demonstrated.

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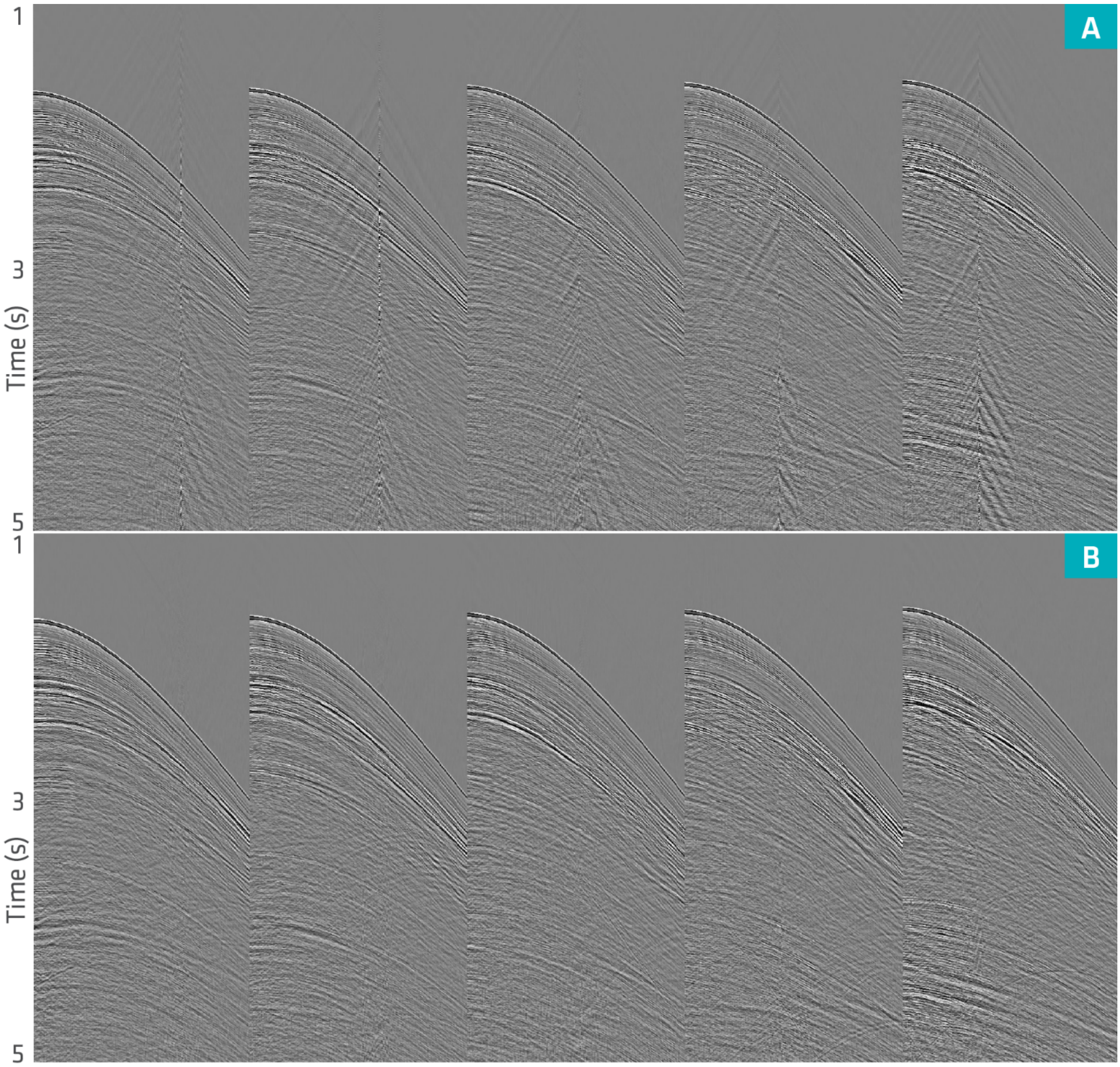

Figure 6. (A) shot gathers showing support vessel noise centred around a few noisy traces corresponding to the SCU location; and (B) after denoise.